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Intangibles and Industry Concentration: Supersize Me

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This paper presents new evidence on the growing scale of big businesses in the United States, Japan, and Europe. It finds broad evidence of rising industry concentration across the majority of countries and sectors over the period 2002 to 2014. Rising concentration is strongly associated with intensive investment in intangibles, particularly innovative assets, software, and data. This relationship appears to be stronger in more globalised and digital-intensive industries. The results are consistent with intangibles disproportionately benefiting large firms and enabling them to scale up and increase market shares. We find nuanced implications of these new business models for competition – rising markups and reduced churning amongst the top firms, but falling industry prices.

Keywords: Competition; Industry and entrepreneurship; Innovation

JEL Classification: E22, L1, L25

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Big businesses are growing bigger. The share of industry sales due to the largest firms has been increasing in the United States across many sectors of the economy, and studies have documented similar trends in Europe. This has led to a surge in interest in competition among policy makers and broader public. However, an appropriate policy response requires understanding the mechanisms behind these trends. The increasing concentration of activity in a few firms could indeed be a sign of *weakened* competition, but it could also be consistent with *intensified* competition if, for example, globalisation or technological change allows the most innovative and productive firms increase their market shares while competing more intensely with one another.

This paper argues that investment in intangible assets has played an important role in the observed concentration trends. Intangibles – such as business research and development, software and training – are an increasingly important part of leading firms' business models. For some economies, aggregate intangible investment now dwarfs that in tangible assets, such as buildings, machinery and equipment. A crucial property of most intangible assets is that they are easily scalable. An invention or software can be applied in many different markets at low (and sometimes near zero) marginal costs. This gives an inherent advantage to the largest global firms, which have the cash needed to invest heavily in intangibles (that can be difficult to finance) and the scale needed to recoup the sunk costs.

This paper finds broad evidence of rising industry concentration, across the majority of countries and sectors over 2002 to 2014, which is strongly related to intangible investment. It documents a robust correlation between intangible investment intensity and changes in industry concentration (the share of 8 largest firms in industry sales) of a country-industry, using data from 11 European countries, plus Japan and the United States. Those countries and industries experiencing the largest increases in concentration, are those that invest most intensively in intangibles. The results are robust to instrumental variable estimation, and other commonly cited factors (such as mergers and acquisitions or tighter product market regulations) do not strongly predict changes in industry concentration.

This paper also finds that the relationship between industry concentration and intangibles is stronger in country-industries that are more open to trade and more digital intensive. The scalability of intangibles should mean they are more valuable to companies in more open economies, with better access to foreign markets. Adopting new digital technologies often requires investment in intangibles, such as training, workplace reorganisation etc. Therefore, intangibles should be particularly conducive to growth of the largest firms in digital-intensive industries, as well as those in more open economies.

In terms of implications for competition and business dynamism, our result that increasing concentration is associated with intangible investment, rather than with mergers and acquisitions or weaker regulation of product markets, can be seen as good news. Exploring how rising concentration is related to other proxy measures of the intensity of competition, the paper finds that increasing concentration is positively correlated with rising markups of the largest firms, but this could reflect firms making sunk investments to reduce their marginal costs, rather than rising market power. Indeed, our results indicate that industry-level prices increase *less* in country-industries with stronger concentration increases.

This does not, however, mean that the recent rise in industry concentration does not raise concerns for competition and business dynamism in the longer-term. The paper finds that increasing concentration is associated with less churning among the largest firms – the biggest businesses are increasingly here to stay. Furthermore, increasing concentration is associated with the largest firms increasingly filing patents intended to impede competition rather than to explore new technology areas and, in digital-intensive industries, increased M&A activity.

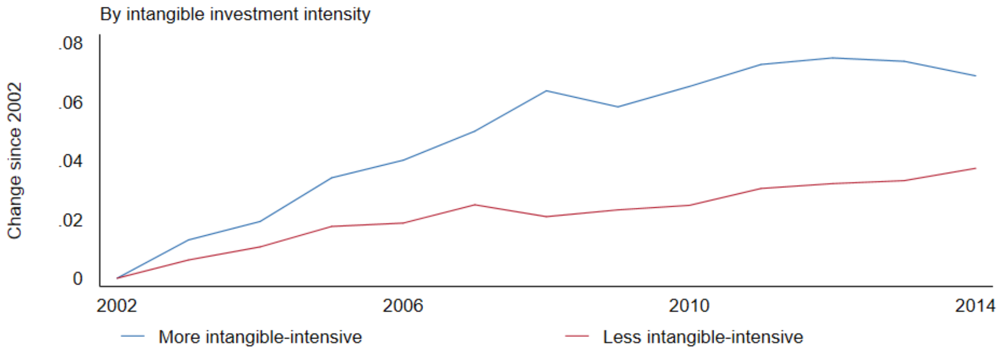
1. Introduction

Big businesses are growing bigger. The share of industry sales due to the largest firms has been increasing in the United States across many sectors of the economy,[1] and studies have documented similar trends in Europe (e.g. Bajgar et al., 2019). This has led to a surge in interest in concentration among policy makers and broader public, with numerous newspaper articles discussing the growth of big business and running special reports on competition.[2] The increasing concentration of activity in a few firms could indeed be a sign of weakened competition (Gutiérrez and Philippon, 2017a,b, 2019), but it could also be consistent with *intensified* competition if, for example, globalisation or technological change allows the most innovative and productive firms increase their market shares while competing more intensely with one another (Autor *et al.*, 2020). Independent of its cause, the increasing scale of big business today might have dynamic implications for competition and innovation in the coming years. An appropriate policy response requires understanding which mechanisms have allowed the largest firms to further increase their shares in economic activity and, looking forward, if more concentrated economies represent a threat to competition, business dynamism, innovation and growth.

Intangibles – such as business research and development (R&D), software, data, marketing and training[3] – are an increasingly essential part of leading firms' business models. They are much more important in today's knowledge-intensive, digital, service-intensive and globalised economy than they were in the past (Borgo *et al*., 2013; Corrado *et al.*, 2016). For some economies, aggregate intangible investment now dwarfs that in tangible assets (Haskel and Westlake, 2017). This change in production technology may have disproportionately benefited the largest global firms and, thus, facilitated an increase in industry concentration. A crucial property of most intangible assets is that they are non-rival in nature and easily scalable. An invention or software can be applied in many different markets at low (and sometimes near zero) marginal costs. This gives an inherent advantage to large companies, which have the finance available to invest heavily in intangibles and the scale needed to recoup the sunk costs.

This paper argues that investment in intangible assets has indeed been strongly related to the observed trends of increasing concentration. We use data for 11 European countries, plus Japan and the United States, over the period 2002-2014, to shed new light on the factors that have facilitated recent concentration trends. We construct measures of industry concentration for 13 economies based on matched Orbis-Worldscope-Zephyr data. We find that the share of sales due to the largest 8 business groups increased in about two thirds of country-industries in the sample, with an average concentration increase between 2002 and 2014 of around 5 percentage points.[4] We then link these measures to data on intangible investment coming from the INTAN-Invest database (Corrado *et al.*, 2012), together with information on other industry characteristics that could be associated with the observed concentration trends, such as openness to trade, digital intensity, product market regulations, occurrence of large mergers and acquisitions (M&As) and initial industry concentration.

Figure 1. Trends in top 8 concentration by intangible inv. intensity - change since 2002



Note: The figure shows changes in the (unweighted) mean concentration across country-industry pairs compared to the base year 2002. The concentration trends are shown separately for country-industries above- and below-median intensity of intangible investment (calculated as the mean value over the sample period). Countries included are BEL, DEU, DNK, ESP, FIN, FRA, GBR, GRE, FRA, JPN, PRT, SWE and USA. Included 2-digit industries cover manufacturing, construction and non-financial market services.

Our econometric results confirm descriptive evidence (**Error! Reference source not found.**) indicating that changes in industry concentration are positively related to intangible investment intensity, particularly in innovative assets, data and software. The estimates are relatively large: a 1-standard deviation difference in intangible investment (as a share of value added) is associated with a 1.6 percentage point increase in concentration over the next 4 years.[5] This relationship is robust to controlling for country-year and industry-year unobservables, and using instrumental variable (IV) estimation, with instruments based on intangible investment in other countries and changes in R&D tax subsidies. Furthermore, it is specific to intangibles – investment in tangible assets is not positively correlated with industry concentration. In addition, we find little evidence for alternative narratives: concentration increases do not appear to be *directly* associated with increasing globalisation or with large mergers and acquisitions, and there is only weak evidence they are associated with product market deregulation.

We extend our baseline results to consider the extent to which complementary trends – such as globalisation and digitalisation - can magnify the effects of intangible investment on concentration. If intangible assets are more valuable to those companies that are able to leverage them over larger markets, they should be particularly important in highly tradable industries. Given complementarities between digitalisation and intangible investments (Brynjolfsson and Hitt, 2000; Bresnahan et al., 2002; Brynjolfsson et al. 2002), intangibles should also be particularly conducive to growth of the largest firms in digital-intensive industries. Indeed, we find that the relationship between intangibles and concentration changes is stronger in (initially) more open and digital-intensive country-industries.

Finally, the paper sheds light on whether the observed increase in concentration reflects a worsening competitive environment, proxied by different measures of competition and business dynamism. Concentration changes are found to be positively correlated with changes in the markups of the largest firms, consistent with an increase in the market power of the top firms but also with a greater role of fixed costs, possibly in the form of intangible investment. There is, however, no evidence of industry-level prices growing as concentration increases.[6] For competition in the longer run, the growing sales share of the largest firms is less of a concern if there is a lot of churning *amongst* the largest firms, i.e. if there is still competition at the top. However, our results indicate that rising industry concentration is associated with increasing persistence in the composition of the group of largest firms, in both their relative ranking and their market shares. In addition, we present evidence for two channels which might be contributing to this increase in persistence. First, rising concentration appears associated with a greater share of defensive patents by the largest firms and second, in digital-intensive industries, it is linked to more acquisitions by these firms.

