DISCUSSION PAPER SERIES

DP13972

PRODUCTIVITY GROWTH, CAPITAL REALLOCATION AND THE FINANCIAL CRISIS: EVIDENCE FROM EUROPE AND THE US

Jonathan Haskel, Carol Corrado and Cecilia Jona-Lasinio

MACROECONOMICS AND GROWTH

MONETARY ECONOMICS AND FLUCTUATIONS

ISSN 0265-8003

PRODUCTIVITY GROWTH, CAPITAL REALLOCATION AND THE FINANCIAL CRISIS: EVIDENCE FROM EUROPE AND THE US

Jonathan Haskel, Carol Corrado and Cecilia Jona-Lasinio

Discussion Paper DP13972
Published 31 August 2019
Submitted 02 August 2019

Centre for Economic Policy Research
33 Great Sutton Street, London EC1V 0DX, UK
Tel: +44 (0)20 7183 8801
www.cepr.org

PRODUCTIVITY GROWTH, CAPITAL REALLOCATION AND THE FINANCIAL CRISIS: EVIDENCE FROM EUROPE AND THE US

Abstract

How has capital reallocation affected productivity growth since the financial cri- sis? For example, have low interest rates disrupted the reallocation process? This paper calculates the effect on productivity growth of capital reallocation between industries. It uses an accounting framework, due to Jorgenson and his co-authors, that computes the contribution of capital services to productivity growth relative to one where rates of return are equalised between sectors: if capital persists in the low return sectors, the reallocation measure falls. Using data from 11 countries (the major EU economies plus the US), in 1997-2013, we nd: (a) the contribution of capital reallocation to productivity growth is lower in most economies after than before the financial crisis, notably in Mediterranean countries; (b) more capital real- location is correlated with lower real interest rates, contrary to the hypothesis that low real interest rates have hurt capital reallocation; (c) controlling for shocks, lower capital reallocation is associated with lower optimism, and weaker financial systems.

JEL Classification: O47, E22, E01

Keywords: Productivity Growth, capital reallocation, Intangible Capital

Jonathan Haskel - j.haskel@imperial.ac.uk
Imperial College Business School and CEPR

Carol Corrado - carol.corrado@conference-board.org
The Conference Board, New York

Cecilia Jona-Lasinio - cjonalasinio@luiss.it
LUISS University, Rome

Acknowledgements
We are grateful to the European Commission FP-7 grant agreement 612774 (SPINTAN) for financial support and Dan Andrews and seminar participants at the Groningen Growth and Develop- ment Centre 25th Anniversary conference for comments. Errors are our own.

Productivity Growth, Capital Reallocation and the Financial Crisis: Evidence from Europe and the US*

Carol Corrado[†], Jonathan Haskel[‡], Cecilia Jona-Lasinio[§]

July 2019

Abstract

How has capital reallocation affected productivity growth since the financial crisis? For example, have low interest rates disrupted the reallocation process? This paper calculates the effect on productivity growth of capital reallocation between industries. It uses an accounting framework, due to Jorgenson and his co-authors, that computes the contribution of capital services to productivity growth relative to one where rates of return are equalised between sectors: if capital persists in the low return sectors, the reallocation measure falls. Using data from 11 countries (the major EU economies plus the US), in 1997-2013, we find: (a) the contribution of capital reallocation to productivity growth is lower in most economies after than before the financial crisis, notably in Mediterranean countries; (b) more capital reallocation is correlated with lower real interest rates, contrary to the hypothesis that low real interest rates have hurt capital reallocation; (c) controlling for shocks, lower capital reallocation is associated with lower optimism, and weaker financial systems.

Keywords: productivity growth, capital reallocation, intangible capital.
JEL reference: O47, E22, E01

*Contact: Cecilia Jona-Lasinio, LUISS University, Viale Romania 32, 00197 Rome, Italy. cjonalasinio@luiss.it. We are grateful to the European Commission FP-7 grant agreement 612774 (SPINTAN) for financial support and Dan Andrews and seminar participants at the Groningen Growth and Development Centre 25th Anniversary conference for comments. Errors are our own.

[†]The Conference Board and Georgetown University Center for Business and Public Policy.

[‡]Imperial College Business School, CEP, CEPR and IZA.

[§]ISTAT and LUISS Lab of European Economics, Rome.

1 Introduction

It is widely alleged that, since the financial crisis, the financial system has been impaired so that it functions less well in allocating capital thus restraining productivity growth; see for a review e.g. Borio, Drehmann, and Xia (2018). Whilst this suspicion is widespread, it has proved difficult to gather evidence to examine it.

This is perhaps unsurprising because determining financial impairment and its impact is hard for at least four reasons. First, we require a plausible counter-factual against a well-functioning system. That is we need to calculate (1) productivity (or productivity growth) if capital were being allocated to "right" sectors and compare that to (2) productivity (or productivity growth) under the current, allegedly, misallocated situation. Second, we need information before and after the financial crisis (and perhaps over countries as well). Third, we need a sense of scale. Suppose for example that a very particular, new high technology investment is misallocated. Since much of the extant (business) capital stock is buildings, any such reallocation might be too small scale to make much material difference. Finally, if we do manage to find evidence of capital misallocation, we want to know what is causing it. Maybe low interest rates make for more misjudged investment. Or, perhaps the problem is inadequate bank competition or regulation.

We see two broad streams of research that speak to the question of whether capital movement has been impaired post-financial crisis. We propose to complement these with a third. The first broad stream of work follows from the more general work on misallocation and productivity exemplified by Hsieh and Klenow (2009). This has been implemented on cross-country data before and after the financial crisis by, for example Gopinath, Kalemli-Özcan, Karabarbounis, and Villegas-Sanchez (2017), Dias, Marques, and Richmond (2016), and Gamberoni, Giordano, and Lopez-Garcia (2016); see Restuccia and Rogerson (2013) for an extensive survey. This work calculates total factor productivity (TFP) *levels* relative to a benchmark undistorted equilibrium predicted by theory.

The second broad stream of work centers on financial "frictions". Broadly, this literature regresses measures of TFP growth on candidate variables measuring financial frictions that might impair the movement of capital from less to more productive activities. Cecchetti and Kharroubi (2015) look at TFP growth and R&D, Cette, Fernald, and Mojon (2016) focus on TFP growth and interest rates, Caggese and Perez-Orive (2017) develop a model that predicts low interest rates impair investments in an intangible-intensive economy, and McGowan, Andrews, and Millot (2017) investigate whether slow TFP growth is linked to debt-laden ("zombie") firms.

In this paper we implement a third method using a measure developed by Jorgenson and co-authors (e.g., Jorgenson, Gollop, and Fraumeni, 1987; Jorgenson, Ho, Samuels, and Stiroh, 2007) that we see as complementary to the above literature, the contribution of "capital reallocation" to productivity growth. The Jorgenson capital reallocation effect falls out of industry-level growth accounting. For a given type of capital used in a given industry, it is the contribution to aggregate economic growth of that capital minus the contribution calculated as if the capital earned the average, economy-wide return to all capital used in all industries. This is a reallocation effect because if capital is flowing to above-average return industries, the measure will be positive; if capital is flowing to below-average return industries it will be negative. Thus this is a *growth* counterfactual that is similar in spirit to the level counterfactual in Hsieh and Klenow (2009). Note too that the Jorgenson measure refers to reallocation *between* industries, whereas the Hsieh and Klenow-inspired and closely related (and so-called) "reallocation" literature (e.g., Bartelsman, Haltiwanger, and Scarpetta, 2013, in which there is no conterfactual) are *within* industry findings. All told, following Jorgenson and co-authors, we shall use the term "capital reallocation" or "reallocation" in this paper, not "misallocation".

We calculate capital reallocation for countries over time, 1998-2013, and then explore factors potentially affecting it, such as real interest rates, economic optimism and banking regulation. Thus our paper is new in the following regards. First, we calculate capital reallocation over countries and time, before and after the financial crisis. Second, we perform this calculation with and without intangible assets and look at whether reallocation differs between intangible and tangible assets to determine whether the growing intangible intensity changed the relation between allocation and interest rates as argued in Caggese and Perez-Orive (2017). Third, we study the relationship between both the level and change in reallocation and the set of financial and non-financial indicators that we use to uncover the main drivers of capital reallocation.

To preview our results, our findings are the following. First, we document how reallocation varies over time. It has generally fallen in most economies since the 2000s, has fallen notably in Mediterranean countries and fell in most countries in the financial crisis years. Second, we examine some correlates of this fall. These associations reveal that reallocation has fallen in countries with more economic uncertainty and weaker financial systems. We also find that reallocation is negatively correlated with real interest rates, contrary to the hypothesis that low real interest rates have hurt reallocation, and that the effects are somewhat stronger for intangibles.

The rest of this paper proceeds as follows. The next section reviews the related literature in more detail, and following that, section three sets out some theory. Section four illustrates some descriptive results, and section five reports econometric results. Section six concludes.

2 Related literature

Other papers have calculated industry-level reallocation effects as we have in this paper, most obviously in the work of Jorgenson and co-authors cited above, although their work is mostly for the United States. Samuels (2017) is a cross-country study covering many of the same countries as this paper. However, the Samuels study ends in 2006, before the financial crisis, and does not test the effect of financial variables on reallocation.[1] In addition, his work covers all industries while we look at the non-farm business sector given the significant difficulties in assigning a rate of return, r, to the public sector.

Another industry-level cross-country approach, similar in spirit to Hsieh and Klenow (2009) is Aoki (2012). In his approach, distortions drive a wedge between input/output ratios and their factor shares and, assuming the United States is undistorted, he derives cross-country comparisons of how aggregate TFP levels differ from this benchmark. His data are before the financial crisis. For other work in this spirit see Marconi and Upper (2017) about China, India, Mexico, Korea, Japan and the United States and Di Stefano and Marconi (2016) for India and China.

Restuccia and Rogerson (2013) survey papers on productivity and misallocation under two headings, direct and indirect. The direct method is to study the link between some likely source of capital misallocation (regulation, taxes, imperfect markets e.g. for credit) and TFP or TFP growth. Thus for example Cecchetti and Kharroubi (2015) regress various measures of sector TFP growth on indicators of the size of the financial sector, and find that larger financial sectors are associated with lower TFP growth in non-financial sectors. Thus the counterfactual is one where finance is smaller, back for example, to historically lower sizes. Misallocation is inferred. Leroy (2016) implicitly looks for capital misallocation by looking at the links between banking competition and manufacturing productivity growth for 11 manufacturing industries in 10 European countries, 1999–2009. They regress country-industry-time $\Delta lnTFP$ on Rajan-Zingales' measure of the industry dependence on financing interacted with a banking competition measure due to Boone (2008) implemented by Clerides, Delis, and Kokas (2015). Cette et al. (2016) regress industry TFP growth on real interest rates and argue that financial impairment would affect industries differentially, whilst McGowan et al. (2017) look for a relation between TFP growth and the number of zombie firms (defined as firms unable to cover interest payments over three successive years).

A second approach is the indirect method. This starts from the view that total TFP might be lowered via a somehow suboptimal mix of sectoral/company TFP; that is, misallocation comes from a "mix" effect rather than effects on each sector. Thus the counterfactual is the non-distorted economy, where the mix of sectoral TFPs maximises overall TFP.

Perhaps the best-cited paper is Hsieh and Klenow (2009) who present a model where economy-wide TFP is a weighted average of firm-level TFP. With their chosen functional forms, total TFP levels are less than a theoretical maximum when there is dispersion in firm-level revenue TFP levels. Thus they identify misallocation as dispersion in firm-

[1]Samuels (2017) checks the impact of fiscal balance, age-dependency ratios, productivity, governance, openness and GDP relative to trend. We set out the correlations between our measures and Samuels in the Appendix.

level revenue TFP.[2] A close relation to this method is used by Barnett, Broadbent, Chiu, Franklin, and Miller (2014). They take UK data and ask what productivity sacrifice would occur is the economy reacted to sectoral shocks by only adjusting labour and not capital. Such a productivity level sacrifice turns out to rise with the variance of prices across sectors.

A number of recent papers have implemented and/or built on the Hsieh and Klenow method on cross-country data over time. Gopinath et al. (2017) for example, look at company-level manufacturing data from successive waves of ORBIS-AMADEUS, where in their model marginal revenue products differ across firms due to distortions plus adjustment costs and financing constraints. They find persistently growing gaps between the undistorted and distorted TFP level for manufacturing in Spain, Italy and Portugal but not in France, Germany and Norway (interestingly, we find increasingly poor TFP growth due to lack of re-allocation in Spain and somewhat in Italy, but no trend in Germany and France). Gamberoni et al. (2016) use company data from CompNet and find worsening capital allocation in Belgium, France, Italy and Spain, but not Germany. [3]

Why might misallocation occur? Hsieh and Klenow (2009) assume misallocation is due to sector/firm specific distortions that drive wedges between marginal products and undistorted factor prices, with these wedges being unspecified. A more recent literature tries to model explicitly why capital might remain in low productivity sectors. Azariadis and Kaas (2016) present a model where, following sectoral shocks, capital does not flow to the more productive sectors due to financial frictions. The frictions are that capital from less productive sectors might be unable to move to more productive sectors if such capital is required for borrowing in the unproductive sectors.

