Supersize Me: Intangibles and Industry Concentration

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The paper presents new evidence on the growing scale of big businesses in the United States, Japan and Europe. It documents a rising industry concentration across the majority of countries and sectors over the period 2002 to 2014. Industry-level and firm-level econometric analysis indicates that intangibles, particularly innovation, R&D and patents, play a key role in enabling large firms to scale up and increase their market shares. The role of intangibles appears to be stronger in more globalised and more digital-intensive industries.

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1 Introduction

Big companies 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. This increase has been well documented using different data sets and concentration metrics.[2] Evidence for other parts of the world is scarcer. Bajgar et al. (2019) study changes in industry concentration in Europe, as well as North America, over the period 2000-2014 and find that industry concentration increased in both regions in about three out of four 2-digit industries.

What is allowing the largest companies to capture a larger part of the market? One possibility is that economies are becoming less competitive: tight regulations, anti-competitive behaviour and mergers and acquisitions (M&As) give market power to large incumbent firms and protect them from the challenge of smaller and younger competitors (Gutiérrez and Philippon, 2019). This explanation is supported by an increase in profits and mark-ups that have been documented both in the US and internationally.[3] However, it is at odds with the finding that US industries which saw a larger increase in concentration on average experienced a *stronger* growth in productivity and innovation (Bessen, 2017; Autor et al., 2019), although this may have changed over time (Covarrubias et al., 2019).

An alternative explanation posits that the largest and most productive firms have disproportionately benefited from technological change, integrated global markets and low interest rates, as winner-take-most dynamics allowed them to increase their shares in industry sales (Autor et al., 2019; Liu et al., 2019). If this were the case, concentration would not necessarily be bad news and could go hand-in-hand with disruptive innovation and rising productivity.[4]

The increasing importance of investment in intangible assets – such as business research and development (R&D), software, marketing and training – may also have played an important role in driving up industry concentration.[5] 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 are able to leverage a given intangible investment over higher sales and larger markets.

This paper explores if investment in intangible assets has contributed to the observed rise of industry concentration. It constructs measures of industry concentration for the US, Japan and eleven European economies from 2002 to 2014 based on matched Orbis-Worldscope-Zephyr data. It then links the

[2] See, for example, Crouzet and Eberly (2019), Furman and Orszag (2015), Grullon et al. (2019) and Autor et al. (2019).

[3] For the US, see, for example, Gutiérrez and Philippon (2017) and Barkai (2019) on profits, De Loecker and Eeckhout (2017) 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.

[4] See also Akcigit and Ates (2019a,b) who show that the increasing concentration, together with several concurrent business dynamics trends, can be explained by a break-down in knowledge diffusion.

[5] For an overview of intangible capital and its rise, see Corrado et al. (2009), Corrado and Hulten (2010) and Haskel and Westlake (2017).

concentration metrics to industry-level and business group-level measures of intangible investment, together with proxies of other potential drivers of industry concentration.

The results indicate that the share of sales due to the largest 8 business groups increased in about two thirds of country-industry pairs in the sample and on average concentration increased by around 5 percentage points over 2002 to 2014. Changes in industry concentration seem to be positively related to industry intensity of intangible investment, particularly in innovative assets. The estimates are relatively large, a 10 percentage point increase in intangible investment (as a share of value added) is associated with a 1.8 percentage point increase in concentration over the next 4 years. Intangible investment appears to be a notably stronger predictor of increasing concentration in our data than alternative potential drivers such as openness to trade, industry digital intensity or product market regulations, and the relationship continues to hold after controlling for country and industry fixed effects as well as other potential drivers. Furthermore, it is specific to intangibles – investment in tangible assets is not positively correlated with industry concentration and controlling for it does not significantly change the findings for intangibles.

Our results are also in line with the idea that intangible assets are particularly valuable to companies which are able to leverage them in large markets. The positive relationship between intangible investment and concentration change is particularly strong in country-industries that are open to international trade and FDI and start off with high initial concentration. Industry digital intensity also strengthens the relationship between intangibles and concentration changes, indicating a complementarity between digitalisation and other intangible investments (Brynjolfsson and Hitt, 2000; Bresnahan et al., 2002; Brynjolfsson et al. 2002).