To the best of our knowledge, this paper is the first to document a relationship between intangibles and rising industry concentration in a cross-country context, suggesting that the link is not unique to the United States. It is most closely related to Crouzet and Eberly (2019), who demonstrate for the United States that a higher ratio of intangible to tangible investment is associated with higher market shares and, depending on the industry, productivity or mark-ups of the largest companies. Covarrubias et al. (2019) also examine the relationship between industry concentration and intangibles and argue that increases in US industry concentration were related to intangible capital deepening (and were largely pro-competitive) in the 1990s but became associated with depressed investment, weakened competition and increased barriers to entry after 2000. De Ridder (2019) builds – and tests on French data – a theoretical model where a rise of intangible inputs generates a shift from variable to (endogenous) fixed costs, and firms better able to adopt new techniques gain competitive edge and expand, deterring potential competitors.

In addition to providing a cross-country dimension, this paper further sheds light on how the intangibles-concentration link interacts with other industry characteristics such as openness to trade and digital intensity, hinting at a crucial role of the scalability property of intangible capital. A growing literature documents important structural changes in the business sector of OECD economies. In addition to increasing industry concentration, mounting evidence points to rising profits and markups,[7] declining business dynamism,[8] a growing productivity gap between leaders and laggards,[9] falling investment rates[10] and a decline in the labour share of income.[11] Autor et al. (2020) show how such reallocation can result from a globalisation shock, but they also note that other forces with "winner take most" characteristics, such as scale-biased technological change, could have similar effects. Our results highlight the complementary roles of intangible investment, globalisation and digital technologies in enabling this reallocation across several countries.

The paper also contributes to a growing literature investigating if the structural trends observed in OECD economies represent signs of weaker competition. Gutiérrez and Philippon (2017a,b) document a link between relatively weak investment in the United States (given the high Tobin's Q) on one hand and increasing concentration and less intense competition on the other. Gutiérrez and Philippon (2019) argue that a decline in the elasticity of business entry with respect to Tobin's Q in the US is due to lobbying and regulations. The increase in profits and markups, documented both in the US and internationally, can also be seen as indicative of weakened competition. On the other hand, the hypothesis of weakened competition is at odds with findings suggesting that US industries which saw a larger increase in concentration on average experienced a *stronger* growth in real output, productivity and innovation, while their prices did not grow any faster than those of other industries (Bessen, 2017; Autor et al., 2020; Ganapati, 2020). Our results on churning, patenting and M&As amongst top firms suggest that, even though the rising concentration need not imply weaker static competition, it could be associated with weaker dynamic competition as the largest firms entrench their position.[12]

Last but not least, the paper contributes to the ongoing debate on whether the rise in industry concentration is a US-specific phenomenon or has also taken place in other OECD countries. Using Orbis data, Gutiérrez and Philippon (2019) and Kalemli-Özcan et al. (2019) have found industry concentration in Europe to be flat or decreasing. In contrast, Bajgar et al. (2019) find a steady increase in European industry concentration between 2000 and 2014, both (i) when they focus on the largest business groups in Orbis and treat Europe as a single market, and (ii) when they calculate the sales share of 10% largest firms within each country-industry based on representative national microdata in 10 countries.[13] Koltay et al. (2020) similarly find clear evidence of rising concentration amongst the 5 largest European economies between 1998 and 2017. Affeldt et al. (2021), using novel data based on EU merger cases between 1995 and 2014, find large average increases in market concentration. Lashkari et al. (2019) and De Ridder (2019) both find evidence of rising concentration using administrative data for France. The present paper builds on the measures in Bajgar et al. (2019) by showing that a similar upward trend documented while treating Europe as a single market is also observed *within* most European countries in the sample and within Japan and the United States.

The rest of the paper is structured as follows. Section 2 explains how industry concentration is measured and describes concentration trends in the thirteen countries studied. Section 3 introduces the empirical strategy and the data used in the estimation. Section 4 presents the results. Section 5 concludes.

2. Trends in Industry Concentration

2.1. Measuring concentration

For each country-industry, we measure industry concentration as the share of the largest business groups in the total sales of that country and industry. Our preferred measure focuses on the share of 8 largest firms (CR8) but also test robustness of the results to using 4 or 20 largest firms (CR4, CR20). We calculate concentration as

$$CR^{8}_{c,i,t} \equiv \sum_{g=1}^{8} s_{g,c,i,t}$$ **Equation 1**

s_{gcit} denotes the share of business group g in the sales of industry i in country c, where the group is among the 8 business groups with the largest sales in year t. Note that our data does not allow us to separate domestic sales from exports, and it also does not contain any information on firm-specific imports. The observed concentration, thus, reflects a concentration of domestic production rather than of sales in the domestic markets.

The top 8 entities in sales are not measured at the level of individual firms but at the level of business groups, which may comprise multiple subsidiaries sharing the same ultimate owner. This is a preferable way to measure concentration. On average in our data, a top 8 group in a country and an industry comprises 3 subsidiary firms in that country and industry. It would be incorrect to consider an industry un-concentrated because industry sales are spread over a large number of firms, if all these firms are part of the same group. At the same time, it would also be inaccurate to assign *all* sales of a business group to the country and industry of the group headquarters. This could easily result in concentration levels exceeding 100% as many multinational enterprises generate more sales in foreign subsidiaries than in the home country. For this reason, we only aggregate firm sales up to the group level *within* each country and industry.[14] We calculate the industry sales shares of each business group as

$$s_{g,c,i,t} = \frac{S^{ORBIS}_{g,c,i,t}}{S^{STAN}_{c,i,t}},$$ **Equation 2**

where $S^{ORBIS}_{g.c.i.t}$ marks group sales in country c and industry i and $S^{STAN}_{c.i.t}$ designates the total sales of the industry.

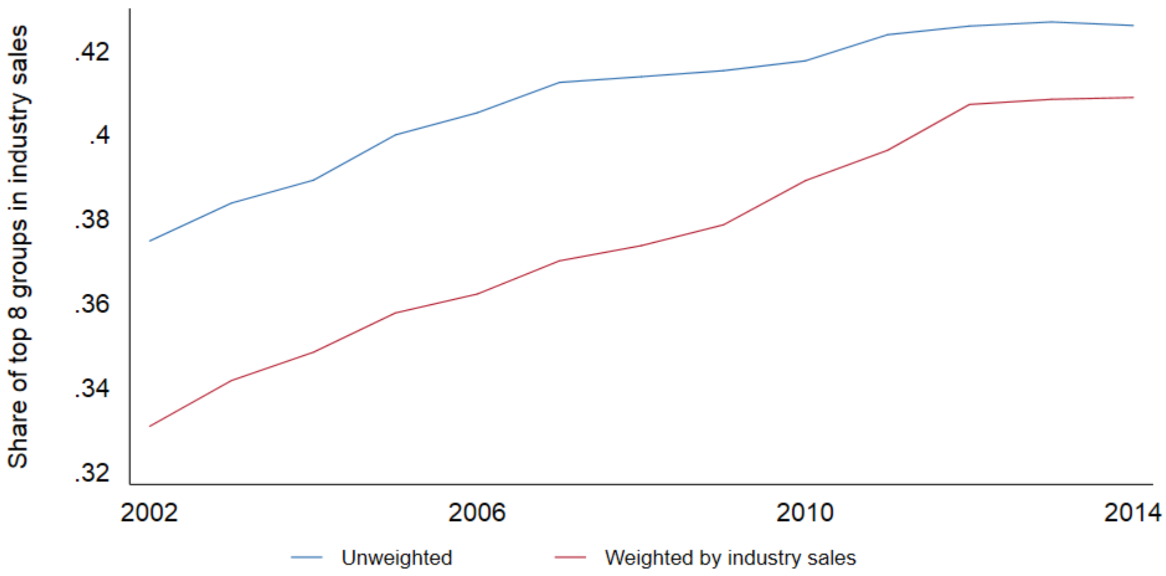
The primary source of firm sales data is Orbis, where we focus on a subset of countries with a good coverage of large firms over the sample period.[15] We complement it with Worldscope to achieve a more complete coverage among publicly traded firms, mainly in the United States prior to 2006. Aggregating firm sales to the group-level requires firm ownership information. Orbis contains extensive information on ownership linkages and reports the global ultimate owner of each firm, but there are some missing ownership linkages prior to 2007. We complete and correct the ownership information using ownership changes observed in the Zephyr merger and acquisitions (M&A) database, alongside a battery of automated checks and extensive manual checks for the largest firms. Further details on these adjustments are detailed in Bajgar *et al.* (2019). We also restrict the sample to countries with a good and stable coverage in Orbis between 2002 and 2014.[16]

Using the right denominator is essential for measuring concentration correctly. Orbis offers substantially better coverage for larger firms (Bajgar et al., 2020); this, together with manually checking information for top 8 business groups in each country industry, makes it a reasonably reliable data source for the numerator of the formula for industry concentration. However, variation in Orbis coverage across smaller firms and over time makes it problematic to construct the denominator of the formula by simply adding output of firms in Orbis. For this reason, we instead base the denominator on industry output observed in the OECD STAN database,[17] derived from national accounts.[18] In order to maximise country and industry coverage, some NACE Rev. 2 2-digit industries are aggregated together to match the STAN A64 classification.[19]

2.2. Concentration trends

Between 2002 and 2014, the share of top 8 business groups in the sales of the average country-industry grew by about 5 percentage points, roughly from 37.5% to 42.5% (Figure 2). When industries are weighted by their sales, the level of concentration at the beginning of the sample period is lower by about 4.5 percentage points, indicating that larger industries tend to be somewhat less concentrated. However, the increase in concentration becomes even greater, at about 8 percentage points over the sample period. Figure A A 1 in the online appendix also shows that the proportional concentration increase was very similar for the top 4 and top 20 business groups.