Other papers build on the frictions idea. In Cecchetti and Kharroubi (2015) entrepreneurs find high productivity projects are harder to fund with collateral. Caggese and Perez-Orive (2017) present a model of an economy with tangible and intangible capital. By assumption, intangible capital is more productive than tangible and so productivity growth is higher with a shift to intangible capital, but such a shift is impeded by intangible-specific frictions: firms cannot borrow against intangible capital and so have to fund intangible capital investment out of retained earnings. The steady state of the economy then depends on the interaction of (endogenous) interest rates and the (exogenous) intangible capital intensity, so for example, as the intangible sector gets larger firms with

[2]Bartelsman and Wolf (2017) for example discuss some of the criticisms of Hsieh and Klenow (2009). For example, the effect on aggregate TFP due to dispersion depends in part on the assumed imperfect substitutability between goods (in an economy where all consumers wear shoes and socks, high TFP in shoes but low TFP in socks means resources have to be reallocated from shoes to socks thus lowering overall TFP). For a discussion of how such dispersion might also be consistent with differing adjustment costs, see Asker, Collard-Wexler, and Loecker (2014).

[3]Midrigan and Xu (2014) set out an explicit model of entrepreneurs seeking financing which they then calibrate to plant-level data for Colombia and South Korea. Schivardi, Sette, and Tabellini (2017) using company data for Italian firms look at the whether the correlation between bank lending and firm-characteristics has changed before and after the crisis.

cash, "saving up" to invest in intangibles, are hurt with lower interest rates, since their savings accumulate more slowly, and so invests less in intangibles. The prediction of their model, which they test by simulation, is that growth falls when interest rates fall in an intangible-intensive economy.

3 Reallocation in a sources of growth model

3.1 Sources-of-growth approach

This paper computes capital reallocation term set out in papers such as Jorgenson et al. (1987); Jorgenson et al. (2007); Jorgenson and Schreyer (2013) which is different to the approaches above. In the HK model, the highest TFP level is where "revenue TFP" is equalised across firms. So any observed deviation from that gives, by assumption, the potential gains in TFP levels from reallocation.

In the growth-accounting approach, the benchmark is equal rates of return to capital across sectors. Thus the counterfactual is to ask: what would the contribution of capital services to productivity growth if there was a uniform rate of return across sectors? As we shall see, the index so calculated is higher when capital flows to the high rate of return sectors and low if capital flows to the low return sectors. Reallocation and so productivity growth therefore falls if capital is "trapped" in the low rate of return sectors.

3.2 Capital contribution measures as indicators of reallocation

There are a capital types. The capital stock K_a of each type is built from the perpetual inventory model:

$$K_{a,t} = \frac{P^*{}_{Ia} I_a}{P_{I,a}} - \delta^{Ka} K_{a,t-1} \tag{1}$$

where nominal investment in asset $P^*{}_{I,a} I_a$ is deflated by an asset deflator $P_{I,a}$. The asset deflator may or may not be a good measure of the "true" asset price $P^*{}_{I,a}$ depending on e.g. quality-adjustment of the deflator.

The price of capital services is given by the user cost or rental price expression initially formulated by Jorgenson (1963). User costs are imputed prices and reflect how much would be charged in a well-functioning market for a one-period rental of a capital good. User costs reflect the net after-tax rate of return r applied to the the purchase price of a new asset, $P_{I,a}$, of the costs of depreciation δ_a and the expected capital gain/loss due to change in the asset's price (proxied here as the actual price change $\pi_a = dlnP_{I,a}$):

$$P_{K,a} = \tau_a P_{I,a}(r + \delta_a - \pi_a)$$
$$= \tau_a P_{I,a}(r + d_a) \quad (2)$$

where τ_a is the Hall and Jorgenson (1967) tax factor for asset a, and d_a combines expected capital gains with depreciation costs.

3.3 Measurement of r

To measure the rental cost in (2), we need a measure of r. But we do not observe r directly, and so use the *ex post* method to infer it. We may estimate an industry-specific (r_i) or an economy-wide r. In the former case the sum of the payments to capital in the industry sum to observed industry profits. That is, for an industry-specific r_i, where i denotes industry:

$$P_{Qi}Q_i - P_{Li}L_i = \sum_{a=1}^{A} P_{Ka,i}K_{a,i} = \sum_{a=1}^{A} \tau_a P_{Ia}(r_i + d_a)K_{a,i} \quad (3)$$

where $P_{Li}Li$ are payments to labour and we assume that $P_{I,a}$ does not vary across industry (i.e. the same building purchased in two different industries costs the same). By contrast, for economy-wide r, the sum of payments to capital in the whole economy sum to observed economy-wide profits:

$$\sum_{i=1}^{I} P_{Qi}Q_i - \sum_{i=1}^{I} P_{Li}L_i = \sum_{i=1}^{I}\sum_{a=1}^{A} P_{Ka,i}K_{ai} = \sum_{i=1}^{I}\sum_{a=1}^{A} \tau_a P_{Ia}(r + d_a)K_{a,i} \quad (4)$$

where there are I industries.

3.4 Capital contributions and measuring reallocation

To see some intuition, consider two sectors, D and E. We just write down the contributions of capital growth of the assets $a = 1...A$ to output growth in each sector when r is sector-specific:

$$s_D^K \Delta ln{K_D}^{r=r_i} = \sum_{a=1}^{A} \Big(\frac{\tau_{a,D} P_{Ia}(r_D + d_a)K_{a,D}}{P_{Q,D}Q_D}\Big)\Delta lnK_{aD}$$
$$s_E^K \Delta ln{K_E}^{r=r_i} = \sum_{a=1}^{A} \Big(\frac{\tau_{a,E} P_{Ia}(r_E + d_a)K_{a,E}}{P_{Q,E}Q_E}\Big)\Delta lnK_{aE} \quad (5)$$

Following Jorgenson, contrast this with a model in which $r_i = r$. Let us write this as

(6)
$$s_D^K \Delta lnK_D{}^{r=r} = \sum_{a=1}^{A} \Big(\frac{\tau_{a,D} P_{Ia}(r + d_a) K_{a,D}}{P_{Q,D} Q_D}\Big) \Delta lnK_{aD}$$
$$s_E^K \Delta lnK_E{}^{r=r} = \sum_{a=1}^{A} \Big(\frac{\tau_{a,E} P_{Ia}(r + d_a) K_{a,E}}{P_{Q,E} Q_E}\Big) \Delta lnK_{aE}$$

Inspection of (5) and (6) reveals the following. Suppose sector D has a relatively high rate of return so that $r_D > r > r_E$. Suppose capital is flowing to the high return sector. Thus $\Delta lnK_D > \Delta lnK_E$.[4] From (5) the contribution of capital services are high in D and low in E and the sum of contributions will be higher in the r_i case than the r case. By contrast, if capital is accumulating in the low return sectors, the sum of contributions will be lower in the r_i case than the r case.

Thus define capital reallocation (REALL) as:

(7)
$$\begin{aligned} REALL &\equiv \sum_{i=1}^{I} (s_i^K \Delta lnK)^{r=r_i} - \sum_{i=1}^{I} (s_i^K \Delta lnK)^{r=r} \\ &= \sum_{i=1}^{I} \sum_{a=1}^{A} \Big(\frac{\tau_{a,i} P_{Ia}(r_i + d_a) K_{a,i}}{P_{Q,i} Q_i}\Big) \Delta lnK_{ai} - \sum_{i=1}^{I} \sum_{a=1}^{A} \Big(\frac{\tau_{a,i} P_{Ia}(r + d_a) K_{a,i}}{P_{Q,i} Q_i}\Big) \Delta lnK_{ai} \\ &= \sum_{i=1}^{I} \sum_{a=1}^{A} \Big(\frac{\tau_{a,i} P_{Ia} K_{a,i}}{P_{Q,i} Q_i}\Big) \Delta lnK_{ai} (r_i - r) \end{aligned}$$

From (7), if capital is flowing to the high (respectively, low) r sectors, there is a positive (negative) covariance between ΔK_i and r_i. This causes industry specific r contributions to be high (low) relative to when r is measured economy-wide. Thus $REALL > 0$ ($REALL < 0$).

A number of points are worth making. First, REALL depends upon the covariance between r and ΔlnK, but also on the weights. This is as it should be, since there might be severe reallocation of an asset a but if it is of small scale then it should make a small contribution to REALL. So this then is the sense in which, as referred to in the introduction, the impact on productivity of reallocation of a particular asset is correctly scaled.

Second, one might criticise the *ex post* method used in this paper since it assumes e.g. perfect foresight (Oulton, 2007) or equal risk in industries. This would produce a bias if there has been systematic change in such factors (in fact in our regressions we use time and country dummies so the change would have to be net of time and country effects). Third,

[4] Or $\Delta K_D > \Delta K_E$ since there K appears in the numerator of the bracket in (5).

economies differ according to how well they double-deflate their value-added measures, suggesting real value added by industry might be mismeasured.

Fourth, this approach assumes perfect competition in output markets. With imperfect competition the true *ex post* contribution of capital growth to output growth is $= (1 - \mu s_L)\Delta lnK$ (where s_L is the labour share and $\mu >= 1$ is the price/marginal cost mark-up).[5] Assume for simplicity one capital good. Then we can write the true reallocation, accounting for imperfect competition, in terms of the measured reallocation which turns out to be

$$(8) \qquad REALL^{True} = REALL^{Measured} + \Big(\Sigma(1-\mu_i s_{Li})\Delta lnK_i) - \Sigma(1-s_{Li})\Delta lnK_i\Big) - \Big((1-\mu s_L) - (1-s_L)\Big)\Sigma\Delta lnK_i.$$

Thus imperfect competition biases $REALL$ to the extent of correlation of μ_i with s_{Li} and ΔlnK_i; in, for example, a high s_{Li} industry, the measured contribution will be low (due to the high s_{Li}), but should be even lower if there is a high μ_i. Notice that if μ is constant across all industries and over time, then measured REALL is too large by a fraction of $(\Sigma(1-s_{Li})\Delta lnK_i)$.

Without data on how μ covaries across industries with s_{Li} and ΔlnK_i it is hard to quantify this bias. It is worth noting, however, that available estimates of the overall level of μ show, in fact, almost no change *over our sample period.* De Loecker and Eeckhout (2017) and De Loecker and Eeckhout (2018) estimate mark-ups on US and global firm data. For Europe they find almost no rise in the mark-up from the late 1990s to early 2010s, which is our sample period (all the European rise is from 1980 to the late 1990s, and after 2012 (see their figure 3). Note too that on the US data they find very little rise in mark-ups using industry data (their firm data aggregated into industries), from around 1.25 in the mid-1990s to 1.29 in the 2010s (see their Figure B5b) suggesting that quite lot of the rise in the mark-up that they find is in firms within industries, which our dataset does not pick up by construction.

3.5 Interpretation

Finally, we should further discuss our interpretation of reallocation. Consider a standard partial adjustment/error-correction model describing ΔlnK that encompasses many

[5] When the *ex post* method is used to calculate r, the capital share is assumed to be unity minus the labour share: with imperfect competition it should be unity minus the labour share minus the abnormal profit share. As Basu and Fernald (1997) show, the abnormal profit share (under constant returns) can be written $1 - 1/\mu$, in which case the contribution of capital is as given above.

investment models:

$$\Delta lnK = \lambda\Big(\frac{K^* - K_{t-1}}{K_{t-1}}\Big) \tag{9}$$

where K^* is the target K to which firms are adjusting and λ is the speed of that adjustment, with faster-adjusting economies having a larger λ. Thus we can write $REALL$ as

$$REALL = \sum_{i=1}^{I}\sum_{a=1}^{A}\Big(\frac{\tau_{a,i}P_{Ia}K_{a,i}}{P_{Q,i}Q_i}\Big)\Big(\lambda_i\frac{K^*_{a,i} - K_{a,i,t-1}}{K_{a,i,t-1}}\Big)(r_i - r) \tag{10}$$

which puts us in a position to understand whether differences in $REALL$ between countries might correspond to some notion whether those countries have more frictions or not.

To start with, consider a baseline example. Consider two economies with different λs but the same shares of activity in sectors, hit by the same distribution of successive shocks that open up a wedge between r_i and r. Such a wedge would open up a gap between the target K^* and actual K, so there would be an implied adjustment. If economy A has a bigger λ so that it adjusts faster then $REALL_A > REALL_B$. Thus the ordering of $REALL$ gives information on which economy has the most frictions: high $REALL$ economies have high adjustment speeds and so are *low* friction economies. Notice, in passing, that this still holds if there are different sized shocks as $REALL$ is the covariance between ΔlnK and the deviation of r from its average, so that if there are different sized shocks, these are absorbed in the average.

When might this baseline example not hold? One is if the industrial structure differs across countries. $REALL$ is not the simple sum of covariances between $\Delta lnK_{a,i}$ and $r_i - r$, but the weighted sum. If the structure of the economy (i.e. the weights) differs then the ordering of $REALL$ might not correspond to the ordering of λ. That said, recall that the weights are required to translate the covariances into the overall effect on productivity growth. If there are two economies with, say, the same covariances but radically different weights then $REALL$ will correctly identify how that translates into overall productivity growth.

Second, suppose the economies start from a steady state so that $REALL$=0. They are hit by the same one-off shock to $r_i - r$, but economy A has no frictions. In that case, there is instant reallocation, so $REALL = 0$ for the friction-free economy, but $REALL > 0$ for the friction-ridden economy. Then low REALL economies are *low* friction economies, exactly the opposite of above.

We regard this as a corner case. If there are literally no frictions, then capital adjusts instantly and $r_i = r$ always. In this corner case, the most friction free economy would have the lowest REALL=0 always. As long as a shock opens up some wedge between r_i and r, then there will be some gap between target K^* and K_{t-1} and hence $REALL$ will depend on the λs.