To better understand the mechanisms behind these findings the paper then moves to business group-level analysis. It finds that industry-level intangibles investment is positively related with market share growth for the (initially) largest firms. Using a business group-level measure of intangibles, it further finds that market-share increases are also positively correlated with increases in business group patent stocks and there is some evidence this is also true for firms with highest productivity. However, we find that the dominant mechanism for intangibles is via size – big business gets bigger.

Overall, the results are in line with the stylised model of superstar firms sketched by Autor et al. (2017), where large and highly productive firms disproportionately benefit from a change in the economic environment. In their paper, the change is due to globalisation or greater competition, but our results suggest that the rising importance of intangible assets can play a similar role. The superstars have the cash needed to invest heavily in intangibles (that can be difficult to finance) and the scale needed to recoup the sunk costs. Intangibles can be leveraged throughout the organisation, allowing lead firms to scale up and serve ever more customers while preserving their existing – already high – level of productivity. In line with this narrative, we find that increasing concentration is associated with increasing markups but falling prices, in particular in countries and industries with strong investment in intangible assets.

A growing literature documents important structural changes in the business sector of OECD economies. In addition to the increasing industry concentration and increasing mark-ups, it highlights declining business dynamism,[6] a growing productivity gap between leaders and laggards,[7] falling investment rates[8] and a decline in the labour share of income.[9] Interestingly, much of the evidence is driven by changes in the composition of the firm population and reallocation across firms rather than within-firm change. For

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

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

[8] 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.

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

example, Autor et al. (2019) find that the drop in aggregate labour share is mainly due to reallocation of sales towards firms which have a relatively low labour share rather than due to labour share falling within firms. Our paper points to an important role of intangible investment in driving or enabling this reallocation. It is in line with the idea that the core activity of many top companies is innovations in products, services and processes that then allows them to scale up and serve a larger number of customers while preserving productivity and quality. This is also in line with Ayyagari et al.'s (2019) findings that star firms in the United States are characterised by higher innovation, sales growth and *levels* of productivity.

To the best of our knowledge, our paper is the first to study intangibles as a driving force for rising industry concentration in a cross-country context, suggesting that the link is not unique to the United States. It further sheds light on how the intangibles-concentration link interacts with other industry characteristics (e.g. openness to trade, digital intensity), hinting at a crucial role of the scalability property of intangible capital. It is most closely related to several studies using US data which also investigate the role of intangibles in driving industry concentration. Crouzet and Eberly (2019) demonstrate for the United States that intangible investment explains a large part of the investment gap suggested by calculations that only take into account tangible investment. They further show that the importance of intangibles relative to tangibles is positively associated with market shares and, depending on the industry, productivity or mark-ups of leading companies. Covarrubias et al. (2019) argue that increases in US industry concentration were related to intangible capital deepening and largely pro-competitive in the 1990s and in industries with low initial concentration, but they became associated with depressed investment, weakened competition and increased barriers to entry after 2000.

The paper also 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. Gutiérrez and Philippon (2018) find an increase in industry concentration in the US but not in Europe, and Valetti et al. (2017) similarly do not find evidence of increasing concentration in Europe, although it is important to note that the latter study only looks at period 2010-2015. 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 14 countries.[10] The present paper builds on the measures in Bajgar et al. (2019) and complements them by calculating concentration based on the largest groups *within* each country-industry and showing that it, too, indicates an upward trend in concentration.

The rest of the paper is structured as follows. Section 2 explains the data and how industry concentration is measured, and Section 3 presents evidence on concentration trends in the nine countries studied. Section 4 introduces the empirical strategy for estimating the relationship between intangibles and industry concentration changes, and Section 5 presents the results. Finally, Section 6 discusses implications of the results for related research and for policy.

[10] 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.

2 Data and measurement

For each country-industry pair, we measure industry concentration as a share of the largest business groups in the sales of each industry in each country. We mainly focus 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

$$CR_{cit}^{8} \equiv \sum_{g=1}^{8} s_{gcit}. \quad [1]$$

s_{gcit} denotes the share of business group g in the sales of industry i in country c, where the group is among 8 business groups with largest sales in year t. The top 8 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: it would be a mistake 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.[11]

We calculate the industry sales shares of each business group as

$$s_{gcit} = \frac{S_{gcit}^{ORBIS}}{S_{cit}^{STAN}}, \quad [2]$$

where S_{gcit}^{ORBIS} marks group sales in country c and industry i and S_{cit}^{STAN} designates the total sales of the industry.