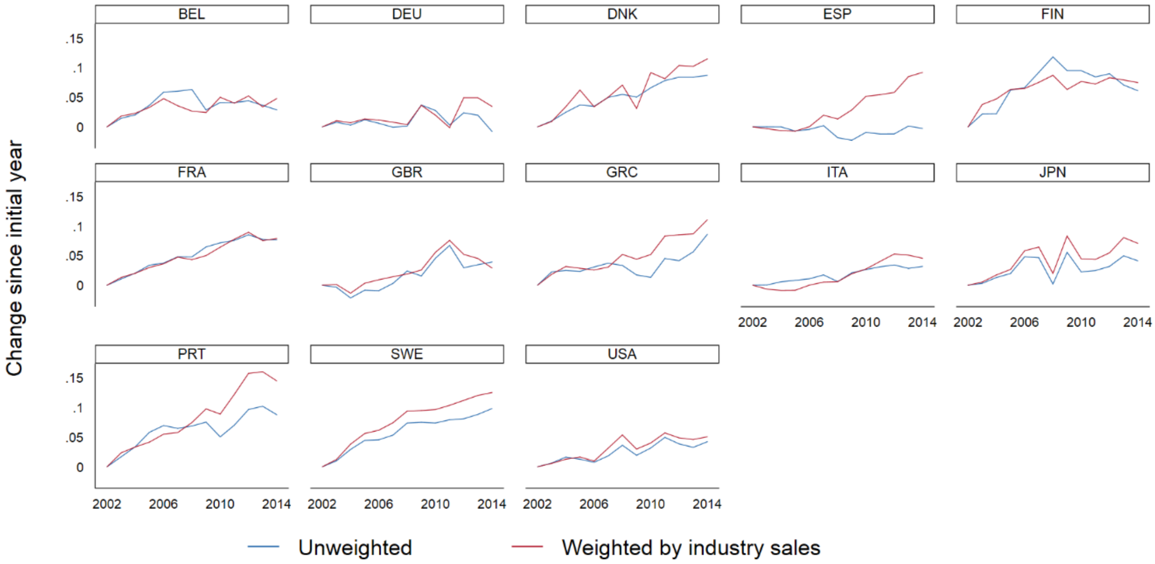
Figure 2. Top 8 industry concentration



Note: The figure shows changes in the unweighted and weighted mean concentration across country-industry pairs. The weighted mean reweights concentration across industries within each country based on time-varying weights given by the share of each industry in the total country-level sales. Countries included are BEL, DEU, DNK, ESP, FIN, FRA, GBR, GRE, FRA, JPN, PRT, SWE and USA. Included 2-digit industries cover manufacturing, construction and non-financial market services.

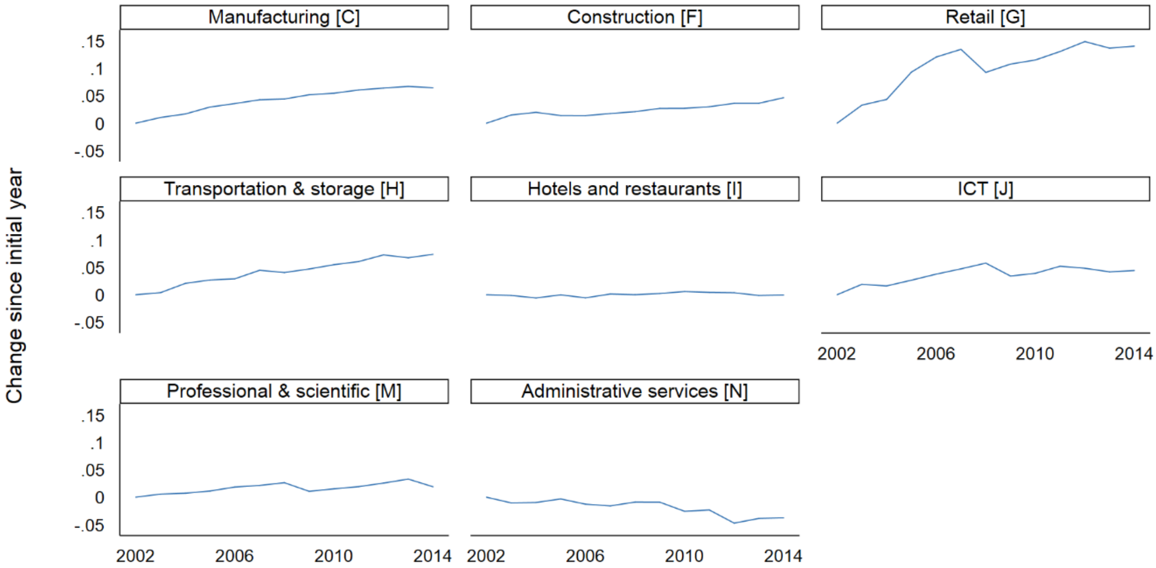
Overall, concentration increased in 68% of country-industries. Looking at unweighted averages across industries, all countries except Germany and Spain experienced an increase in concentration; and with weighting all countries did (**Error! Reference source not found.**).[20] The trends are qualitatively similar to findings using representative country-specific firm-level data for France and the US (De Ridder, 2019; Autor et al, 2020).[21] Concentration increased in 29 out of 37 2-digit industries. Among broad sectors, the concentration increase was particularly pronounced in "Retail", "ICT", "Transportation and Storage" and "Manufacturing", whereas concentration slightly decreased in "Administrative Services" (Figure 4).

Figure 3. Trends in top 8 concentration by country – change since 2002



Note: For each country, the figure shows changes in the unweighted and weighted mean concentration across industries compared to the base year 2002. The weighted mean reweights concentration across industries within each country based on time-varying weights given by the share of each industry in the total country-level sales. Included 2-digit industries cover manufacturing, construction and non-financial market services.

Figure 4. Trends in top 8 concentration by industry – change since 2002



Note: For each A21 industry, the figure shows changes in the (unweighted) mean concentration across countries compared to the base year 2002. Countries included are BEL, DEU, DNK, ESP, FIN, FRA, GBR, GRE, FRA, JPN, PRT, SWE and USA. Included 2-digit industries cover manufacturing, construction and non-financial market services.

3. Empirical approach and data

3.1. Empirical approach

3.1.1. Industry concentration and intangible investment

We examine the relationship between intangible investment intensity and changes in industry concentration using the following baseline specification:

$$\Delta CR^{8}_{c,i,t+k,t} = \alpha_1 Intan_{c,i,t-1} + \alpha_2 \Delta \log S_{c,i,t+k-1,t-1} + \alpha_3 Tan_{c,i,t-1} + Z_{c,i,t-1}\alpha_4 + \delta_{ct} + \delta_{it} + \varepsilon_{c,i,t} \quad \text{Equation 3}$$

$\Delta CR^{8}_{c,i,t+k,t}$ designates the change in the top 8 industry concentration (as defined in section **Error! Reference source not found.**) in country *c* and industry *i* between years *t* and *t*+*k*. Our baseline examines 4-year changes in concentration ($k = 4$), and we test robustness to using shorter and longer concentration changes. $Intan_{c,i,t-1}$ denotes the intensity of intangible investment in *t-1*, measured at the industry-level as intangible investment divided by value added. An alternative approach would be to use changes in intangible capital stocks over the 4-year period, but stock data are not available for many countries. To control for country and industry-specific business cycle dynamics, the specification controls for 4-year growth of real output in country *c* and industry *i*, lagged by one year compared to the period over which concentration is measured ($\Delta \log S_{c,i,t+k-1,t-1}$). The baseline specification further controls for the intensity of tangible investment ($Tan_{c,i,t-1}$), also measured as a share in value added and at the industry level. This is important given that intangible and tangible investment intensities are strongly and positively correlated. The specification also allows including other factors that may be related to the observed changes in industry concentration ($Z_{c,i,t-1}$) such as the occurrence of mergers and acquisitions or changes in trade openness. Country-year and industry-year fixed effects ($\delta_{c,t}, \delta_{i,t}$) ensure that the observed correlations are not driven by general country-specific or industry-specific characteristics and time variation.

Whilst we examine *changes* in industry concentration, which removes time-invariant factors affecting concentration levels, familiar endogeneity concerns remain. A positive correlation between the changes in industry concentration and intangible investment could mean that when the largest firms increase their market shares, they stand to gain more from investing in intangibles, or it could reflect omitted factors (e.g. management) that both help firms grow their market shares and lead to a more intensive intangible investment. We are not aware of a natural experiment that would allow us to decisively establish the direction of causality with our data, but we try to reduce the risk of reverse causality or an omitted variable bias by relying on an instrumental variables approach. We construct two instruments for current intangible investment: the first uses intangible investment *growth* in other countries and the latter uses *changes* in the home country's R&D tax subsidies, both interacted with the initial investment levels in the home country.[22] The growth of investment is assumed to be driven by factors that are plausibly exogenous to changes in industry concentration in the home country and industry.

The first instrumental variable combines the (time-invariant) pre-sample (and, thus, pre-determined) investment with time variation in other countries. It is constructed by multiplying the home country's pre-sample intangible intensity by an index of intangible investment intensity in the same industry on average across all other countries in the sample.

Formally, the instrument is defined as

$$IV\_Other\_Countries_{c,i,t-1} = Intan_{c,i,,t=0} * \frac{1}{n-1} \sum_{d \in C, d \neq c} \frac{Intan_{d,i,t-1}}{Intan_{d,i,,t=0}} \qquad \text{Equation 4}$$

where C is the set of 13 countries in our sample (n = 13).

The second instrumental variable instead combines the same pre-sample intangible intensity with time variation in tax incentives for research and development (R&D). While R&D represents only one type of intangible investment, it is the largest individual component of intangibles in our data (see section 3.2 below). The instrument multiplies the pre-sample investment with the change in the implied marginal tax subsidy rate for R&D reported in the OECD R&D Tax Incentives Database relative to year 2000:[23]

$$IV\_RD\_Subsidies_{c,i,t-1} = Intan_{c,i,,t=0} * \left(RDTax_{c,t-1} - RDTax_{c,2000}\right). \qquad \text{Equation 5}$$

If intangibles are inherently complementary with scale, they can be expected to give a greater advantage when the leading firms have big markets in which to grow, in industries where digitalisation facilitates fast expansion, when regulations shield the leading firms from smaller competitors, or when the leading firms already control a large share of their industry's output. To see if this is the case, we examine complementarity between intangibles on one hand and trade openness, digital intensity, the intensity of product-market regulations and initial concentration on the other. In addition, the effects of intangible investment might be particularly pronounced when such investment is accompanied by complementary investment in tangible capital. To test this conjecture, we also examine the complementarity between the intensity of intangible and tangible investment.