Third, different economies might be hit by a different dispersion of shocks, in which case the rankings of $REALL$ might be unconnected with the rankings of λ. Fourth, suppose the economy starts at a steady state and there is a one-off shock to the wedge lasting for, say, n periods. In the n^{th} period $REALL = 0$ since $r_i = r$ by assumption. What happens along that adjustment path? If the wedge remains the same then the faster adjusting economy has higher $REALL$ since capital moves more quickly to the relatively attractive sectors. But the wedge might itself be affected by capital movements. The higher (lower) wedge might be bid down (up) more quickly as capital moves into (outoff) the more (less) remunetarive sector. In a fast-adjusting economy therefore, ΔlnK might move very fast, but $r_i - r$ might correct itself very fast. Thus the fast-adjusting economy has a spike in $REALL$ in t-1, and then $REALL$ moves back to near zero in the following periods, whereas the slow-adjusting has a small rise in $REALL$ in t=1, and continues with a relatively higher REALL along the adjustment path. Thus the relative rankings of $REALL$ depend on the endogenous evolutions of ΔlnK and $r_i - r$. In practice, however, it is likely that economies are hit by a succession of shocks and thus $REALL$ is a summary statistic for differences between countries.

Finally, in the baseline example above, the shocks are to the r wedge. Suppose instead the shocks are on the demand-side, to K* for example. If they differ in their intensity and/or history, and, similar to the above, the $r_i - r$ wedge correction is endogenous, then the ranking of REALL may not be linearly correlated with λ.

To recap, the $REALL$ term summarises the effect on productivity in different economies with different industrial structures and different shocks. $REALL > 0$ when capital flows to the above-average return sectors and $REALL < 0$ when flowing to below-average. In the case where there are a series of shocks to relative returns which are similar across ecomomies, an economy with a higher $REALL$ is one with less frictions. In the case where shocks are dissimilar, we cannot necessarily use $REALL$ to rank economies by frictions, but $REALL$ is still a summary statistic on the extent to which capital is flowing to the sectors flagged by different rates of return.

4 Reallocation data and results

4.1 Data

Our data is by country, industry, institutional sector and time. It includes data on both tangible and intangible capital inputs as well as standard growth accounting variables such as output and labour input. The main method for variables other than intangible capital follows the EU KLEMS database (`www.eu-klems.net`; see O'Mahony and Timmer, 2009 for details): that is, we calculate capital services by country, industry and asset from investment data harmonized across countries. The tangible investment data are updated to 2013 using national accounts sources. Market sector intangible capital is taken from the INTAN-invest database (`www.intaninvest.net`) as outlined in Corrado, Haskel, Jona-Lasinio, and Iommi (2016).This dataset divides intangible assets into three broad groups - computerized information (computer software and databases); innovative property (R&D, design etc.) and economic competencies (spending on strategic planning, worker training, investment in brand names). Thus our data is for 1995-2013 and includes a breakdown into 20 industries and for 11 countries: Austria (AT), Germany (DE), Denmark (DK), Finland (FI), France (FR), Italy (IT), the Netherlands (NL), Spain (ES), Sweden (SE), the United Kingdom (UK) and the United States (US).

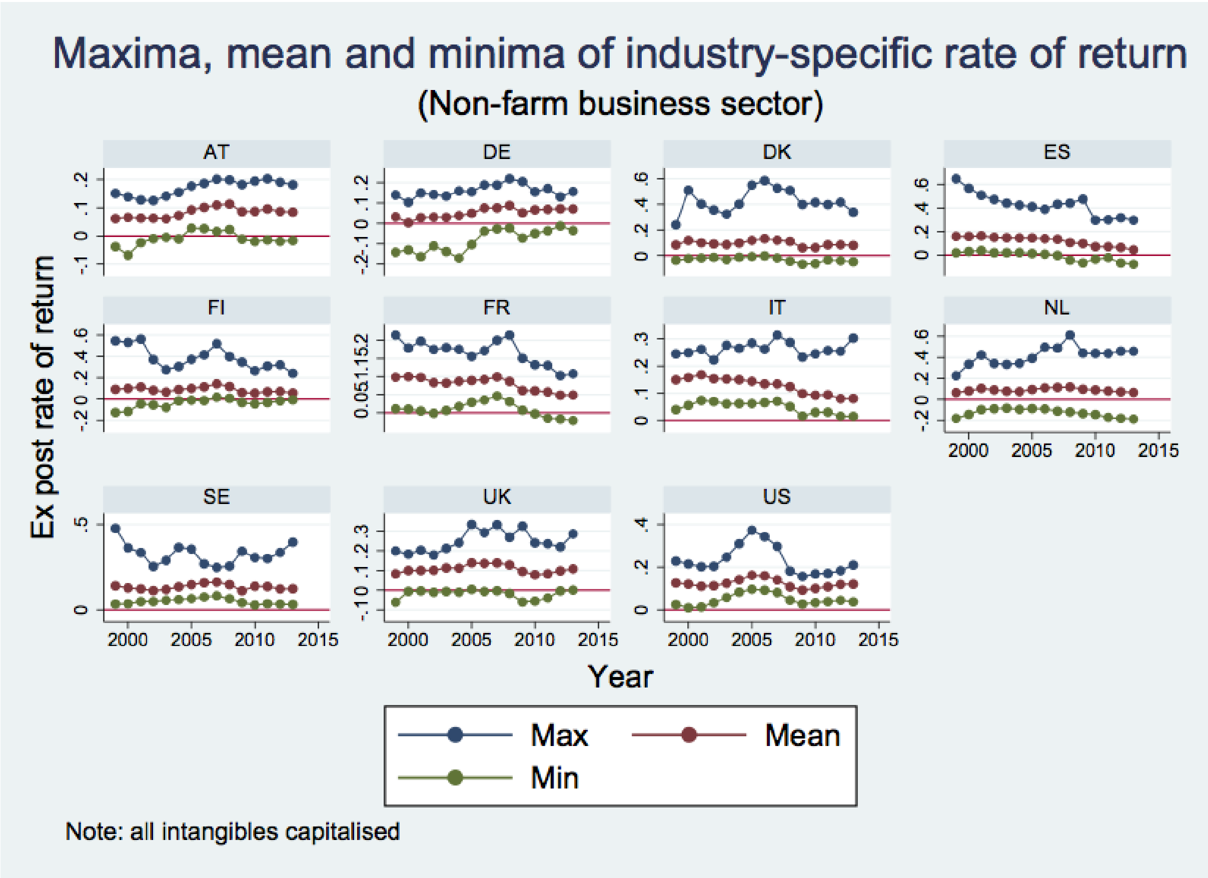
Both tangible and intangible are calculated from real investment using the perpetual inventory method and geometric depreciation. Real value added and the input shares are adjusted to take account of the capitalization of intangible assets not included in national accounts (see Corrado et al., 2016 for further details). Capital services are calculated using the *ex post* method, including returns to intangible capital.

In the light of the theory above, the coverage in our empirical work reported below is as follows. First, as a matter of national accounts convention, non-market institutional sectors do not earn a net rate of return. Likewise, in some industries, sales are insufficient to cover salaries and so subsidies are paid (the Arts for example). Such subsidies are typically not well measured if at all, biasing downwards the measure of rates of return and possibly making it negative. Thus we chose only industries in what we shall call "non-farm business sectors", which drops sectors dominated by the public sector (health, education) and also by subsidies (agriculture) and other badly measured sectors (real-estate, Arts, entertainment and recreation, Activities of households, and Activities of extraterritorial organizations and bodies). We shall check for negative rates of return, see below. Second, we started our analysis in 1998 to guard against capital stock measurement problems from the initial year (1995).

4.2 Measures of r

We start our analysis looking at some descriptive statistics about r_i to get the sense of the characteristics of the sample economies. Figure 1 shows the maxima, mean and minima of r_i by country. Despite only using the non-farm business sector, some industries have a negative r_i, in particular industry S (Other service activities). Those with the highest r_i are typically finance sectors.[6] Figure 2 shows the standard deviation of r_i : it shows no particularly uniform trend and, in particular, deviations of r from zero are long-lasting.

Figure 1: Maxima, mean and minima of industry-specific rate of return



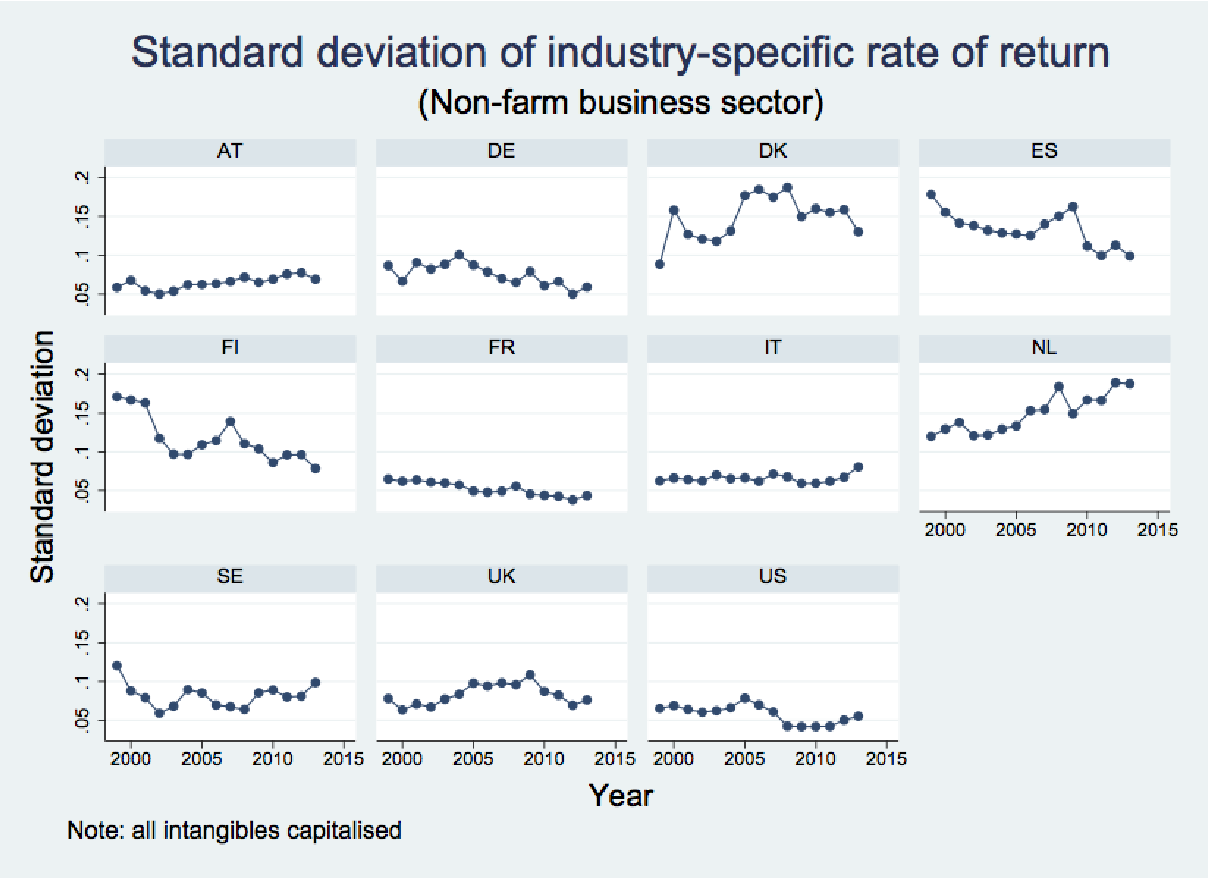
Source authors' calculation

4.3 Measures of REALL

Turning to REALL, Figure 3 shows REALL for when all intangible assets are capitalized (see Appendix Figure 8 for only national accounts intangibles capitalized). First, in the run up to the financial crisis, experience across countries varied. In Spain, US and UK

[6] A number of papers, for example Oulton and Rincon-Aznar. (2012) have documented large variance in rates of return in the EU-KLEMS dataset and suggested they might be implausible. As far as this paper is concerned (a) we tax-adjust which other papers do not do due to lack of data (b) we use more aggregated sectors than in the original EU-KLEMS data (which has 72 sectors) (c) we exclude industries dominated by the public sector (d) our results hinge on the *gap* between the rate of return by industry and by whole economy rather than the level of the return.