The primary source of firm sales data is Orbis. We complement it with Worldscope to improve coverage among publicly traded firms, particularly in the United States prior to 2006. Aggregating firm sales to the group-level requires correct ownership information. In principle, Orbis reports the global ultimate owner of each firm, but there are many missing observations and missing ownership links. 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 cleaning for the largest firms.[12] We also restrict the sample to countries with a coverage in Orbis that is relatively good and also

[11] 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.

[12] For more information on the data cleaning and concentration measurement using business group data, see Bajgar et al. (2019).

stable between 2002 and 2014.[13] In the cleaned data, on average, a top 8 group in a country and an industry consists of 3 firms in that country and industry.

Using the right denominator is essential for measuring concentration correctly. Orbis offers substantially better coverage for larger firms (Bajgar et al., forthcoming); 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, derived from national accounts.[14,15] In order to maximise country and industry coverage, some NACE Rev. 2 2-digit industries are aggregated together to match the STAN A64 classification.[16]

Industry-level data on intangible and tangible investment comes from the INTAN-Invest database described by Corrado et al. (2012).[17] 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.[18] 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 and tangible investment intensity are constructed by dividing the 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
Computer and Software Investment	14%	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.

[13] 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 group sales into the headquarter industry.

[14] 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 Wholesale and Retail.

[15] Bajgar et al. (2019) report that using a denominator based on Orbis rather than on STAN can lead to very different observed concentration trends.

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

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

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

To test mechanisms beyond industry-level results, it would be useful to obtain a firm-level measure of intangibles, in addition to the industry-level metrics. Unfortunately, Orbis does not have a variable similar to the Selling, General & Administrative Expenses (SG&A) available in Compustat and used to study intangibles in the US (see e.g. Crouzet and Eberly, 2019). It does contain a variable for intangible capital, which is, however, likely to largely reflect goodwill rather than investments in R&D or software (Haskel and Westlake, 2017). Instead, we use two other measures of innovative intangible investment: changes in patent stock and intensity of R&D investment.

We construct the growth of patents (i.e. log changes in patent stock) held by each group using the PATSTAT database, which is matched to firms in Orbis using a name-matching algorithm (Squicciarini and Dernis, 2013). We count patent families and reflect patents that are directly filed in the European Patent Office since 1980.[19] Patent stock is constructed using a 15% depreciation rate from the first application filing year in each family. Consistent with the construction of market share (see equation [2]), we aggregate the patent stock of subsidiaries within the same country-industry, to construct a business-group measure of patent growth.

We calculate group-level R&D intensity using information on R&D investment available in Orbis. As reliable information on R&D is only available in consolidated accounts, we construct this measure based on consolidated accounts, which significantly reduces the sample size. We calculate the R&D intensity by dividing consolidated R&D by consolidated sales,[20] dropping observations with missing R&D.[21]

We complement the data on industry concentration and intangible investment with several other types of information:

- *Tangible investment* is measured as Gross Fixed Capital Formation as a share of industry value added, both taken from OECD STAN.
- *Industry digital intensity* is based on taxonomy developed by Calvino et al. (2018). It 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 classify digital intensive industries as those with the upper half intensity using 2001-03 data, the start of our sample period.
- *Trade openness* is calculated as the sum of industry final goods exports and imports divided by industry value added. All variables come from the OECD Trade in Value Added database.
- *Foreign direct investment (FDI) intensity* is calculated as the sum of industry inward and outward FDI stocks reported in the OECD FDI Statistics divided by industry value added from the OECD STAN.
- *Product market regulations (PMR) index* and *Employment protection legislation (EPL)* index vary by country and over time and come from the OECD. A higher value of each index respectively corresponds to more regulated product markets and stronger employment protection.
- *Real gross output* at the country-industry level from the OECD STAN database and converted to 2005 PPP dollars using exchange rates from the World Bank Development Indicators.
- Further information from various sources is utilised for robustness checks in the Appendix.[22]

[19] Using patents filed in either the European Patent Office or the United States Patent and Trademark Office does not change the results.

[20] Using consolidated value added instead of sales further shrinks the sample size by half but gives very similar results.