Specifically, we additionally include an interaction between intangible investment and each of these potential complementary factors ($Compl_{c,i,2002}$), estimating the following equation:

$$\begin{aligned}\Delta CR^{8}_{c,i,t+k,t} = {} & \alpha_1 Intan_{c,i,t-1} + \alpha_2 \Delta \log S_{c,i,t+k-1,t-1} + \alpha_3 Tan_{c,i,t-1} \\ & + \alpha_4 Intan_{c,i,t-1} * Compl_{c,i,2002} + \alpha_5 Compl_{c,i,2002} + \delta_{ct} \\ & + \delta_{it} + \varepsilon_{cit}\end{aligned} \qquad \text{Equation 6}$$

Trade openness is defined as the average of industry imports and exports, divided by industry value added. The measure of industry digital intensity is based on taxonomy developed by Calvino et al. (2018), which classifies A38 industries as more or less digital intensive based on multiple criteria including ICT investment, purchases of intermediate ICT goods and services, robots use, number of ICT specialists and turnover from online sales. We consider industries as digital-intensive if they were classified by Calvino et al. (2018) as medium-high or high digital intensive for the period 2001-2003. Product-market regulations are measured by the OECD Product Market Regulation (PMR) Index, with a higher value of the index corresponding to more regulated product markets. All complementary factors are measured at the beginning of the sample period, in 2002 (2001-2003 in the case of digital intensity).

Equation 3 and Equation 6 are estimated with linear regressions. Robust standard errors are clustered for each country-A21 industry pair, reflecting the variation in the intangible measure.

3.1.2. Industry concentration and measures of business dynamics and competition

In addition to analysing what may have driven the recent concentration trends, examining the extent to which they have gone hand-in-hand with other changes in the business environment (e.g. prices, markups, churning) might help better understand their implications and whether they may be "anti-competitive" in nature. Subsequent analysis, therefore, explores the relationship between changes in concentration and changes in other indicators of competition and business dynamism. We consider below indicators of top firm markups, churning of the top firms, defensive patenting and merger and acquisition activity.

For each indicator, we estimate equation

$$\Delta Comp^{8}_{c,i,t+k,t} = \Delta CR^{8}_{c,i,t+k,t} + \alpha_2 \Delta \log S_{c,i,t+k,t} + \delta_{ct} + \delta_{it} + \varepsilon_{cit} \qquad \text{Equation 7}$$

where $\Delta Comp^{8}_{c,i,t+k,t}$ denotes the change in the relevant competition or business dynamism indicator between $t+k$ and t. The equation is estimated with linear regression, clustering at the level of country-A64 industry pairs.

Equation 3, Equation 6 and Equation 7 are estimated with linear regressions. For Equation 3 and Equation 6, robust standard errors are clustered for each country-A21 industry pair, reflecting the variation in the intangible measure. For Equation 7, clustering is done at the level of country-A64 industry pairs.

The increasing share of top firms in industry sales, could reflect an increase in their market power. The first indicator is the average markup of the largest 8 companies within each country and industry, with markups calculated following the methodology developed by De Loecker and Warzynski (2012).[24] However, higher markups do not necessarily imply higher prices. We, thus, complement markups with a direct measure of prices. As firm-level prices are not available in Orbis, we rely on industry price indices at the level of A64 industries from the OECD STAN database.

The fact that the largest firms represent a greater share of industry output need not indicate weaker competition, as long as the top firms continue to be contested by new rising stars and are engaged in intense competition with each other. The amount of upward and downward mobility among the largest firms in each country and industry is indicative of such competitive activity. We explore three different measures of the churning of top firms. The first measure serves as a proxy for the top firms being displaced by initially smaller rivals. It is defined as the share of firms in the top 8 in year *t* that were not in the top 8 in year *t-1*.[25] The second measure captures mobility among firms that remain in the top 8. It is defined as a rank correlation between the market shares of top 8 firms in *t* and in *t-1* (Joskow, 1960).[26] Where the first two measures focus on the relative ranking of firms, the third measure – market share instability (Sakakibara and Porter, 2001) – captures the variability in firms' market shares. Market share instability (MSI) is defined as the mean absolute value of market share changes between *t* and *t-1* across the 8 largest firms in each country and industry, where the market shares are calculated as each firm's sales divided by the total sales of the 8 largest firms:[27]

$$MSI_{c.i.t} = \frac{1}{8}\sum_{f=1}^{8} \left| \frac{S_{f.c.i.t}^{ORBIS}}{\sum_{f=1}^{8} S_{f.c.i.t}^{ORBIS}} - \frac{S_{f.c.i.t-1}^{ORBIS}}{\sum_{f=1}^{8} S_{f.c.i.t-1}^{ORBIS}} \right| \qquad \text{Equation 8}$$

One mechanism through which leading firms could try to entrench their position at the top is using intellectual property in a defensive way to prevent their competitors from contesting them. Following Akcigit and Ates (2019), we construct a measure of defensive or exploitative patenting, using the prevalence of self-citations in patents held by the 8 largest firms in each country and industry. For each firm amongst the top 8 in an industry-country-year, we calculate stocks of patent self-citations and non-self-citations, where self-citations are defined as citations citing patents held by the same firm as the citing patent (see Akcigit and Kerr, 2018). The data reflect European Patent Office patents from OECD-PATSTAT, which matches patent applicants to Orbis data using harmonised firm name matching procedures. Stocks are constructed using a 15% depreciation rate following common practice since Hall et al. (2005).[28]

Mergers and acquisitions represent another way in which leading firms could try to reduce pressure from competitors. In the context of digital-intensive industries, in particular, a hot debate is under way about "killer acquisitions", where established firms are suspected of strategically buying off start-ups that have a potential to grow into serious competitors for the acquiring firms.[29] We compute the number of acquisitions and minority investments by the largest 8 companies in each country and industry, sourcing information from the Zephyr database. We separate these into digital and non-digital acquisitions using the industry of the acquiring firm and the industry digital intensity indicator of Calvino et al. (2018).

3.2. Data

Concentration measures are calculated from the matched Orbis-Worldscope-Zephyr database for each country, A64 industry and year as discussed in section 2.1.

Industry-level data on intangible and tangible investment comes from the INTAN-Invest database described by Corrado et al. (2012).[30] It contains harmonised information by country, A21 industry and year for 15 European countries and the United States for the period 1995-2015. We complement it with information on intangible investment in Japan from the Japan Industrial Productivity Database.[31] The intangible investment consists of three broad categories: innovative property, computerised information and economic competencies. Table 1 summarises the components of these categories and the average share of each of them in the total intangible investment for our sample. For the analysis, intangible investment intensity is constructed by dividing investment by industry value added, also coming from INTAN-Invest.

Table 1. Categories of intangible investment in INTAN-Invest

	Share in total intangible investment	Components
Innovative Property	40%	R&D (scientific); Mineral exploration; Entertainment and artistic originals; New products/systems in financial services; Design and other new products/systems
Computerised Information	15%	Software; Databases
Economic Competencies	45%	Advertising; Market research; Employer-provided training; Organisational structure

Source: Corrado et al. (2012) and authors' calculations of shares in the estimation sample.

We complement the data on industry concentration and intangible investment with several other types of information. Industry real gross output comes from the OECD STAN database and has been converted to 2005 PPP dollars using exchange rates from the World Bank Development Indicators. Tangible investment intensity is measured as Gross Fixed Capital Formation divided by industry value added, with both variables taken from the OECD STAN database. Trade openness is calculated as the average of industry exports and imports divided by industry value added, with all variables taken from the OECD Trade in Value Added database.[32] The product-market regulations (PMR) index is constructed by the OECD.[33] For each country and year, it measures the degree to which policies promote or inhibit competition in areas of the product market where competition is viable. Occurrence of M&As is measured with an M&A dummy equal to 1 if at least one company in a given country and industry has been a target of an acquisition with value above the 95th percentile among all acquisitions in a given country. The information on M&A deals comes from the Zephyr database. All these measures vary across countries and A64 industries and over time with the exception of the PMR index, which only varies across countries and over time.

The final sample spans years 2002-2014 and includes 13 countries that have a satisfactory coverage in Orbis and industry-level intangibles data available: Belgium, Denmark, Finland, France, Germany, Greece, Italy, Japan, Portugal, Spain, Sweden, the United Kingdom and the United States. The analysis focuses on manufacturing, construction and non-financial market services.[34]

Summary statistics of key variables are presented in Table 2. In the baseline regression sample, the average CR4, CR8 and CR20 industry concentration are, respectively, 32%, 40% and 50%. Industries on average invest around 15% of value added in intangibles, compared to a share of 22% for tangible investment. Our sample of developed economies are relatively open, with trade representing around 70% of value-added for the mean country-industry and with comparatively low levels of product market regulation (see Table 2). 12% observations experienced at least one large M&A and 58% correspond to industries classified as relatively digital intensive. On average, 16% firms among the top 8 in a given country and industry were not in the top 8 in the previous year, the rank correlation between the market shares of top 8 firms in years t and t-1 is 0.89, and the market share instability is about 2 percentage points. About 5% of patent citations by top 8 firms, on average, cite patents held by the same firm, and about 2 acquisitions and minority investments by top 8 firms take place in an average country, industry and year.

Table 2. Summary Statistics

	N	Mean	Standard dev.	Minimum	Maximum
CR8 Concentration	3,827	0.40	0.27	0.02	1.49
CR4 Concentration	3,827	0.32	0.24	0.01	1.28
CR20 Concentration	3,827	0.50	0.30	0.02	2.17
Intangible Investment Intensity (t-1)	3,827	0.15	0.08	0.01	0.36
Innovative Property Investment Intensity (t-1)	3,808	0.07	0.05	0.00	0.21
Computer and Software Investment Intensity (t-1)	3,687	0.02	0.02	0.00	0.09
Economic Competencies Investment Intensity (t-1)	3,823	0.06	0.03	0.01	0.14
Tangible Investment Intensity (t-1)	3,827	0.22	0.09	0.03	0.64
Industry Real Gross Output (bil. of 2005 PPP $, t-1)	3,827	43.14	91.56	0.07	1420.02
Trade Openness (t-1)	3,825	0.68	0.72	0.00	5.28
Product Market Regulation Index (t-1)	3,827	1.62	0.31	1.05	2.62
Large M&A Dummy	3,827	0.12	0.32	0.00	1.00
Digital Intensive Dummy	3,827	0.58	0.49	0.00	1.00
Mean top 8 log markup	3,222	0.11	0.45	-0.74	5.25
Industry price index	3,827	1.03	0.14	0.22	3.13
Share of new firms in the top 8	3,827	0.16	0.12	0.00	0.75
Rank correlation of top 8 firm sales in t and t-1	3,827	0.89	0.15	-0.62	1.00
Market share instability	3,827	0.02	0.01	0.00	0.18
Share of self-citations	2,389	0.05	0.06	0.00	0.33
M&A deals of the largest 8 companies	3,827	2.23	3.97	0.00	63.59

Notes: The number of observations reflects the country-industry-year level.