Figure 2: Standard deviation of industry-specific rate of return



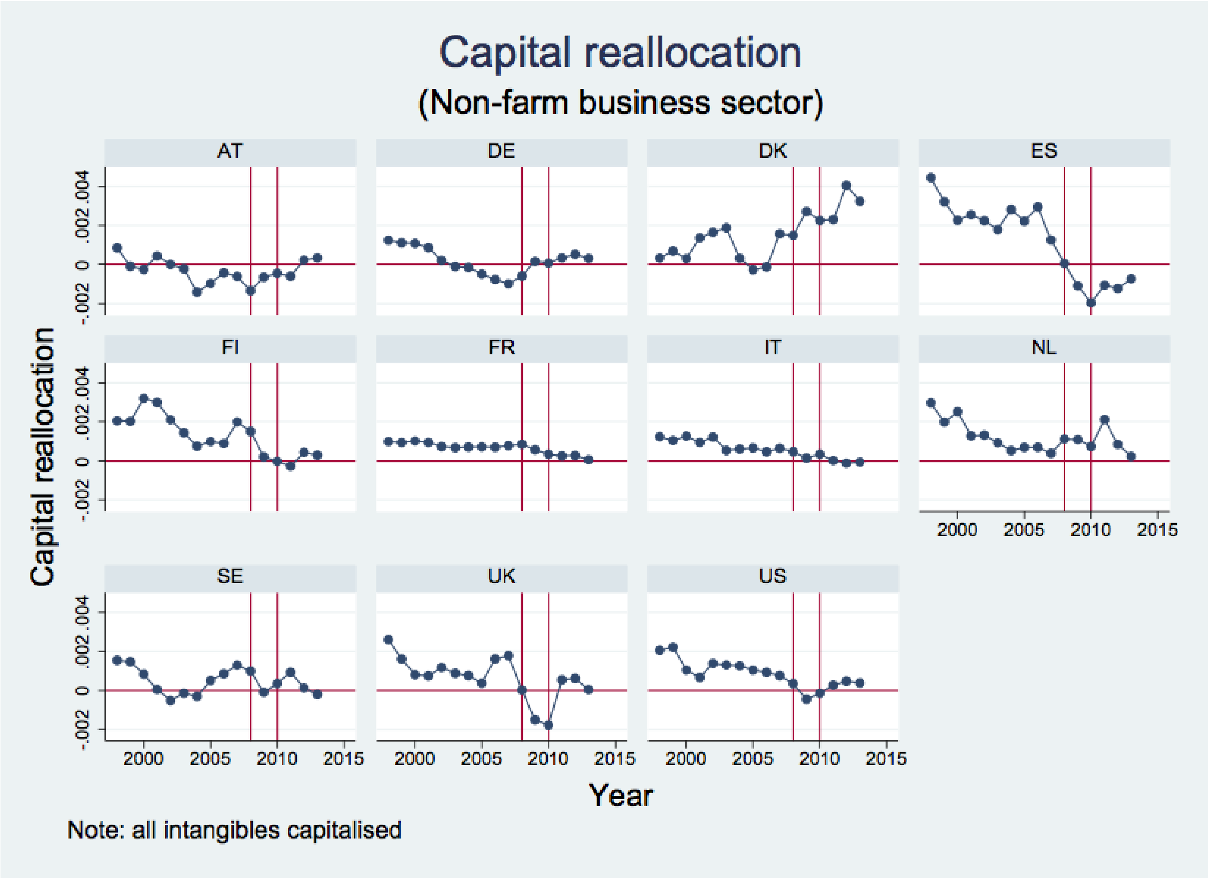
Source authors' calculation

the trend seems downwards, with the contribution turning negative in the UK even in advance of the crisis. Second, in the crisis years themselves (2008 and 2009), both charts suggest that *REALL* became negative in many, although not all countries. The fall in the UK and Spain seems particularly sharp, while in Denmark and Germany REALL improved. Third, after the crisis some countries recovered e.g. the US, Austria and DK. But in many economies REALL kept falling, notably Spain, Finland and Italy.

To get some idea of numbers, Table 1 sets out some average percentage growth over the period. Column 1 shows that, with the exception of Austria, the pre-great recession period, 1998-07 saw positive *REALL* in all sample countries, with, for example, a contribution of 0.245 percentage per annum in Spain. Column 2 shows REALL in the financial crisis years was negative in five economies: the UK is noteworthy as being large. Looking at the average row, REALL fell by 0.082pppa (for reference, TFP growth has fallen by 2.08pppa). Finally, since 2011, REALL has risen, but stayed low relative to the pre-crisis years, at an average contribution of 0.04%pa. The negative contribution of Spain and Italy is notable, and, compared with 1998-07 REALL has fallen in all countries bar Austria, Germany and Denmark.[7]

[7]Most of the variation in REALL is within country, that is, there is twice as much within variation as between variation.

Figure 3: Capital reallocation (all intangibles capitalized)



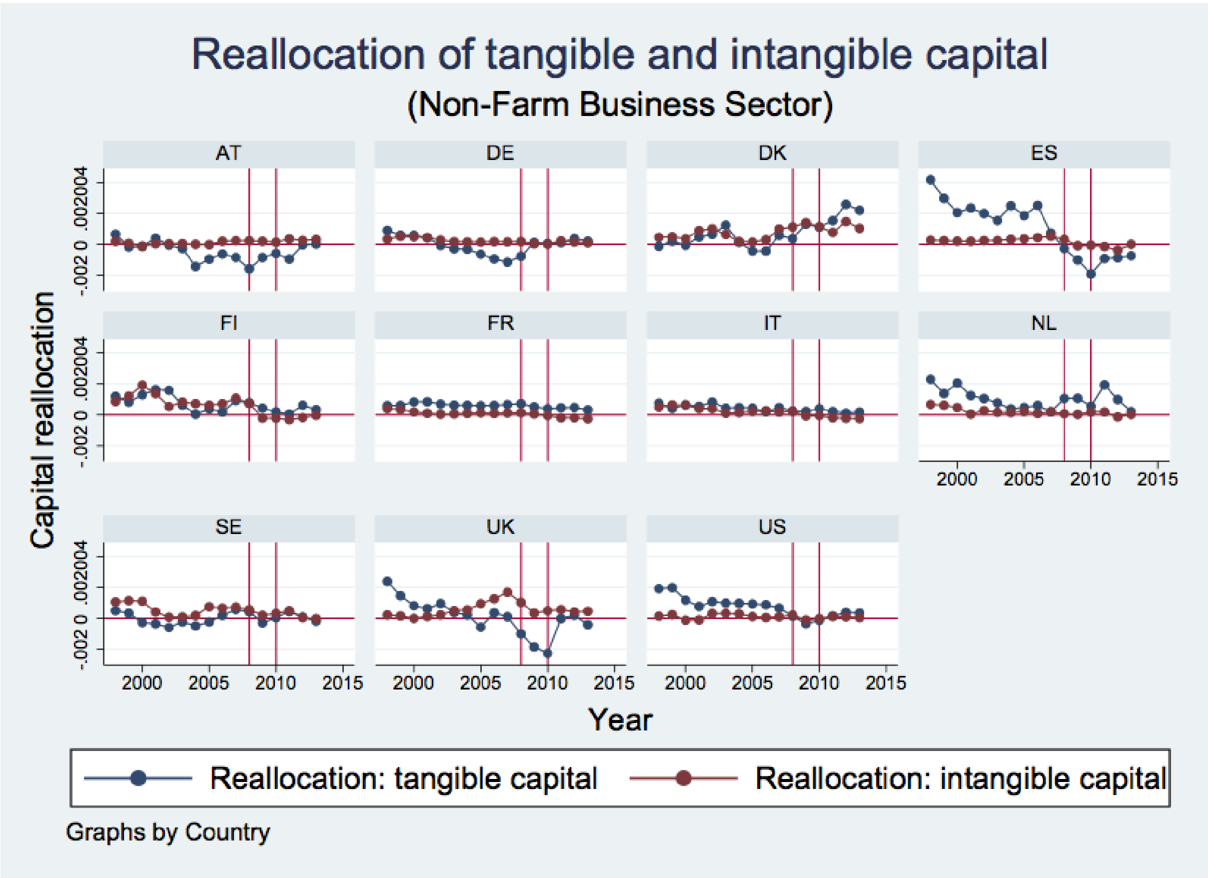
Note: vertical lines are 2008 and 2010. Source: authors' calculation

Figure 4 shows REALL broken down by tangible and intangible. The two are quite correlated with the exceptions of AT, DE and ES where much of the variance in REALL is due to tangible reallocation and the UK, where the recession REALL fall seems very much due to tangible.

Table 1: Capital reallocation (percent per annum, non-farm business)

Country	**1998-07**	**2008-10**	**2011-13**	**Average**
AT	-0.034	-0.08	-0.004	-0.037
DE	0.029	-0.005	0.042	0.025
DK	0.071	0.208	0.304	0.14
ES	0.245	-0.107	-0.096	0.115
FI	0.176	0.054	0.007	0.122
FR	0.075	0.055	0.019	0.061
IT	0.078	0.031	-0.004	0.054
NL	0.127	0.1	0.112	0.119
SE	0.049	0.032	0.016	0.039
UK	0.117	-0.121	0.011	0.053
US	0.118	-0.009	0.039	0.08
Average	0.096	0.014	0.041	0.07

Figure 4: Reallocation of tangible and intangible capital



Source: authors' calculation

4.4 Comparison with other findings

Samuels (2017) computes both capital and labour reallocation but uses EU-KLEMS data, 1995-2008 for the whole economy with no tax adjustment, national accounts intangibles (which did not include R&D at that time) on an older industry classification. We used our data to recalculate capital reallocation for the whole economy, with national accounts intangibles (which include R&D), no tax adjustment but the NACE2 industry composition (a more current composition of around 20 industries). The correlation between our country-time measures and those in Samuels for the periods for which he gives averages were 0.46 (1995-06), 0.43 (1995-2000) and 0.16 (2000-06) i.e. a lower correlation in the 2000s. More information is in the Appendix: further work would be required to see why the correlations deteriorate over the period. As noted above, calculations for the whole economy across countries need assumptions on the rates of return in public-sector dominated industries such as health and education.

This is the most direct comparison. More indirectly, McGowan et al. (2017) calculate the fraction of capital stock in a number of countries of firms classified as "zombie firms", namely those whose value added is less than their debt repayments for three successive years. The relation between REALL and this measure is set out in Appendix 2 [8]. If countries with more zombie firms indicate poor allocation, then the correlation of zombies and REALL should be negative. For IT and ES there seems to be a negative correlation, not so for other countries. Note that the UK has a somewhat positive correlation: according to the zombie measure, the UK has had a fall in the zombie firm capital share since the crisis, i.e. is a particularly "good" by this measure.

5 The empirical model

We turn now to exploring some factors correlated with capital reallocation. We have no new theory model to contribute, nor a "natural experiment" (except perhaps the financial crisis itself) to try to establish causality. Rather, we examine some candidate drivers of reallocation based on speculation in the literature. This then but a start of an wider investigation.

[8] We thank Dan Andrews of OECD for kindly sharing these data.

There are a number of ways we might conduct this investigation. First, as shown in Figure 2, the standard deviation of r is persistently above 0 and as in Figure 3 countries have persistently high or low $REALL$: contrast Denmark and France. It would seem then that different economies have persistently different levels of reallocation. Thus we might reasonably ask: what correlates are associated with differences between economies in their levels of $REALL$? Therefore our investigation should potentially help understand what factors drove the fall of $REALL$ level since the financial crisis, see Table 1. This would suggest a country-year panel regression of the form:

$$REALL_{c,t} = \beta_0 + \beta_1 Z_{c,t} + \lambda_c + \lambda_t + \epsilon_{c,t} \quad (11)$$

where Z are controls, subscripts c and t refer to country and time, and λ_t and λ_c are time and country dummies.

A second investigation would be to argue that the variation of interest is how fast countries return to their equilibrium level of $REALL$ following a disturbance, on the assumption that the resulting reallocation of capital equalises returns. Thus we might look at:

$$REALL_{c,t} = (\gamma_0 + \gamma_1 Z_{c,t-1}) \cdot REALL_{c,t-1} + \lambda_c + \lambda_t + \epsilon_{c,t} \quad (12)$$

that is, the Z variables affect the speed of adjustment of $REALL$. A third, encompassing model, would be where Z affects both the level of $REALL$ and its speed of adjustment:

$$REALL_{c,t} = \beta_0 + \beta_1 Z_{c,t} + (\gamma_0 + \gamma_1 Z_{c,t-1}) \cdot REALL_{c,t-1} + \lambda_c + \lambda_t + \epsilon_{c,t} \quad (13)$$

A number of points are worth making. First, recall that REALL is the covariance of ΔlnK_i with $r_i - r$. The regressions therefore ask whether the strength of the covariation between ΔlnK and rates of return varies with Z. Take then the allegation that low real interest rates have distorted capital allocation. This method looks not at whether low interest rates have raised K, but whether they are associated with a changed covariation between ΔlnK and rates of return (or a change in the speed with which that covariation changes).

Second, we would expect the strength of this covariation to vary for a number of reasons. One would be the nature of capital, including the degree to which it is "general purpose" and/or its ability to be financed (or re-financed). In other words, tangible assets such as an administrative office block or car might be repurposed between industries in the light of market signals, but not so much a purpose-built building or customized heavy-duty truck. The same distinction applies to intangibles such as patents, i.e., some may be sold to other industries whereas others have limited uses outside a given industry. On the other hand, for short-lived intangible assets imbued in workers, such as firm-specific training, or those that are completely nonrival, such as marketing methods, reallocation might be driven largely by new investments (in response to the price signals).

It seems then that the pace of reallocation might vary naturally between countries depending on country-specific capital vintages and the extent of country-industry specificity (e.g. cold countries with snow-clearing airport equipment, hot countries without). In addition, much evidence suggests that intangible capital is very hard to borrow against. Thus a hypothesis would be that reallocation of intangibles will be largely uncorrelated with banking variables, to the extent that such banking variables pick up conventional debt financing that is not used for financing intangibles and perhaps more correlated with optimism to the extent that financing might not help reallocation.

Finally, we might also think the pace of capital reallocation varies with the *dispersion* of shocks to an economy. Other things equal, one might expect economies to need less resource reallocation when shocks are more evenly distributed across industries. As stressed above however, the $REALL$ measure is the (weighted) covariance between capital changes and the deviation of r_i from its average. A shock might raise or lower this covariance: imagine a downward technology shock in a high r_i industry for example. At any rate, we should control for shock dispersion across economies.