4. Results

4.1. Industry concentration and intangible investment

The results show that changes in country-industry concentration (see Table 3) are strongly correlated with intangible investment. The simplest specification that only includes year dummies shows a positive and highly statistically significant association between intangible investment intensity and 4-year changes in concentration (column 1). Controlling for real growth in industry output has little impact on the result (column 2). Importantly, the result is not driven by investment intensity in general – intensity of tangible gross capital formation is not significantly associated with concentration, and including it as a control leads to a further slight increase in the coefficient on intangibles (column 3). Thus, in our sample of countries we do not find evidence of a link between increasing concentration and tangible investment, contrary to what has been suggested for the US by Gutiérrez and Philippon (2017). The coefficient on intangibles almost doubles when we include country-year and industry-year fixed effects to control for broad characteristics and other developments in particular countries or particular industries (column 4).

The instrumental-variable results mirror the baseline findings. In columns 5 and 6, we use instruments for intangible investment based on changes in intangibles in other countries and changes in R&D tax credits at home. First-stage estimates (see online appendix Table A A.1) reveal both instruments to be strongly significant predictors of intangible investment intensity, and the first-stage F-statistic is well above 100 for all specifications. The second-stage estimates in columns 5 and 6 are similar to the OLS estimates of columns 3 and 4.[35]

Table 3. Industry Concentration Changes and Intangible Investment

	(1)	(2)	(3)	(4)	(5)	(6)
Estimation Method:		OLS			IV	
Outcome Variable:			4-year Change in CR8			
Intangible Investment	0.101***	0.113***	0.111***	0.211***	0.121***	0.207**
	(0.033)	(0.034)	(0.033)	(0.073)	(0.036)	(0.086)
4-year Growth in Real Output		-0.058***	-0.059***	-0.073***	-0.059***	-0.073***
		(0.013)	(0.013)	(0.014)	(0.013)	(0.014)
Tangible Investment			0.022	-0.049	0.021	-0.048
			(0.025)	(0.043)	(0.025)	(0.043)
Year FE	yes	yes	yes		yes	
Country-year FE				yes		yes
Industry-year FE				yes		yes
N	3827	3827	3827	3827	3827	3827
First-Stage F-Statistic	N/a	N/a	N/a	N/a	297.4	141.9
Hansen Test p-Value	N/a	N/a	N/a	N/a	0.996	0.899

Note: Regressions are at the country–A64 industry–year level. Robust standard errors are clustered at the country–A21 industry level in parentheses. ***, **, * represent significance at the 1%, 5% and 10% level respectively. Columns 1 to 4 present OLS regressions, 5 and 6 are second stage IV estimates, the first stage is reported in online appendix Table A A.1. The reported first-stage F-statistic is the Kleibergen-Paap cluster-robust weak instrument statistic.

The association between changes in concentration and intangible intensity is economically meaningful. According to our preferred specification (column 4), a 1-standard-deviation difference in the intensity of intangible investment corresponds to a 1.6-percentage-point higher increase in industry concentration over the next four years. This corresponds to about a third of the observed concentration increase in the average country-industry.

Our choice to focus on 4-year changes in CR8 concentration in the baseline specification is driven by the trade-off between explaining medium-term concentration developments (rather than short-run volatility) and having a sufficiently large number of observations for the estimation. Robustness checks using shorter or longer time windows (columns 2 and 3 of Table 4) confirms the robust positive correlation between intangible investment and concentration changes. As expected, the estimated coefficient becomes larger the longer is the time window considered. Similarly, the estimated relationship based on the largest 8 firms in each country and industry (column 1) is robust to considering only the largest 4 firms (column 4) or broadening the group to the largest 20 firms (column 5).

Additionally, in the online appendöix, we document that the main result on intangible investment intensity is robust to excluding any particular country (Table A A.2) and any particular industry (Table A A.3).

Table 4. Alternative Difference Lengths and Concentration Measures

	(1)	(2)	(3)	(4)	(5)
Outcome Variable:	4-Year Change in CR8	2-Year Change in CR8	6-Year Change in CR8	4-Year Change in CR4	4-Year Change in CR20
Intangible Investment	0.211***	0.120***	0.253**	0.212***	0.249***
	(0.073)	(0.033)	(0.114)	(0.071)	(0.075)
4-year Growth in Real Output	-0.073***			-0.060***	-0.094***
	(0.014)			(0.012)	(0.017)
2 Year Growth in Real Output		-0.065***			
		(0.013)			
6 Year Growth in Real Output			-0.083***		
			(0.016)		
Tangible Investment	-0.049	-0.030	-0.063	-0.049	-0.053
	(0.043)	(0.020)	(0.068)	(0.039)	(0.046)
Country-year FE	yes	yes	yes	yes	yes
Industry-year FE	yes	yes	yes	yes	yes
N	3827	4681	2973	3827	3827

Note: Regressions are OLS estimates at the country–A64 industry–year level. Robust standard errors are clustered at the country–A21 industry level in parentheses. ***, **, * represent significance at the 1%, 5% and 10% level respectively. For comparability column 1 repeats the baseline estimates of column 4 from Table 3.

Controlling for other commonly cited factors does not appear to significantly affect the magnitude and statistical significance of the concentration-intangibles relationship (**Error! Reference source not found.**).

A large literature suggests that globalization increases the toughness of the competition and leads to reallocation of production to larger firms, which are able to expand through exports and benefit from a wide range of imported inputs (Melitz, 2003; Melitz and Ottaviano, 2008).[36] This effect could be particularly pronounced in industries where intangibles play a large role in driving the competitive dynamics among firms, as the leading firms respond to the tougher competition by increasing their intangible investment, while weaker companies shrink or exit (Shaked and Sutton, 1987; Sutton, 1991, Bustos, 2011; Antoniades, 2015). To investigate the importance of these mechanisms, we add 4-year changes in trade openness, measured as the average of exports and imports relative to value added, to the regression. We do not find any evidence of a link between changes in trade openness and changes in concentration (column 1).[37] Accounting for changes in trade openness also has little effect on the estimated coefficient for intangible investment. We further interact the changes in trade openness with the initial average intangible-intensity of each country-industry. We do not find evidence of a differential effect of changes in trade openness across industries according to their intangible investment level (column 2).

The increasing concentration could also reflect increasing barriers to entry due to regulation (Bailey and Thomas, 2017). As stricter regulations can be associated with weaker investment in general, and in intangibles in particular (e.g. Alesina et al., 2005; Corrado et al., 2018), the positive estimated coefficient for intangibles could be reflecting the role of regulations. We explore this possibility by including 4-year changes in the OECD Product Market Regulation (PMR) Index[38] in the regression. Column 3 of Table 5 shows that the estimated coefficient on intangible investment remains unchanged when the PMR index is included, but it also suggests a statistically significant negative relationship between product market regulations and concentration.[39] A one-standard-deviation greater 4-year *reduction* in PMR corresponds to a 1.1-percentage-point stronger increase in industry concentration. The regression in Column 4 additionally includes an interaction between investment in intangibles and changes in PMR. The estimated interaction is not statistically significant, while the estimated coefficients on intangible investment and changes in PMR index remain virtually unchanged relative to those presented in column 3. The PMR index is a very broad measure of regulations, so these results should be taken with caution. That said, increasing concentration appears to be associated with *deregulation* rather than increasing regulation in our sample.[40]

Table 5. Industry Concentration Changes, Intangible Investment and Other Factors

	(1)	(2)	(3)	(4)	(5)	(6)
Outcome variable:			4-year Change in CR8			
Intangible Investment (II)	0.211***	0.210***	0.243***	0.239***	0.208***	0.208***
	(0.072)	(0.072)	(0.043)	(0.042)	(0.071)	(0.071)
4-Year Change in Trade Openness (ΔTO)	0.009	0.008				
	(0.010)	(0.011)				
ΔTO x Initial II		0.075				
		(0.309)				
4 Year Change in Product Market Regulation (ΔPMR)			-0.047**	-0.047**		
			(0.019)	(0.019)		
ΔPMR x Initial II				0.454		
				(0.307)		
Large M&A Dummy (M&A)					0.008	0.007
					(0.006)	(0.006)
M&A x Initial II						0.021
						(0.092)
4-year Growth in Real Output	yes	yes	yes	yes	yes	yes
Tangible investment	yes	yes	yes	yes	yes	yes
Country-year FE	yes	yes			yes	yes
Industry-year FE	yes	yes	yes	yes	yes	yes
N	3825	3825	3825	3825	3825	3825

Note: Regressions are OLS estimates at the country–A64 industry–year level. Robust standard errors are clustered at the country–A21 industry level in parentheses. ***, **, * represent significance at the 1%, 5% and 10% level respectively.

Weak antitrust enforcement of mergers and acquisitions has also been proposed as an explanation for divergent concentration trends, with the acquisition of innovative start-ups by incumbent firms potentially weakening future competition (e.g. Cunningham et al., 2018; Gutiérrez and Philippon, 2019). Specifications in the last two columns of Table 5 explore whether there is a connection between concentration changes in our data and large mergers and acquisitions. Specifically, they include a dummy equal to one when at least one large M&A (with value above the 95% percentile among all M&As observed in a given country over the sample period) took place in a given country, industry and year. We find no statistically significant relationship between concentration changes and occurrence of large M&As (column 5) or the interaction of the large M&As with intangible investment (column 6).[41]

Whilst other factors do not directly explain changes in concentration (noted above), the impact of intangibles on industry concentration is magnified by complementary factors, such as trade openness and digitalisation (see Table 6).

If intangible investment allows large firms to further scale up and increase their market shares, this should particularly be the case when these firms have access to larger markets to grow into. Intangible investment is indeed more strongly correlated with concentration growth in country-industries that are (initially) more open to international trade (column 1 of Table 6). One standard deviation higher trade openness corresponds to roughly 50% stronger association between intangible investment and concentration, in line with the idea that access to larger markets complements the scale-up potential of intangible capital.