5.1 Factors affecting reallocation

We test the models outlined in equations (11)-(13) looking at the following variables potentially affecting the extent and the dynamics of capital reallocation. Our main variables of interest are (more details in the data appendix) as follows.

The real interest rate (RINTRATE). We would of course expect more investment with low interest rates, but the question here is whether there is more reallocation with low interest rates. A range of theories are reviewed in Forbes (2017) and Gopinath et al. (2017), most of which center on the idea that lower interest rates promote the existence of less productive firms and hence lower productivity. A variant on this would be to see if the effect on REALL, if any, of interest rates has changed after the crisis, measured by an interaction with a post-crisis dummy. We use the treasury bonds rate minus GDP inflation as our measure of real interest rates.

Economic sentiment/confidence indicator (ESI). Measures of sentiment are also widely thought to correlate with investment via expectations and the like and might also affect reallocation if, for example, irrational exuberance leads to unwise investment. The indicator of economic sentiment is a weighted measure of surveyed confidence from the *Joint Harmonised EU Programme of Business and Consumer Surveys* for the EU while for the US we use the OECD Business climate indicator.

Intangible-intensity (INTAN). A number of models assume that intangibles are harder to raise collateral against and thus might be source of financial frictions. If this impairs reallocation then this is of independent interest, although the level of intangible investment is itself endogenous. The Caggese and Perez-Orive (2017) model predicts that low interest rates impair reallocation in an intangible-intensive economy and thus to test this we interact RINTRATE with INTAN, where INTAN is measured as intangible investment as a share of GDP.

Banking. It might be argued that various features of banking might be associated with less REALL if, for example, banks lend too speculatively, or only to easily collateraliseable projects like mortgages. There are many possible hypotheses and variables so as a first pass we test the following. First, the ratio of tier 1 regulated capital to bank assets ($REGCAP\_ASSETS$) to check if a more sound financial system fosters or discourages capital reallocation. Second, the Boone bank competition indicator ($COMPET$), since this is more consistently available than the Herfindahl or Lerner indices, to explore if more banking competition is associated with more/less capital reallocation. A competitive banking sector may be beneficial because it can exert pressure on prices pushing down lending rates for borrowers and raising deposit rates for lenders, thus stimulating savings and capital accumulation (Cetorelli (2001)) and consequently capital reallocation. On the other hand, more banking competition may shrink credit supply because of adverse selection and moral hazard thus negatively affecting the performance of the banking sector (Beck (2015)) and thus capital reallocation .

Crisis. To see the possible effects of the crisis, we simply entered time dummies for all years and, see below, specific time dummies for 2008-10.

Shock dispersion (varSHOCK). As mentioned above, to control for economies having different shocks we constructed the Lilien (1982) index of weighted employment growth dispersion: this is a commonly-used shock measure. [9] As discussed in Section 3.5, the effect of a shock on $REALL$ is hard to sign. In this case the shock is about the spread of labour adjustment, whereas $REALL$ is the weighted covariance of $DlnK$ and $r_i - r$. Also spread in employment adjustment due to a demand shock might necessitate a similar spread on capital adjustment but if due to a relative price shock, employment and capital adjustment might be negatively correlated. Our purpose here is to control for the fact that the spread of shocks might have varied across countries.

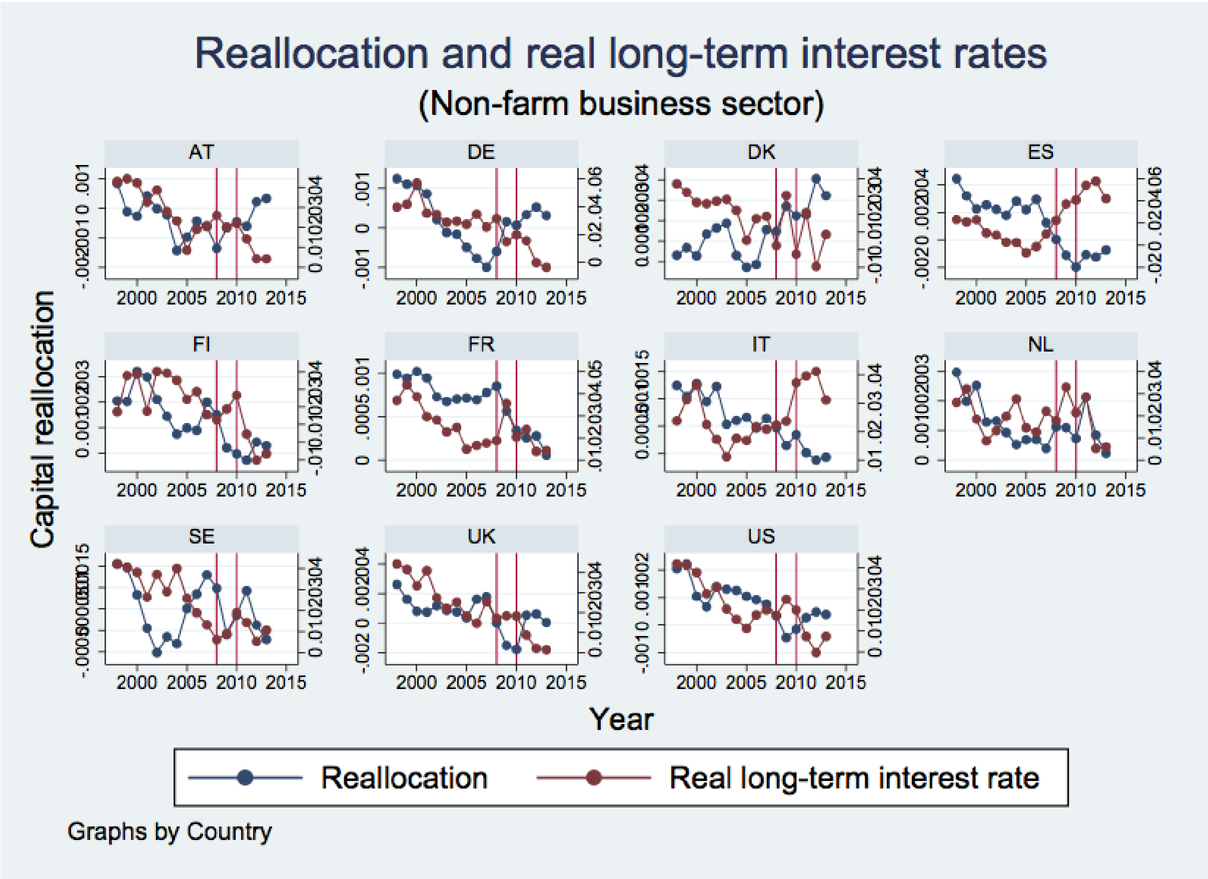
Other variables. To test robustness of our estimates, we also look at other measures of expectations/uncertainty and cost of borrowing (more below).

[9] The measure is $L = \sqrt{\sum(S_{it}) \times \{ln(H_{it}/H_{it-1}) - ln(H_t/H_{t-1})\}^2}$ where S is the share of hours in total hours, i is industry and the sum is over industries for each country. On our data this measure was identical to the 3rd decimal place to a modified version that averages S_it over t and $t-1$.

5.2 Patterns in the raw data.

Figure 5 shows REALL plotted against the real long-term interest rate (on the left y axis). In almost all countries, bar Spain and Italy the interest rate has been falling: as we shall see below, there is a negative correlation between it and REALL.

Figure 5: Reallocation and real long-term interest rates



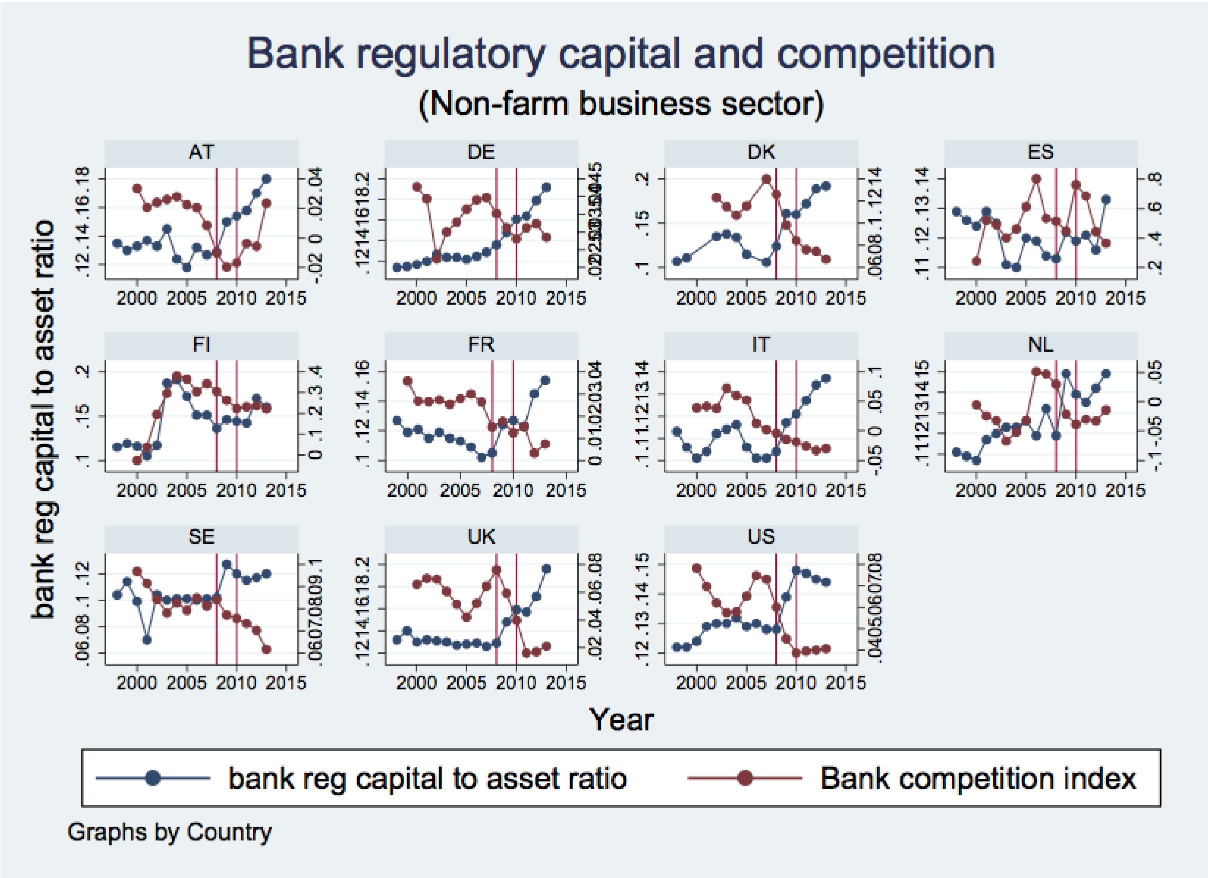
Source: authors' calculation and data from the World Bank.

Figure 6 shows two banking measures, a competition index due to Boone (2008) and a measure of regulatory capital to assets. Especially starting in the period just after the financial crisis competition fell and has fallen since, with some exceptions, the US and the UK. Regulatory capital rose over the crisis and has risen since, strongly so in some cases.

Figure 7 shows REALL and the Lilien shock dispersion index. The dispersion of shocks rose in most countries in the financial crisis, since which it has fallen back.

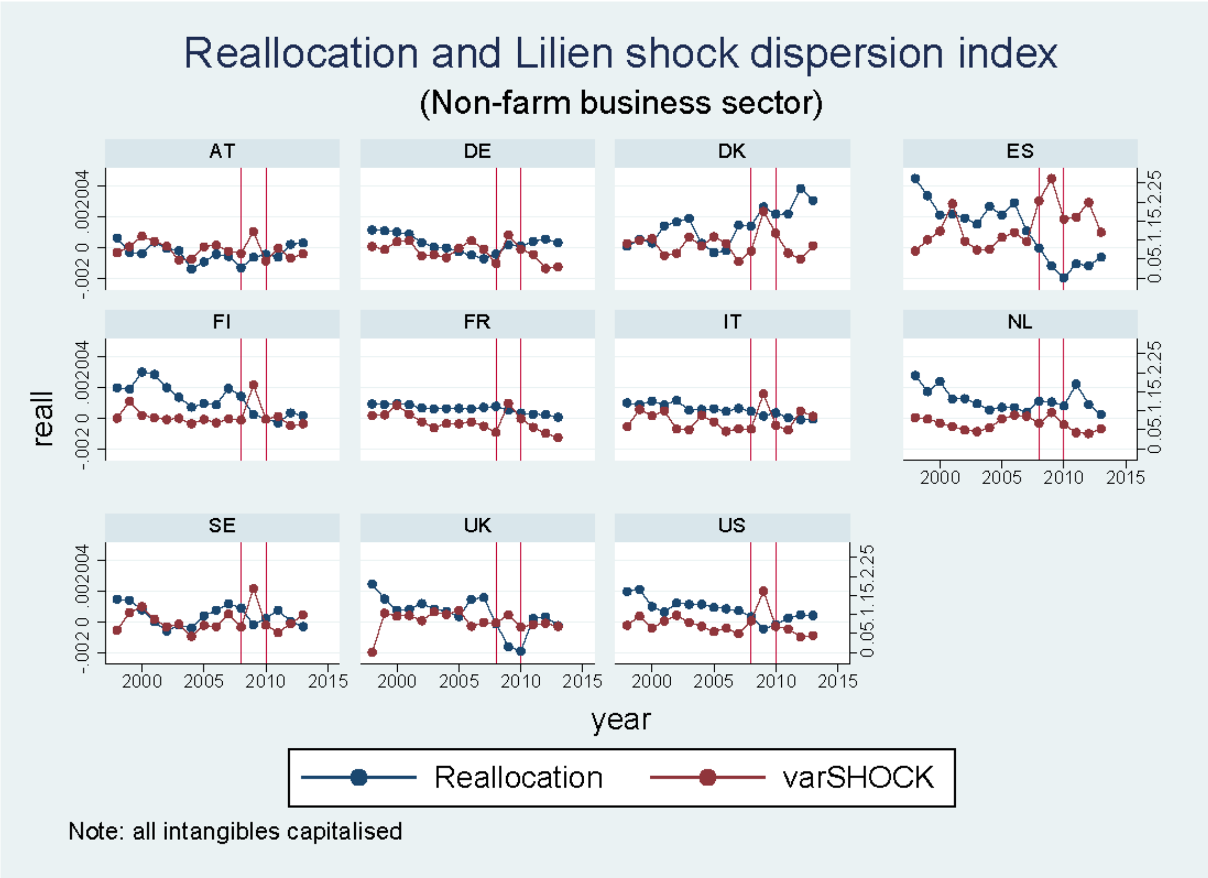
Finally, Table 2, upper panel, sets out period averages of the data. As the table shows, REALL has fallen and then risen, as has ESI. Real interest rates have fallen throughout, and regulatory capital has risen. Competition has risen but then fallen, as has the interaction between regulatory capital and competition i.e. the fall in competition has not been offset by a rise in regulatory capital.

Figure 6: Bank regulatory capital and competition



Source: authors' calculation and data from the World Bank.

Figure 7: Reallocation and the dispersion of shocks



Source: authors' calculation from Lilien (1982).

Table 2: Raw data and regression accounting

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	REALL*100	real int rate	ESI	varSHOCK	Regcap/asset	compet	$compet * regcap$	time dummies	Sum
1999-07	0.096	0.026	1.04	0.081	0.12	0.047	0.005	-0.067	
2008-10	0.014	0.021	0.94	0.102	0.13	0.063	0.008	-0.161	
2011-13	0.041	0.014	0.97	0.070	0.15	0.047	0.006	-0.113	
Regression coefficients		-1.40	0.40	-0.71	1.42	-1.28	9.02		
Actual change 98/07 to 08/10	-0.08	-0.005	-0.10	0.02	0.01	0.02	0.00	-0.09	
Predicted change		0.006	-0.04	-0.02	0.02	-0.02	0.02	-0.09	-0.12
Actual change 08/10 to 11/13	0.03	-0.01	0.03	-0.03	0.02	-0.02	0.00	0.05	
Predicted change		0.01	0.01	0.02	0.03	0.02	-0.01	0.05	0.12

NOTES— Upper panel: unweighted averages per annum, non-farm business; lower panel: regression accounting see text. REALL is multiplied by 100. Changes are percentage point changes.

5.3 Econometric considerations

We estimate equations (11) to (13) with random and fixed effects clustering by country and testing different lag structures of the variables of interest.

In running regressions with lags, we note the following. First, a regression of $REALL_{c,t}$ on $REALL_{c,t-1}$ returns $R^2 = 0.68$. Thus, a lot of variation is soaked up by the lagged dependent variable, potentially leaving little to be explained by other variables. Second, in these regressions we drop fixed effects since they are statistically insignificantly different from each other ($F(10, 164) = 1.46, p > F = 0.16$) and induce bias in panels with lagged dependent variables and small T (15 years) (Nickell (1981) and Baltagi (2013)).

5.4 Estimation results

5.4.1 Level Regressions

Table 3 is representative. Columns 1 and 2 show weak positive relation between REALL and (lagged twice) real interest rates with, respectively, no controls and fixed effects. Column 3 adds time dummies, giving a significant negative association. So controlling for country and time effects, low real interest rates are associated with higher REALL. Column 4 interacts $RINTRATE$ with a post-crisis step dummy (taking value 1 after 2007) to check if the relationship between reallocation and real interest rates changed significantly after the financial crisis. Estimates show no statistically significantly different marginal impact of real interest rates post-crisis. Column 5 shows that low economic sentiment (ESI) is correlated with lower REALL (note this controls for country and time effects). Column 6 adds INTAN (intangible investment as a proportion of total investment) and its interaction with real interest rates. The point estimates suggest that lower REALL is associated with higher intangible intensity and that lower interest rates further reduce capital reallocation when intangible intensity is relatively higher. These effects are in line with the theory predictions of Caggese and Perez-Orive (2017), but the effect is not statistically significant. Column 7 adds $varSHOCK$, and finds that with more dispersed shocks, $REALL$ is lower (a result robuts to lags and time and country fixed effects). This suggests that controlling for the spread of shocks is important [10] but it is interesting to note that the significance of $RINTRATE$ and ESI are unaffected and the magnitudes of $RINTRATE$ rises. Reverse causation might be an issue here, but we are hopeful that using lags reduces this bias considerably: in any case, if more capital reallocation is associated with more labour reallocation, we might expect a positive relation.

Column 8 adds the bank regulatory capital/asset ratio and the banking competition indicator. The results suggest that higher bank regulatory capital is positively correlated to capital reallocation but more banking competition is associated with lower reallocation. To explore this, column 9 therefore interacts regulatory capital and competition indicator

[10] We thank a referee for this suggestion.

and finds a positive interaction. What does this mean? First, a more stable financial system (higher REGCAP) fosters reallocation when banking competition is relatively high. But the effect of banking competition depends upon the extent of capital regulation since less competition is correlated with more REALL but only when REGCAP is small (that is when REGCAP is below 15%, the 2013 average is 16%).

Finally, columns 10 and 11 separate out tangible and intangible capital reallocation. There are (statistically significantly) weaker marginal effects on intangible relative to tangible REALL from the banking variables, consistent with the idea that intangibles are difficult to obtain conventional banking finance for. The point estimates are lower for RINTRATE, but statistically insignificantly different.

Table 3: Regression results (dependent variable: $REALL_{c,t}$)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
VARIABLES					$REALL_{c,t}$				$REALL^{tan}_{c,t}$	$REALL^{intan}_{c,t}$
$RINTRATE_{c,t-2}$	0.07	0.34	-2.95*	-2.34	-2.11*	-4.89	-1.70**	-1.40**	-0.58	-0.81**
	(0.12)	(0.33)	(-2.17)	(-1.56)	(-2.19)	(-1.69)	(-2.42)	(-2.28)	(-1.18)	(-2.87)
$RINTRATE_{c,t-2} * PostCrisis$				-1.32						
				(-0.63)						
$ESI_{c,t-2}$					0.50**	0.50*	0.42***	0.40***	0.43***	-0.03
					(2.26)	(2.22)	(3.45)	(3.24)	(3.82)	(-0.69)
$INTAN_{c,t-2}$						-0.19				
						(-0.40)				
$INTAN * RINTRATE_{c,t-2}$						6.14				
						(1.06)				
$Compet_{c,t-1}$							-0.18***	-1.28***	-1.08***	-0.20
							(-3.80)	(-3.47)	(-3.49)	(-1.53)
$RegCapital_{c,t-1}$							1.29	1.42	0.99	0.43
							(1.18)	(1.74)	(1.65)	(1.61)
$Compet * RegCapital_{c,t-1}$								9.02**	7.37**	1.65
								(3.02)	(3.08)	(1.56)
$varSHOCK_{c,t-2}$							-0.72**	-0.71**	-0.89***	0.18
							(-2.85)	(-2.52)	(-7.50)	(0.84)
$Fixed\ effects$										
$Time\ effects$	X	X	Y	Y	Y	Y	Y	Y	Y	Y
$Cluster\ by\ country$	X	Y	Y	Y	Y	Y	Y	Y	Y	Y
$Observations$	165	165	165	165	165	165	165	165	165	165
$R-squared$	0.00	0.00	0.29	0.30	0.35	0.36	0.47	0.50	0.57	0.24
$Number\ of\ countries$	11	11	11	11	11	11	11	11	11	11

NOTES— Dependent variable in columns 1 to 8 is total capital reallocation ($REALL_{c,t}$), while in columns 9 and 10 is reallocation of tangible ($REALL^{tan}_{c,t}$) and intangible ($REALL^{intan}_{c,t}$) capital, respectively .

5.4.2 Level regressions: robustness

We ran some additional robustness checks by adding the following (lagged) variables to column 8 of Table 3. In all of the following cases the additional variables were insignificant and left the above results unaffected: (a) product market competition and employment market strictness from the OECD (b) deviation of GDP growth from its trend (c) old- and young- age dependency ratios (these were used in (Samuels 2017)) (d) government-debt to GDP ratio (e) cost of borrowing (f) the Bloom uncertainty index and alternative measures of uncertainty [11] based on demand and future profits expectations (DG ECFIN Business survey) [12]. Finally, if we drop finance itself, the statistical significance of the variables is hardly affected, but the coefficients fall somewhat on REGCAP (0.78) and REGCAP*Compet (6.17).

5.4.3 Level regressions: economic significance

To get some idea of the magnitudes involved, return to Table 2, lower panel. Consider the first group of numbers in the lower panel, setting out the change from before the crisis (1999-07) to the crisis years (2008-10). REALL fell sharply, by 0.08pppa (first data column). Real interest rates fell, and multiplying that fall by its coefficient predicts a rise in REALL by 0.006ppa. The ESI index fell too and multiplying that fall by its coefficient predicts a fall of 0.04ppa. Shock dispersion (varSHOCK) rose by 0.02pppa, contributing therefore a fall in REALL by 0.02pppa. As for bank policy variables; regulatory capital, competition and their interaction all rose, predicting rises in REALL of a total of 0.02ppa. Finally, the time dummies predict a fall in REALL of 0.09ppa. So this model mostly "accounts" for the fall in REALL via the time dummies, but suggests reinforcing effects from low economic sentiment, an increased shock variance, but offsetting effects from banking characteristics.

The final rows in the lower panel of Table 2 looks at the recovery of REALL between 2008/10 and 2011/13. That rise was helped by falling real interest rates, a slight rise in ESI and in regulatory capital, a fall in $varSHOCK$ and a fall in competition, somewhat offset by rising competition/regulatory capital interactions. Once again, however, the time dummies have a strong effect.

All in all, most of the behavior is accounted for by time dummies, i.e. unknown shocks. But, if the remaining effects are causal, then the table does suggest that adverse shocks to reallocation can be offset by lower real interest rates, improved economic sentiment, a fall in the spread of shocks, more regulatory capital and more competition.

[11]We thank an anonymous referee for this suggestion

[12]In this latter case results are weakly significant

5.5 Change regressions

Column 1 of Table 4 repeats column 8 of Table 3 but estimated with random effects, it varies little. Column 2 inserts the lagged dependent variable, which reduces the statistical significance of the included variables. The reason for this is suggested by Column 3, which shows a regression of $REALL_{c,t}$ on $REALL_{c,t-1}$: this is strongly statistically significant and with a high R^2 i.e. much of the variation is accounted for by up by $REALL_{c,t-1}$. The rest of the table shows the $Z_{c,t}$ variables and interacted, one by one, with $REALL_{c,t-1}$ and uninteracted; there is some significance (regulatory capital asset), but nothing consistent.

The lack of statistical significance in these results is, perhaps, not surprising, given that the lagged dependent variable absorbs so much variation. If the meaningful variation is in the speed with which countries return to their $REALL$ levels, we have been unable to detect country-specific correlates of that varying speed: either there are none to be found, or we have the wrong Z variables, or we have too short/narrow a panel, with too few disturbances, to be able to estimate this.

Table 4: Regression results (dependent variable: $REALL_{c,t}$)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
VARIABLES				$REALL_{c,t}$				
$RINTRATE_{c,t-2}$	-2.43***	-0.89		-0.91***				
	(-3.31)	(-1.35)		(-2.62)				
$ESI_{c,t-2}$	0.46***	0.18**			0.19*			
	(2.99)	(2.40)			(1.69)			
$RegCapital_{c,t-1}$	1.08	0.28				0.14		
	(1.36)	(0.85)				(0.70)		
$Compet_{c,t-1}$	-0.82*	-0.20					-0.04	
	(-1.64)	(-0.97)					(-1.35)	
$Compet * RegCapital_{c,t-1}$	8.23**	1.97						
	(2.29)	(1.30)						
$REALL_{c,t-1}$		0.70***	0.77***	0.77***	0.66	0.62**	0.75***	0.73***
		(12.83)	(22.60)	(7.65)	(1.08)	(2.20)	(14.94)	(12.45)
$REALL_{c,t-1} * RINTRATE_{c,t-2}$				-1.65				
				(-0.50)				
$REALL_{c,t-1} * ESI_{c,t-2}$					0.08			
					(0.13)			
$REALL_{c,t-1} * RegCapital_{c,t-1}$						1.10		
						(0.49)		
$REALL_{c,t-1} * Compet_{c,t-1}$							0.22***	
							(2.72)	
$REALL_{c,t-1} * Postcrisis$								0.04
								(0.23)
Postcrisis								-0.01
								(-1.13)
$varSHOCK_{c,t-2}$	-0.43**	-0.16						
	(-2.29)	(-1.40)						
Observations	165	165	165	165	165	165	165	165
$R-squared$	0.332	0.699	0.647	0.690	0.690	0.684	0.685	0.651

Robust z-statistics in parentheses
*** p<0.01, ** p<0.05, * p<0.1

6 Conclusions

We have looked at whether the financial crisis has affected the reallocation of capital and so productivity growth. Our analysis is based on the calculation of the Jorgenson reallocation term, which gives a measure of the contribution to aggregate productivity growth due to the allocation of capital growth across sectors relative to a benchmark economy where rates of return are equalized. We have done this for 11 major economies before and after the financial crisis. We have two main findings: (a) some facts about reallocation and (b) some correlates of reallocation. First, the raw data indicates that reallocation got worse in many countries between 2008 and 2010, has recovered since then, but not back to pre-financial crisis levels. Second, we have explored some factors potentially driving reallocation. Rising $REALL$ is associated with rising economic optimism and financial stability, as measured by the bank regulatory capital, and with the effects of bank competition depending on the banking endowment of regulatory capital. Low real interest rates are associated with higher $REALL$, contrary to the assertion that the lowering of real interest rates by central banks has itself worsened capital reallocation. Finally, the financial crisis shock was quite dispersed: since then, shocks have been narrower and this is associated with a rise in $REALL$. We have not found any robust results about how the speed of adjustment of $REALL$ is correlated with various variables: to do this, we need more countries over more time, so it will be a topic for future research.