The relationship between intangibles and concentration changes should also be stronger in industries where intensive use of digital technologies facilitates further scaling up of large firms. Digitalisation often goes hand-in-hand with intangible investments to leverage these new technologies and embed them into new business models (Brynjolfsson and Hitt, 2000; Bresnahan et al., 2002; Brynjolfsson et al. 2002; Brynjolfsson and McAfee, 2011). This seems to be the case, as the relationship between changes in concentration and intangible investment is estimated to be about twice as strong in the more digital intensive industries (column 2 of Table 6).

In contrast, we do not find any evidence of the association between intangibles and concentration changes being different in countries with stronger product market regulations (column 3) or higher initial level of industry concentration (column 4).

Intangible investment may also be more strongly associated with increasing concentration when accompanied with investment in tangibles. Firm investments in intangible assets are often correlated with their investment in tangibles – for example, intangible data often requires IT hardware, and new machinery may necessitate worker training (Bisztray et al., 2020; Kaus et al., 2020; McGrattan and Prescott, 2014). Our results indeed suggest that this is the case, with one standard deviation greater initial intensity of tangible investment corresponding to about 40% stronger association between intangible investment and concentration.

Table 6. Intangible Investment Complementarities

	(1)	(2)	(3)	(4)	(5)
Outcome Variable:			4-year Change in CR8		
Exposure Variable:	Initial Trade Openness	High Digital Intensity	Initial Product Market Regulations	Initial Concentration	Initial Tangible Investment Intensity
Intangible Investment	0.224***	0.111*	0.214***	0.242***	0.177**
	(0.074)	(0.064)	(0.074)	(0.064)	(0.073)
Exposure variable	-0.005			-0.033***	-0.012
	(0.007)			(0.009)	(0.011)
Intan. Invest. * Exposure Var.	0.099**	0.133**	-0.024	0.051	0.072**
	(0.044)	(0.061)	(0.036)	(0.050)	(0.036)
4-year Growth in Real Output	yes	yes	yes	yes	yes
Tangible investment	yes	yes	yes	yes	yes
Country-year FE	yes	yes	yes	yes	yes
Industry-year FE	yes	yes	yes	yes	yes
N	3824	3824	3824	3824	3824

Note: Regressions are OLS estimates at the country–A64 industry–year level. All regressions include (4 year) growth in industry sales and tangible investment intensity as control variables, which are omitted for parsimony. Robust standard errors clustered at the country–A21 industry level in parentheses. ***, **, * represent significance at the 1%, 5% and 10% level respectively. All exposure variables reflect 2002 demeaned values (the start of our sample period), with the exception of the digital intensity indicator which uses 2001-2003 data.

The analysis so far has used total intangible investment, but intangibles encompass a broad range of investments that may have differing impacts and policy implications. Table 7 decomposes intangible investment into three subcategories outlined in section **Error! Reference source not found.**: innovative property (R&D, design…); computerised information (data and software); and economic competencies (advertising, marketing, training...).

Table 7. Decomposing Total Intangible Investment

	(1)	(2)	(3)	(4)
Outcome Variable:		4-Year Change in CR8		
Innovative Property Investment	0.265***			0.232***
	(0.085)			(0.087)
Computerised Information Investment		0.725*		0.588*
		(0.369)		(0.325)
Economic Competencies Investment			0.155	0.070
			(0.202)	(0.168)
4-year Growth in Real Output	yes	yes	yes	yes
Tangible investment	yes	yes	yes	yes
Country-year FE	yes	yes	yes	yes
Industry-year FE	yes	yes	yes	yes
N	3668	3668	3668	3668

Note: Regressions are OLS estimates at the country–A64 industry–year level. All regressions include (4 year) growth in industry sales and tangible investment intensity as control variables, which are omitted for parsimony. Robust standard errors clustered at the country–A21 industry level in parentheses. ***, **, * represent significance at the 1%, 5% and 10% level respectively.

The results for total intangible investment appear to be mostly driven by investments in innovative property and computerised information. Investment in innovation is statistically significant both when it is included alone (column 1) or together with the other types of intangible investment (column 4). Investment in computerised information also gives significant estimates both alone (column 2) and when included jointly with other intangibles (column 4). The point estimates for computerised information are greater than those for innovative property, but they are less precisely estimated; this could reflect that in most industries firms invest relatively less in this type of intangibles, or it could be related to measurement challenges for this type of intangibles (e.g. value of data). Based on column 8, a 1-standard-deviation difference in the intensity of innovative investment and investment in computerised information correspond, respectively, to a 1.2-percentage-point and 1-percentage point higher increase in industry concentration over the next four years. In contrast, investment in economic competencies does not appear associated with concentration changes (column 3). This might be due to economic competencies (e.g. training) being less readily scalable than other intangibles (e.g. innovations, software) or providing more homogenous benefits across firms of different size and with different market shares.

4.2. Industry concentration and measures of business dynamics and competition

The analysis so far indicates that the observed rise in industry concentration is strongly predicted by investment in intangible assets, which allows large business groups to further scale up. An important question that follows is what the concentration increases imply for business dynamism and competition – and whether they simply reflect new large-firm biased business models or whether they might be a sign of a worsening competitive environment.

Greater shares in industry sales held by the largest firms could be associated with stronger market power of these firms. To examine this, we regress 4-year changes in the average markup of the 8 largest groups in each country and industry on the 4-year changes in industry concentration (column 1 of Table 8).[42] The results indicate a positive association between concentration and markups, with a 10-percentage-point increase in concentration corresponding to 1.3% higher markups of the largest firms. However, rising markups by themselves do not indicate rising market power.[43] If increasing concentration is a symptom of weak competition, it should be positively correlated with prices (Berry et al., 2019). We explore this in column 2 of Table 8. As information on firm-level prices is not available, we use 4-year growth in industry price indices.[44] We find a strong negative correlation, implying that a 10-percentage-point increase in concentration corresponds to a 2.3% reduction in industry prices. Taken together, the results for markups and industry prices are consistent with models where large business groups incur the fixed costs of investing in intangible assets and are rewarded by reduced marginal costs (De Ridder, 2019). Prices decline but marginal costs decline *even more*, leading to an increase in markups.

Table 8. Industry concentration, markups and prices

	(1) Markups of Top 8 Firms	(2) Industry Price Index	(3) Share of New Top 8 Firms	(4) Size Rank Persistence	(5) Market Share Instability	(6) Share of Internal Citations	(7) More Digital M&As	(8) Less Digital M&As
4-year Change in CR8	0.129**	-0.227***	-0.057*	0.096**	-0.014***	0.032*	1.455***	-0.424
	(0.064)	(0.020)	(0.030)	(0.043)	(0.005)	(0.017)	(0.554)	(0.914)
4-year Growth in Real Output	0.042	-0.645***	-0.009	0.023	-0.003	0.013*	0.307	-0.282
	(0.030)	(0.011)	(0.015)	(0.017)	(0.002)	(0.008)	(0.279)	(0.229)
Country-year FE	yes	yes	yes	yes	yes	yes	yes	yes
Industry-year FE	yes	yes	yes	yes	yes	yes	yes	yes
N	3044	3044	3424	3424	3424	2324	2179	1598

Note: Regressions are OLS estimates at the country–A64 industry–year level. Robust standard errors clustered at the country–A64 industry level in parentheses. ***, **, * represent significance at the 1%, 5% and 10% level respectively.

The growing market shares of the largest firms may be consistent with intense competition, provided that the top firms continue to be contested by initially smaller competitors and by each other. We measure such competitive activity by exploring churning amongst the largest firms in each country and industry. We investigate how concentration changes are related to three measures of firm mobility at the top: the share of top 8 firms that were not in the top 8 a year earlier, the correlation of top 8 firm relative ranking with its rank a year earlier and the market share instability measure (capturing the annual variability in firms' market shares).

The results for all three measures consistently indicate that increased concentration is associated with reduced churning at the top (columns 3-5 of Table 8). Specifically, a 10-percentage-point increase in industry concentration corresponds to a 0.6-percentage-point reduction in the share of new firms among the top 8 (a 4% reduction compared to the mean share), a 1-percentage-point increase in the year-on-year rank correlation of firm's market shares within the top 8 (a 1.1% increase compared to the mean value) and a 0.14-percentage point reduction in the market share instability (a 9% reduction compared to the mean value). These results are in line with evidence found for the US (Bessen *et al.*, 2020) showing that the displacement of industry-leading firms has declined sharply since 2000 and that the greater persistence at the top is closely linked to investments in proprietary software by dominant firms.

The results above suggest that increases in industry concentration have been associated with a reduced churning amongst top firms. We now turn to two examples of mechanisms that might be helping the leading firms to stay at the top. Firstly, leading firms could increasingly use intellectual property in a defensive way to prevent their competitors from contesting them (Akcigit and Ates, 2019). To see if this is the case, we regress 4-year changes in the share of self-citations among all citations by patents of the top 8 firms against 4-year changes in concentration. We find evidence in support of such a mechanism, although it is only weakly significant (column 6 of Table 8).[45]

Leading firms can also bolster their position through mergers and acquisitions. The role of M&As is hotly debated especially in the context of digital-intensive industries where established firms are suspected of strategically buying off start-ups that have a potential to grow into serious competitors for acquiring firms (for example, Argentesi et al., 2019a, 2019b). In the remaining columns of Table 8, we test if changes in industry concentration are associated also with changes in the number of M&As (acquisitions and minority investments) by the top 8 firms in each industry. For M&As in digital intensive industries, we find evidence of a positive relationship with concentration. A 10-percentage-point increase in industry concentration is associated with 0.14 additional M&As by the top 8 firms per year, which corresponds to a 7% increase relative to the mean (column 7). In contrast, we find no evidence of a relationship between changes in concentration and in M&A activity in less digital-intensive industries (column 8).

5. Conclusion

Since the early 2000s, industry concentration has increased in a number of OECD economies and in many industries. Using panel data at the country-industry level for 13 countries and years 2002-2014, the analysis indicates that intangibles have played a significant role in this increase. Intangibles disproportionately benefit large firms, which are both able to better leverage them in greater sales and are also better placed to invest in them in the first place. The results are consistent with intangibles, in particular innovative assets, software and data, having allowed large firms to further increase their market shares. This effect appears to be amplified in globalised and digital-intensive industries and countries. In contrast, the concentration increases do not appear to be directly associated with increasing globalisation, with large mergers and acquisitions or robustly with changes in product market regulations alone.