References

Aoki, S. (2012). A simple accounting framework for the effect of resource misallocation on aggregate productivity. Journal of the Japanese and International Economies 26(4), 473–494.

Asker, J., A. Collard-Wexler, and J. D. Loecker (2014). Dynamic inputs and resource (mis)allocation. Journal of Political Economy 122(5), 1013–1063.

Azariadis, C. and L. Kaas (2016). Capital misallocation and aggregate factor productivity. Macroeconomic Dynamics 20(2), 525–543.

Baltagi, B. H. (2013). Econometric analysis of panel data (5th ed.). John Wiley and Sons.

Barnett, A., B. Broadbent, A. Chiu, J. Franklin, and H. Miller (2014). Impaired Capital Reallocation and Productivity. National Institute Economic Review May(228), R35–R48.

Bartelsman, E., J. Haltiwanger, and S. Scarpetta (2013, February). Cross-country differences in productivity: The role of allocation and selection. American Economic Review Assets, Tangibility(1), 305–34.

Bartelsman, E. J. and Z. Wolf (2017). Measuring productivity dispersion. Tinbergen Institute Discussion Papers (20170033).

Basu, S. and J. G. Fernald (1997). Returns to scale in U.S. production: Estimates and implications. Journal of Political Economy 105(2), 249–283.

Beck, T. (2015, February-March 24-27). Bank competition: Winning isn't everything. Financial world.

Boone, J. (2008). A new way to measure competition*. The Economic Journal 118(531), 1245–1261.

Borio, C., M. Drehmann, and D. Xia (2018). The financial cycle and recession risk. BIS Quarterly Review 16 December.

Caggese, A. and A. Perez-Orive (2017). Capital Misallocation and Secular Stagnation. Finance and Economics Discussion Series 2017-009 2912297.

Cecchetti, S. and E. Kharroubi (2015). Why does financial sector growth crowd out real economic growth? CEPR Discussion Papers 10642, C.E.P.R. Discussion Papers.

Cetorelli, N. (2001). Competition among banks: good or bad? Economic Perspectives (Q II), 38–48.

Cette, G., J. Fernald, and B. Mojon (2016). The pre-great recession slowdown in productivity. European Economic Review 88(Supplement C), 3 – 20. SI: The Post-Crisis Slump.

Clerides, S., M. D. Delis, and S. Kokas (2015). A new data set on competition in national banking markets. Financial Markets, Institutions and Instruments 24(2-3), 267–311.

Corrado, C., J. Haskel, C. Jona-Lasinio, and M. Iommi (2016). Intangible investment in the eu and us before and since the great recession and its contribution to productivity growth. EIB Working Papers 2016/08, Luxembourg.

De Loecker, J. and J. Eeckhout (2017). The Rise of Market Power and the Macroeconomic Implications. Working Paper 23687, NBER.

De Loecker, J. and J. Eeckhout (2018). Global Market Power. NBER Working Papers 24768, National Bureau of Economic Research, Inc.

Di Stefano, E. and D. Marconi (2016). Structural Transformation and Allocation Efficiency in China and India. SSRN Electronic Journal.

Dias, D. A., C. R. Marques, and C. Richmond (2016). Misallocation and productivity in the lead up to the eurozone crisis. Journal of Macroeconomics 49(Supplement C), 46 – 70.

Forbes, K. (2017). Failure to launch. In Speech at the Bank of England.

Gamberoni, E., C. Giordano, and P. Lopez-Garcia (2016, September). Capital and labour (mis)allocation in the euro area: Some stylized facts and determinants. Questioni di Economia e Finanza (Occasional Papers) 349, Bank of Italy, Economic Research and International Relations Area.

Gopinath, G., Ş. Kalemli-Özcan, L. Karabarbounis, and C. Villegas-Sanchez (2017). Capital allocation and productivity in south europe*. The Quarterly Journal of Economics 132(4), 1915–1967.

Hall, R. E. and D. W. Jorgenson (1967). Tax policy and investment behavior. The American Economic Review 57(3), 391–414.

Hsieh, C.-T. and P. J. Klenow (2009). Misallocation and manufacturing tfp in china and india*. The Quarterly Journal of Economics 124(4), 1403–1448.

Jorgenson, D. W. (1963). Capital theory and investment behavior. American Economic Review 53(2), 247–259.

Jorgenson, D. W., F. M. Gollop, and B. Fraumeni (1987). Productivity and U.S. Economic Growth. Harvard University Press.

Jorgenson, D. W., M. S. Ho, J. D. Samuels, and K. J. Stiroh (2007). Industry origins of the american productivity resurgence. Economic Systems Research 19(3), 229–252.

Jorgenson, D. W. and P. Schreyer (2013). Industry-level productivity measurement and the 2008 system of national accounts. Review of Income and Wealth 59(2), 185–211.

Leroy, A. (2016). Banking competition, financial dependence and productivity growth in europe. International Economics.

Marconi, D. and C. Upper (2017). Capital misallocation and financial development: A sector-level analysis. BIS Working Papers 671(671).

McGowan, M. A., D. Andrews, and V. Millot (2017, January). The Walking Dead?: Zombie Firms and Productivity Performance in OECD Countries. OECD Economics Department Working Papers 1372, OECD Publishing.

Midrigan, V. and D. Y. Xu (2014). Finance and misallocation: Evidence from plant-level data. American Economic Review 104(2), 422–58.

Mirzaei, A. and T. Moore (2014). What are the driving forces of bank competition across different income groups of countries? Journal of International Financial Markets, Institutions and Money 32(Supplement C), 38 – 71.

Nickell, S. J. (1981). Biases in Dynamic Models with Fixed Effects. Econometrica 49(6), 1417–26.

O'Mahony, M. and M. P. Timmer (2009). Output, input and productivity measures at the industry level: The eu klems database*. The Economic Journal 119(538), F374–F403.

Oulton, N. (2007). Ex post versus ex ante measures of the user cost of capital. Review of Income and Wealth 53(2), 295–317.

Oulton, N. and A. Rincon-Aznar. (2012). Rates of Return and Alternative Measures of Capital Input: 14 Countries and 10 Branches, 1971-2005., Volume Industrial Productivity in Europe: Growth and Crisis. Edward Elgar Publishing, Incorporated.

Rajan, R. G. and L. Zingales (1998). Financial dependence and growth. American Economic Review 88(3), 559–586.

Restuccia, D. and R. Rogerson (2013). Misallocation and productivity. Review of Economic Dynamics 16(1), 1 – 10. Special issue: Misallocation and Productivity.

Samuels, J. D. (2017). Assessing aggregate reallocation effects with heterogeneous inputs, and evidence across countries. Review of World Economics 153(2), 385–410.

Schivardi, F., E. Sette, and G. Tabellini (2017). Credit Misallocation During the European Financial Crisis. CESifo Working Paper Series.

A Appendix 1.

The Figure 8 below shows REALL with only national accounts intangible capitalized.

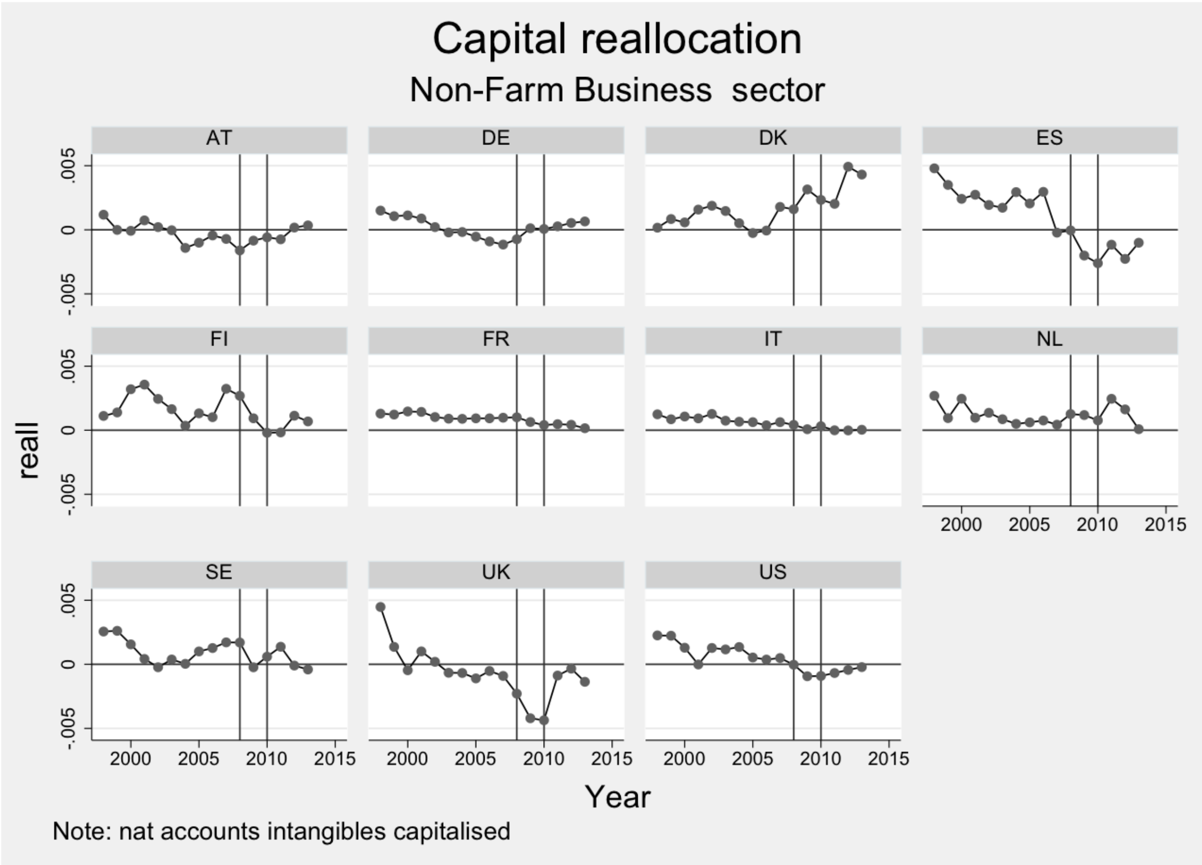


Figure 8: Capital reallocation (only national accounts intangibles capitalized)

Figure 9 below shows that the correlation between the two measures is very high.

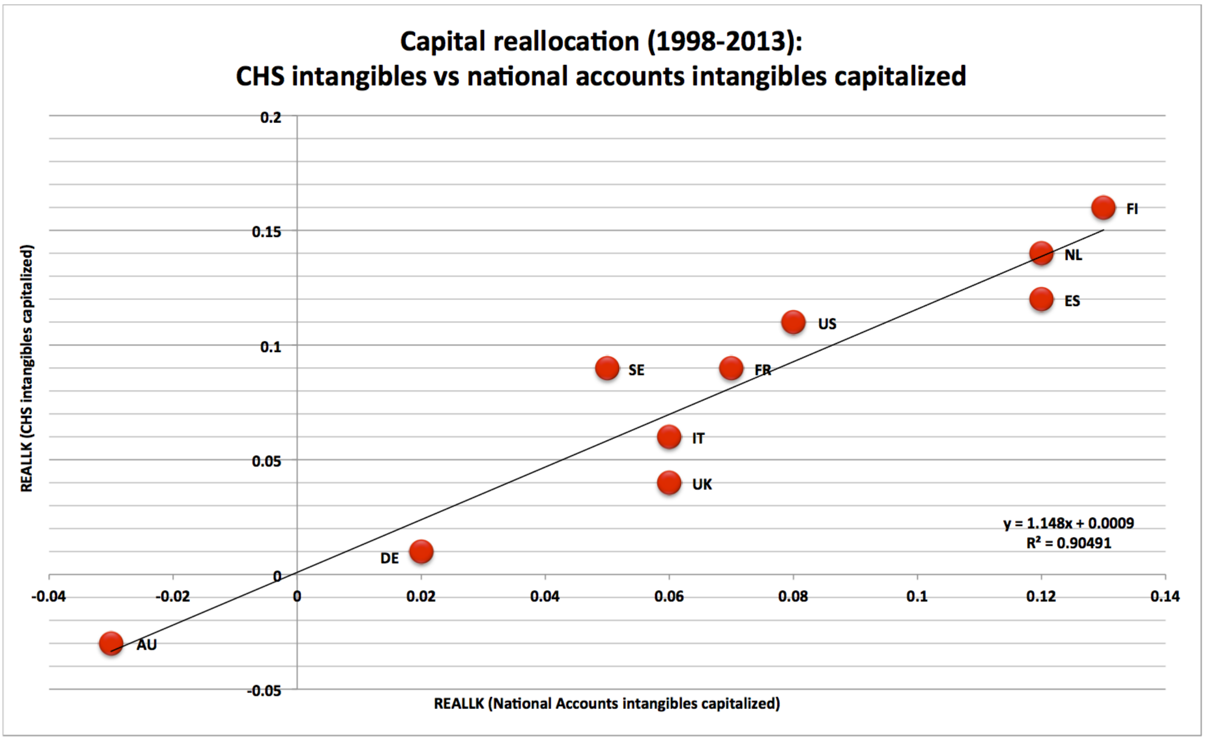


Figure 9: Reallocation: Comparison with all and only national accounts intangibles capitalized

B Appendix 2

The graph below shows a comparison with Samuels (2017), where the Samuels data is for the whole economy and taken from a table in his paper that shows the time intervals as below.

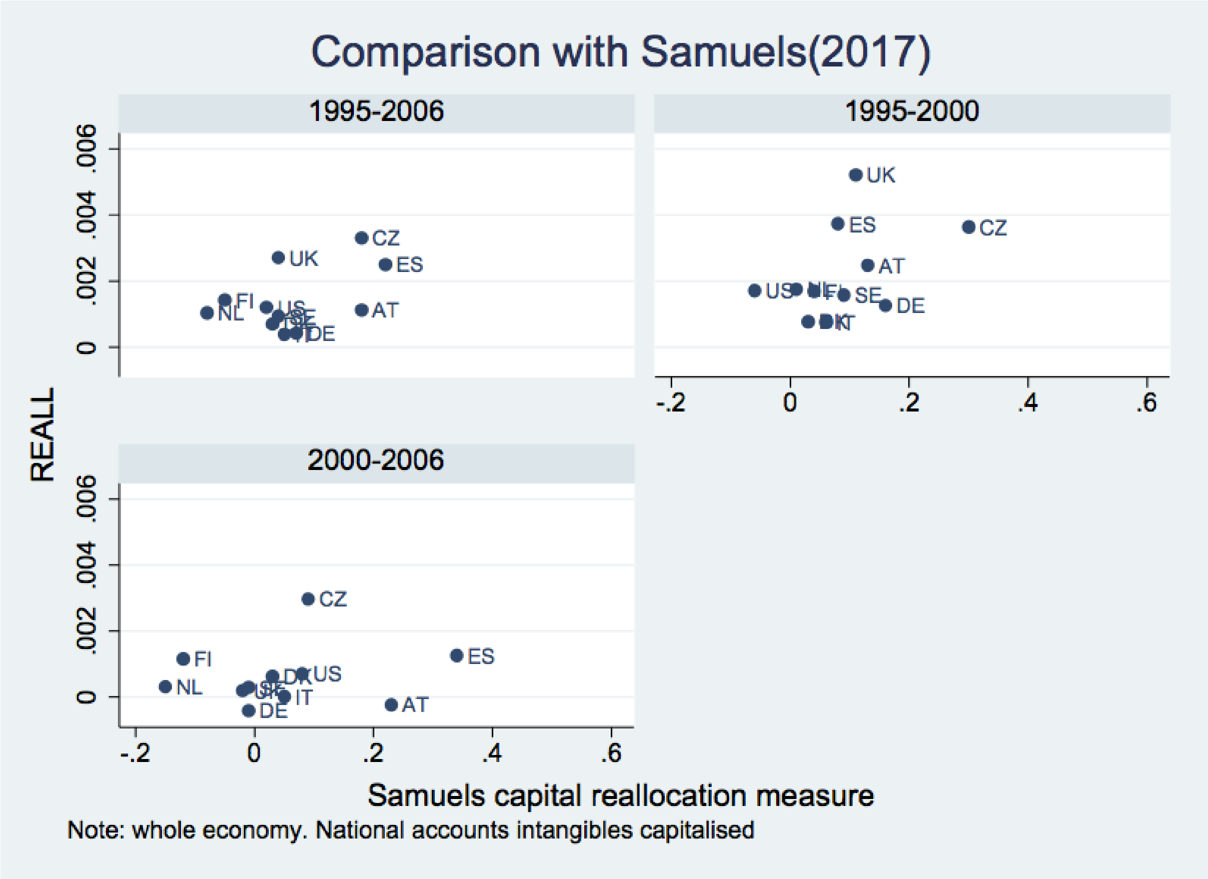


Figure 10: Comparison with Samuels (2017)

C Appendix 3: comparison with Zombie firms calculation

In a recent paper, McGowan et al. (2017) calculate the fraction of capital stock in a number of countries of firms classified as "zombie firms", namely those whose value added is less then their debt repayments for three successive years. We thank Dan Andrews of OECD for sharing these data. For IT and ES there seems a (negative) correlation, which one might expect: not so for the other countries. Note that the UK has a somewhat positive correlation: according to the zombie measure, UK has falls in the share of zombie firms which would raise TFP by this measure.

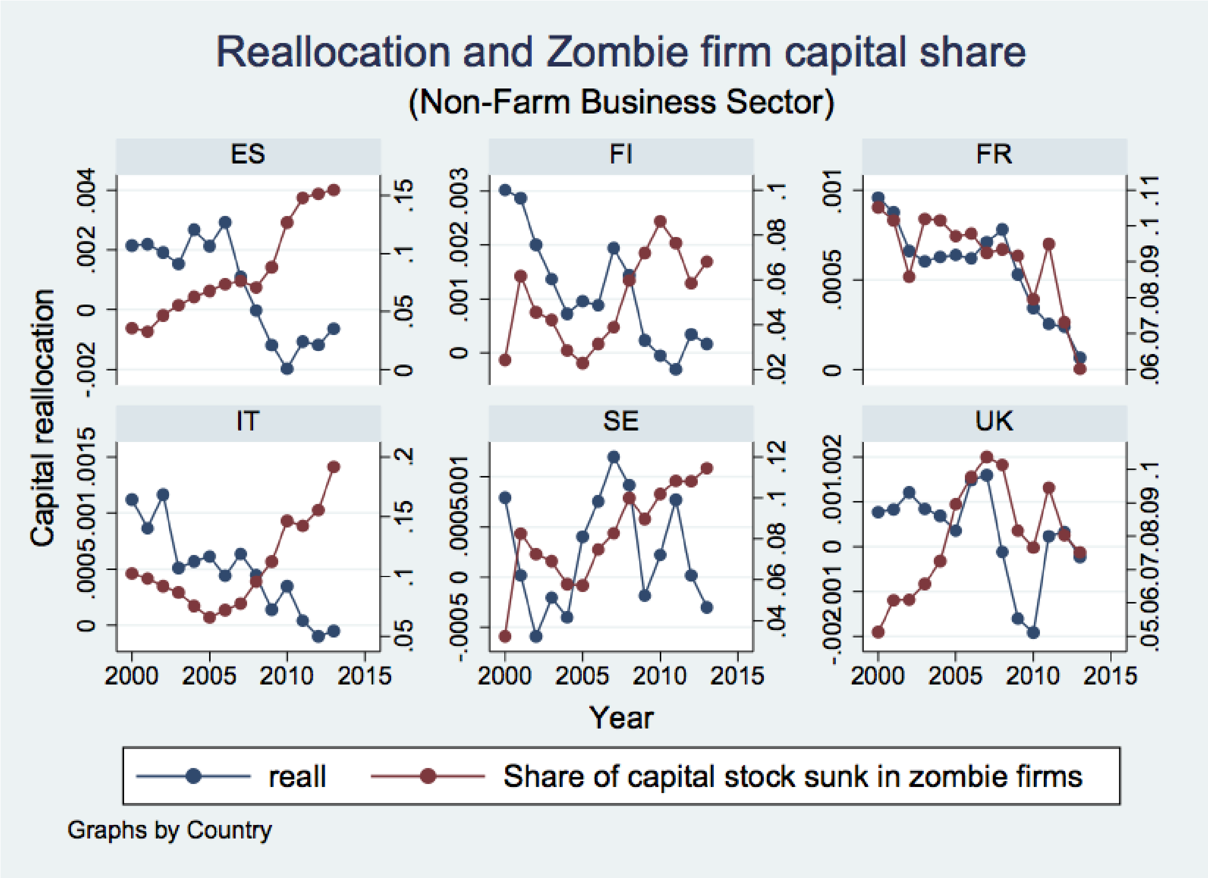


Figure 11: Capital reallocation (all intangibles capitalized) and share of capital in Zombie firms according to OECD calculations in (McGowan, Andrews, and Millot 2017)

D Data appendix

The main variables (tangible gross fixed capital formation, value added, labour input) are from EUKLEMS and National Accounts. Other variables are from the sources indicated below:

The Economic Sentiment Indicator (ESI) is a composite indicator made up of five sectoral confidence indicators with different weights: Industrial confidence indicator, Services confidence indicator, Consumer confidence indicator, Construction confidence indicator Retail trade confidence indicator. Confidence indicators are arithmetic means of seasonally adjusted balances of answers to a selection of questions closely related to the reference variable they are supposed to track (e.g. industrial production for the industrial confidence indicator). Surveys are defined within the Joint Harmonised EU Programme of Business and Consumer Surveys. The economic sentiment indicator (ESI) is calculated as an index with mean value of 100 and standard deviation of 10 over a fixed standardised sample period. For the US we use the OECD Business climate indicator. Source: EUROSTAT.

Economic Policy Uncertainty index based on newspaper coverage frequency and developed by Scott R. Baker, Nicholas Bloom and Steven J. Davis
SOURCE: *http://www.policyuncertainty.com/index.html*

Proxies for economic uncertainty. Indicators based on demand and future profits expectations defined as follows: **Demand Index** covers the capacity utilisation rate and sales prospects. The degree of certainty as to how these variables will change is likely to be as relevant as the change itself; **Financial resources or expected profits indicator** covering the availability of resources for investment (and their cost) together with the return on investment and the lack of opportunities for the company to use its resources more profitably than by investment (notably by purely financial operations).

SOURCE: DG ECFIN Business survey, EUROSTAT.

Long term interest rate: (Maastricht criterion bond yields (mcby)) definition used for the convergence criterion for EMU for long-term interest rates (central government bond yields on the secondary market, gross of tax, with around 10 years' residual maturity). Source: EUROSTAT.

Cost of borrowing it is the composite cost-of-borrowing indicator for new loans to non-financial corporations (percentages per annum, rates on new business) computed by the European Central Bank. It covers the following countries: Austria, Germany, Spain, Finland, France, Italy and the Netherlands. For the UK, US and Sweden we have used the average annual rates for new loans to SMEs (defined as loans up to EUR 1 million), base rate plus risk premium; for maturity less than 1 year, enterprises only, from the OECD. SOURCE: ECB and OECD.

Bank competition. The World Bank [13] discusses a number of competition indicators. The Boone index is available from the World Bank and from Cerides et al (the Herfindahl and Lerner indices are incomplete in years and countries). Leroy favours the Clerides indicator (he argues there are less outliers and it uses a superior methodology). The Clerides indicator is in fact more noisy than that of the Bank (it might be an updated version and so we used the Bank indicator, smoothing it with a three year moving average). For a discussion of these various indicators see Mirzaei and Moore (2014). The Boone indicator regresses, for a sample of banks, (log) profits on (log) marginal costs,($ln\pi = \beta lnMC$) and obtains a negative relation. The more negative in absolute value, the more there is competition. Why? As Clerides explains, suppose a bank becomes less efficient i.e. its MC rises. A small (in absolute value)β, say -0.01, means a small penalty to being inefficient. A large (in absolute value) β, say -0.1, means a larger penalty to being inefficient. As a matter of data, this index is quite noisy and so we smoothed it with a

[13]($www.worldbank.org/en/publication/gfdr/background/banking - competition$)

simple ($t+1$, t, $t-1$) moving average, hence the data goes from 2000-2014. Finally, we multiplied the index by -1, and called it a competition indicator: that is, if it rises, then competition rises. Source: World Bank.

Bank regulatory capital to assets ratio. It is defined as "ratio of total regulatory capital to its assets held, weighted according to risk of those assets". This ratio captures the degree of robustness of financial institutions to withstand shocks to their balance sheets. Source: World Bank.

Intangible intensity.
Ratio of total intangible spending to GDP.
Source: www.intaninvest.net

Age dependency ratio, old, is the ratio of older dependents — people older than 64 — to the working-age population — those ages 15-64. Data are shown as the proportion of dependents per 100 working-age population. Source: World Bank. **Age dependency ratio, young**, is the ratio of younger dependents — people younger than 15 — to the working-age population — those ages 15-64. Data are shown as the proportion of dependents per 100 working-age population. Source: World Bank.

Central government debt, total (% of GDP). Debt is the entire stock of direct government fixed-term contractual obligations to others outstanding on a particular date. It includes domestic and foreign liabilities such as currency and money deposits, securities other than shares, and loans. It is the gross amount of government liabilities reduced by the amount of equity and financial derivatives held by the government. Because debt is a stock rather than a flow, it is measured as of a given date, usually the last day of the fiscal year. Source: World Bank.

Lilien shock dispersion index. This is obtained as the Lilien index (1982) and is calculated using the industries, countries and years in the existing data set and using person-hours in the index.