In terms of implications for competition and business dynamism, the finding that the increasing concentration is associated with investment rather than with M&As or stricter regulations can be seen as good news. The finding that concentrating industries see markups of leading firms grow need not indicate a presence of particular anti-competitive forces, but may instead be a result of the largest firms making fixed investments in intangible assets to reduce their marginal costs (De Ridder, 2019); indeed, industry prices seem to increase less, not more, in country-industries with stronger concentration increases.

This does not, however, mean that the recent rise in industry concentration does not represent a threat to competition and business dynamism. The finding that increasing concentration is consistently associated with reduced churning among the largest firms may indeed indicate a weakening of the competitive process. The largest firms are also increasingly filing defensive patents intended to impede competition rather than to explore new technology areas and acquiring potential competitors through M&As in digital-intensive industries. These trends might, therefore, represent a threat for future competition and for consumers if the position of the dominant firms acts as a barrier to the entry of new firms, or slows knowledge diffusion to competitors and their growth.

Endnotes

[1] This increase has been well documented using different data sets and concentration metrics. See, for example, Crouzet and Eberly (2019), Furman and Orszag (2015), Grullon *et al.* (2019) and Autor *et al.* (2020).

[2] See, for example, https://www.economist.com/special-report/2018/11/15/across-the-west-powerful-firms-are-becoming-even-more-powerful, https://www.brookings.edu/blog/up-front/2018/06/28/competition-challenges-in-the-digital-economy/, https://www.ft.com/content/489c7acc-a175-11e8-85da-eeb7a9ce36e4 and the Jackson Hole symposium 2018.

[3] For an overview of intangible capital and its rise, see Corrado et al. (2009), Corrado and Hulten (2010) and Haskel and Westlake (2017). Demmou and Franco (forthcoming) provide a recent summary of the literature, also discussing the implications of the COVID-19 pandemic for the potential role of intangible capital.

[4] The results are robust to using alternative concentration measures (see Section 4).

[5] To avoid measuring short-term fluctuations, the analysis relates intangible investment intensity with 4-year changes in industry concentration; our results also hold for changes over longer or shorter periods.

[6] Ganapati (2020) finds that industry concentration increases in the US between 1972 and 2012 are uncorrelated with price changes.

[7] For the US, see, for example, Gutiérrez and Philippon (2017) and Barkai (2019) on profits, De Loecker *et al.* (2020) and Hall (2018) on mark-ups and Bessen (2016) on operating margins. For international evidence, see IMF (2019) on profits and Calligaris et al. (2018), as well as Diez et al. (2018), on mark-ups.

[8] See Decker et al. (2014, 2016) for the US and Calvino et al. (2015) for cross-country evidence.

[9] Andrews et al. (2016) document a faster productivity growth at the global productivity frontier, and Berlingieri et al. (2017) study productivity divergence within countries.

[10] See, for example, Gutiérrez and Philippon (2017) and Alexander and Eberly (2018) for the US and Lewis et al. (2014) and Bussiere et al. (2015) for international evidence.

[11] Karabarbounis and Neiman (2013) and ILO and OECD (2015) show that labour shares have declined in many countries. See Barkai (2019), Autor et al. (2020) and Zhu (2017) for evidence on the US.

[12] This concern is expressed, for example, by Ayyagari et al. (2019) and Autor et al. (2020).

[13] The national microdata cover the entire firm population for all countries except Germany and Austria; excluding these two countries from the sample leaves the results unchanged.

[14] We primarily rely on unconsolidated financial data. In cases where unconsolidated accounts of the parent company are not available, we set sales of the parent company to the consolidated group sales minus the combined sales of all its subsidiaries.

[15] We follow the cleaning procedures outlined by Kalemli-Ozcan et al. (2019), which we complement with additional automated checks and manual corrections based on company annual reports and other sources. For more information on the data cleaning and concentration measurement using business group data, see Bajgar et al. (2019).

[16] As is well known, Orbis has a limited coverage of US firms. Complementing the data with information from Worldscope ensures good coverage of publicly traded firms but coverage of private firms remains problematic. This could lead to allocating too much of the group sales into the headquarter industry.

[17] See oe.cd/stan. Note that due to differences in variables available in each dataset, we use Orbis *sales* in the numerator but STAN *output* in the denominator. Sales and output are very similar in

most industries, although a significant difference might exist in certain industries, such as "Retail". Our results are robust to excluding retail industries.

[18] Bajgar et al. (2019) report that using a denominator based on Orbis rather than on STAN can lead to very different observed concentration trends. Using STAN-based denominators unfortunately means that we are not able to calculate concentration at a finer industry detail.

[19] For information on A64, A38 and A21 classifications, see http://www.oecd.org/sti/ind/3max.pdf.

[20] The large difference between unweighted and weighted trends for Spain is mainly due to some highly concentrated industries that have become more important over the sample period (e.g. telecommunications) and some comparatively low-concentration industries that have become relatively less important (e.g. construction). Using different data, a report by Monopolkomission (2018) also finds a flat industry concentration in Germany in recent years.

[21] This is despite methodology differences. For instance, unlike our paper, these country-level studies do not account for firms being part of the same business group.

[22] To remove year-on-year noise, initial, pre-sample intangible intensities (at $t=0$) are defined as unweighted averages across years 1995-2000 (we measure concentration from 2002 onwards).

[23] See oe.cd/rdtax. Year 2000 is the first year for which the tax subsidy data are available.

[24] We use labour as a flexible input and estimate industry-specific output elasticities from Orbis data following Wooldridge (2009). The estimation sample contains firms with 20 or more employees.

[25] For studies examining turnover among the leading firms see, for example, Mueller (1986), Marlow and Wright (1987), Kato and Honjo (2006) and Honjo et al. (2018).

[26] Only firms that are in top 8 in both years are used in the calculation.

[27] The total sales of 8 largest firms, rather than the total industry sales, are used as a denominator to avoid building in a mechanical relationship between changes in industry concentration and the market share instability measure.

[28] "Patents" here represent unique patent families filed with the European Patent Office (EPO) from 1980 onwards. All applications referring to the same priority patent are defined as a patent family. This avoids double counting of filing of patents in multiple patent offices. We focus on EPO patents, since data on self-citations is not available to us for other patent offices, and our sample of firms largely reflects European countries. Note we aggregate patents belonging to subsidiaries of the firm, using our detailed subsidiary ownership data.

[29] See Cunningham et al. (2018), Gauthier and Lamesh (2020), Kim (2020) and Motta and Peitz (2020).

[30] See http://www.INTAN-Invest.net.

[31] See https://www.rieti.go.jp/en/database/JIP2011/index.html#04-6.

[32] See oe.cd/tiva.

[33] See oe.cd/pmr.

[34] Due to data differences in measuring output, we exclude wholesale trade (industries 45 and 46) for all countries, and due to changes in coverage we exclude industry 41-43 for Belgium and industries 19, 21, 47, 50, 51, 52, 58 and 61 for Germany. We further exclude highly heterogeneous "residual" A64 industries 74-75 and 80-82. Finally, we exclude industry 68, for which INTAN-Invest data are only available for Japan.

[35] The Hansen test of over-identifying restrictions does not reject the null hypothesis of exogenous instruments.

[36] Autor et al (2020) discuss globalisation as a potential explanation of the recent concentration increases in the US.

[37] Trade openness is defined at the level of A64 industries rather than A21 industries. Clustering standard errors at the country-A64 industry level, rather than country-A21 industry level, does not affect the results.

[38] A greater value of the PMR index indicates more regulated product markets.

[39] Note that the specifications in columns 3 and 4 control for only country rather than country-year fixed effects. The PMR index does not vary across industries, so controlling for country-year effects in a similar way as in columns 1 and 2 would cause the PMR index to drop out of the regression.

[40] We test the robustness of this somewhat surprising result in online appendix Table A A.4. As the PMR index is a country-level measure, we cluster standard errors by countries rather than country-industry pairs throughout the table. Column 1 replicates the results from column 3 of **Error! Reference source not found.**, indicating that the different clustering makes little difference. Not controlling for country fixed effects leads to a smaller but more precisely estimated coefficient on the PMR index (column 2). The coefficient is not effected by excluding intangible investment intensity from the regression (column 3) and by dropping outlier PMR changes, defined as observations with a 4-year change in the PMR that is more than two standard deviations away from the mean PMR change in the estimation sample (column 4). Finally, when we split the aggregate PMR index into its three components, we estimate negative coefficients for all of them, although only the coefficient for Barriers to Entrepreneurship is at least weakly statistically significant.
[41] Defining large M&As using a lower threshold (value above 90th or 75th percentile among M&As which took place in a given country over the course of the sample period) or using M&A counts instead of a binary indicator does not qualitatively alter the results.
[42] Throughout this subsection, standard errors are clustered at the country-A64 industry level.
[43] See, for example, Calligaris et al. (2018).
[44] The price indices used are value added deflators from the OECD STAN database. Unlike gross output deflators, value added deflators are not mechanically affected by changes in input prices.
[45] The estimate implies that a 10-percentage-point increase in concentration is associated with a 0.32% increase in the share of self-citations, which represents a 7% increase relative to the mean value.

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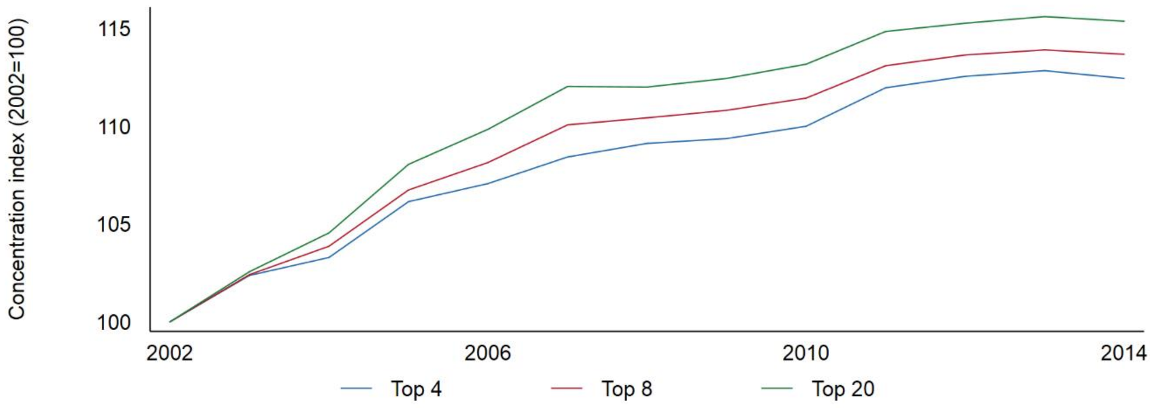
Annex A. Appendix

Figure A A 1. Proportional changes in top 4, top 8 and top 20 industry concentration



Note: The countries include BEL, DEU, DNK, ESP, FIN, FRA, GBR, GRE, FRA, JPN, PRT, SWE and USA. Included industries cover 2-digit manufacturing, construction and non-financial market services. Concentration is measured by the share of top 4, top 8 and top 20 business groups in the sales of each industry in each country. The figure shows proportional changes in the (unweighted) mean concentration across country-industry pairs.

Table A A.1. First-stage regressions

	(1)	(2)
Outcome Variable:	Intangible investment	
IV – Other Countries	0.750***	0.621***
	(0.042)	(0.037)
IV – R&D Subsidies	0.660***	0.443***
	(0.180)	(0.167)
4-year Growth in Real Output	yes	yes
Tangible Investment	yes	yes
Year FE	yes	
Country-year FE		yes
Industry-year FE		yes
N	3827	3827

Note: The table shows first-stage regressions for instrumental variable estimation. The second stage results are displayed in columns 5 and 6 of Table 3. Regressions are at the country–A64 industry–year level. Robust standard errors are clustered at the country–A21 industry level in parentheses. ***, **, * represent significance at the 1%, 5% and 10% level respectively. IV – Other Countries is constructed from the initial pre-sample (home country) investment with time variation in other countries. IV – R&D Subsidies combines the same pre-sample intangible intensity with time variation in tax incentives for research and development (R&D). These are discussed further in section 3.

Table A A.2. Industry Concentration Changes and Intangible Investment – Dropping One Country at a Time

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Excluded Country:	None	BEL	DEU	DNK	ESP	FIN	FRA
Outcome Variable:	4-Year Change in CR8						
Intangible Investment	0.211***	0.209**	0.247***	0.254***	0.222***	0.232***	0.210***
	(0.073)	(0.083)	(0.079)	(0.075)	(0.073)	(0.078)	(0.079)
4-Year Growth in Real Output	-0.073***	-0.068***	-0.072***	-0.072***	-0.079***	-0.076***	-0.079***
	(0.014)	(0.015)	(0.014)	(0.014)	(0.014)	(0.016)	(0.014)
Tangible Investment	-0.049	-0.048	-0.085	-0.057	-0.032	-0.053	-0.049
	(0.043)	(0.043)	(0.053)	(0.045)	(0.040)	(0.045)	(0.044)
N	3827	3539	3566	3554	3494	3521	3494
	(8)	(9)	(10)	(11)	(12)	(13)	(14)
Excluded Country:	GBR	GRE	ITA	JPN	PRT	SWE	USA
Outcome Variable:	4-Year Change in CR8						
Intangible Investment	0.189**	0.151**	0.226***	0.203***	0.224***	0.184**	0.200***
	(0.075)	(0.059)	(0.079)	(0.073)	(0.083)	(0.077)	(0.072)
4-Year Growth in Real Output	-0.076***	-0.068***	-0.073***	-0.072***	-0.066***	-0.074***	-0.073***
	(0.014)	(0.017)	(0.014)	(0.015)	(0.014)	(0.014)	(0.014)
Tangible Investment	-0.047	-0.042	-0.052	-0.036	-0.062	-0.046	-0.035
	(0.045)	(0.043)	(0.045)	(0.043)	(0.045)	(0.043)	(0.039)
N	3521	3554	3494	3557	3548	3521	3561

Note: Regressions are at the country–A64 industry–year level. Robust standard errors are clustered at the country–A21 industry level in parentheses. ***, **, * represent significance at the 1%, 5% and 10% level respectively. All regressions control for country-year and industry-year fixed effects.

Table A A.3. Industry Concentration Changes and Intangible Investment – Dropping One A64 Industry at a Time

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Excluded A64 Industry	None	10	13	16	17	18	19	20	21	22
Outcome Variable:	4-Year Change in CR8									
Intangible Investment	0.211***	0.208***	0.214***	0.218***	0.215***	0.210***	0.210***	0.205***	0.203***	0.216***
	(0.073)	(0.074)	(0.075)	(0.072)	(0.073)	(0.073)	(0.071)	(0.074)	(0.069)	(0.073)
4-Year Growth in Real Output	-0.073***	-0.074***	-0.071***	-0.073***	-0.074***	-0.073***	-0.081***	-0.075***	-0.074***	-0.072***
	(0.014)	(0.014)	(0.014)	(0.015)	(0.014)	(0.015)	(0.014)	(0.014)	(0.014)	(0.014)
Tangible Investment	-0.049	-0.049	-0.049	-0.052	-0.045	-0.050	-0.047	-0.042	-0.045	-0.051
	(0.043)	(0.042)	(0.043)	(0.043)	(0.042)	(0.042)	(0.042)	(0.043)	(0.041)	(0.041)
N	3827	3710	3710	3719	3719	3710	3764	3710	3728	3710
	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)	(20)
Excluded A64 Industry	23	24	25	26	27	28	29	30	31	33
Outcome Variable:	4-Year Change in CR8									
Intangible Investment	0.207***	0.222***	0.209***	0.210***	0.205***	0.226***	0.207***	0.194***	0.212***	0.222***
	(0.073)	(0.072)	(0.072)	(0.073)	(0.076)	(0.074)	(0.074)	(0.074)	(0.071)	(0.078)
4-Year Growth in Real Output	-0.073***	-0.073***	-0.073***	-0.078***	-0.077***	-0.071***	-0.070***	-0.068***	-0.072***	-0.057***
	(0.015)	(0.015)	(0.014)	(0.015)	(0.016)	(0.014)	(0.014)	(0.014)	(0.014)	(0.013)
Tangible Investment	-0.051	-0.048	-0.046	-0.053	-0.052	-0.052	-0.050	-0.050	-0.045	-0.056
	(0.043)	(0.042)	(0.042)	(0.043)	(0.043)	(0.042)	(0.043)	(0.043)	(0.041)	(0.044)
N	3719	3728	3710	3737	3710	3710	3719	3737	3710	3728

Industry Concentration Changes and Intangible Investment – Dropping One A64 Industry at a Time (cont.)

	(21)	(22)	(23)	(24)	(25)	(26)	(27)	(28)	(29)	(30)
Excluded A64 Industry	41	47	49	50	51	52	53	55	58	59
Outcome Variable:					4-Year Change in CR8					
Intangible Investment	0.224***	0.188**	0.208***	0.212***	0.209***	0.204***	0.215***	0.210***	0.209**	0.233**
	(0.076)	(0.073)	(0.074)	(0.074)	(0.074)	(0.075)	(0.073)	(0.075)	(0.082)	(0.098)
4-Year Growth in Real Output	-0.073***	-0.071***	-0.072***	-0.078***	-0.079***	-0.072***	-0.074***	-0.072***	-0.072***	-0.071***
	(0.014)	(0.014)	(0.014)	(0.014)	(0.015)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)
Tangible Investment	-0.059	-0.053	-0.047	-0.037	-0.047	-0.046	-0.047	-0.050	-0.052	-0.061
	(0.047)	(0.043)	(0.044)	(0.041)	(0.041)	(0.045)	(0.045)	(0.043)	(0.045)	(0.050)
N	3719	3719	3712	3764	3747	3730	3749	3710	3721	3712
	(31)	(32)	(33)	(34)	(35)	(36)	(37)	(38)		
Excluded A64 Industry	61	62	71	72	73	77	78	79		
Outcome Variable:					4-Year Change in CR8					
Intangible Investment	0.145**	0.199***	0.229***	0.214***	0.223***	0.235***	0.215***	0.226***		
	(0.060)	(0.062)	(0.074)	(0.074)	(0.077)	(0.074)	(0.076)	(0.070)		
4-Year Growth in Real Output	-0.074***	-0.074***	-0.075***	-0.073***	-0.070***	-0.071***	-0.074***	-0.066***		
	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)	(0.014)		
Tangible Investment	-0.033	-0.030	-0.048	-0.048	-0.052	-0.062	-0.049	-0.082**		
	(0.037)	(0.039)	(0.043)	(0.043)	(0.044)	(0.048)	(0.046)	(0.041)		
N	3721	3712	3728	3746	3719	3719	3728	3728		

Note: Regressions are at the country–A64 industry–year level. Robust standard errors are clustered at the country–A21 industry level in parentheses. ***, **, * represent significance at the 1%, 5% and 10% level respectively. All regressions control for country-year and industry-year fixed effects.

Table A A.4. Industry Concentration Changes and Changes in Product Market Regulation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Outcome variable:				4-Year Change in CR8			
Intangible Investment	0.211**	0.245***		0.206**	0.202**	0.201**	0.209**
	(0.074)	(0.040)		(0.074)	(0.073)	(0.073)	(0.074)
4-Year Change in Product Market Regulations	-0.086**	-0.052***	-0.083*	-0.086**			
	(0.039)	(0.011)	(0.040)	(0.039)			
4-Year Change in Barriers to Trade and Investment					-0.041		
					(0.054)		
4-Year Change in Barriers to Entrepreneurship						-0.037*	
						(0.021)	
4-Year Change in State Control							-0.023
							(0.019)
4-Year Growth in Real Output	yes	yes	yes	yes	yes	yes	yes
Tangible investment	yes	yes	yes	yes	yes	yes	yes
Country FE	yes		yes	yes	yes	yes	yes
Industry-Year FE	yes	yes	yes	yes	yes	yes	yes
N	3825	3825	3825	3765	3675	3675	3675

Note: Regressions are OLS estimates at the country–A64 industry–year level. Robust standard errors are clustered at the country level in parentheses. ***, **, * represent significance at the 1%, 5% and 10% level respectively. Barriers to Trade and Investment, Barriers to Entrepreneurship and State Control are the three components of the aggregate Product Market Regulations Index. Column 4 excludes observations with a 4-year change in the PMR more than two standard deviations above or below the mean 4-year change in the PMR in the estimation sample.