[21] The results are robust to assuming R&D to be zero when it is missing.

[22] Employment Protection Legislation is taken from the OECD. Job Churning Rate reflects the sum of job destruction and creation rate and is available for a more limited set of countries and industries, this is taken from OECD Dynemp. Gross Operating Surplus is measured as a share of industry gross output and taken from OECD STAN. Trade

The final sample spans years 2002-2014 and includes 13 countries that have a consistent 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. Summary statistics of key variables are presented in Table 2. In our regression sample, 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 56% of value-added for the mean country-industry and with relatively low levels of Product Market Regulation. 57% of the industries in our data are classified as digital intensive. Over 4 year periods, CR8 concentration increases on average by about 1.6 percentage points, and the mean growth in real gross output is 2.4%, although there is considerable variation around these mean values.

Table 2. Summary Statistics of Industry-Level Variables

	N	mean	s.d.
4 Year Change in CR8	3,717	0.016	0.086
Intangible Investment	3,717	0.146	0.075
Innovative Property Investment	3,717	0.066	0.050
Computer and Software Investment	3,570	0.020	0.017
Economic Competencies Investment	3,717	0.057	0.026
Tangible Investment	3,717	0.219	0.088
Trade Openness	3,703	0.555	0.708
FDI Intensity	2,701	0.976	1.396
Above Median Digital Intensity	3,717	0.571	0.495
Product Market Regulation	3,717	1.555	0.259
4 Year Growth in Real Gross Output	3,717	0.024	0.254

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

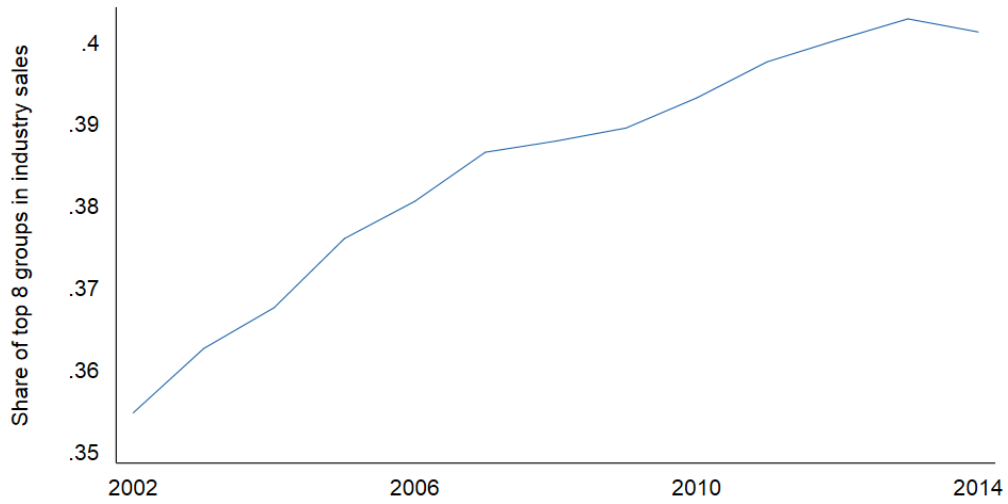
openness (intermediates) reflects total industry imports and exports of intermediate goods and services as a share of value added and is taken from OECD Trade in Value-Added Database. GVC Participation reflects the foreign value added content of exports and is taken from OECD Trade in Value-Added Database. Interest rates reflect government bond rates from the IMF.

3 Trends in Industry Concentration

Between 2002 and 2014, the share of top 8 business groups in the sales of an average country-industry grew by about 5 percentage points, from 35% to 40% (Figure 1). The growth was relatively steady throughout the period, with a slightly faster growth rate prior to 2007. Figure A.1 in the appendix shows that the proportional concentration increase was very similar for the top 4 and top 20 business groups.[23]

Overall, about 67% of country-industry pairs experienced an increase in concentration. All countries except Germany and Spain increased concentration, and so did 31 out of 38 industries.[24] Among broad sectors, the concentration increase was particularly pronounced in "Wholesale & Retail", "ICT", "Transportation and Storage" and "Manufacturing" (Figure 2). On the contrary, concentration slightly decreased in "Real Estate Activities" and especially "Administrative Services".

Figure 1. Top 8 industry concentration

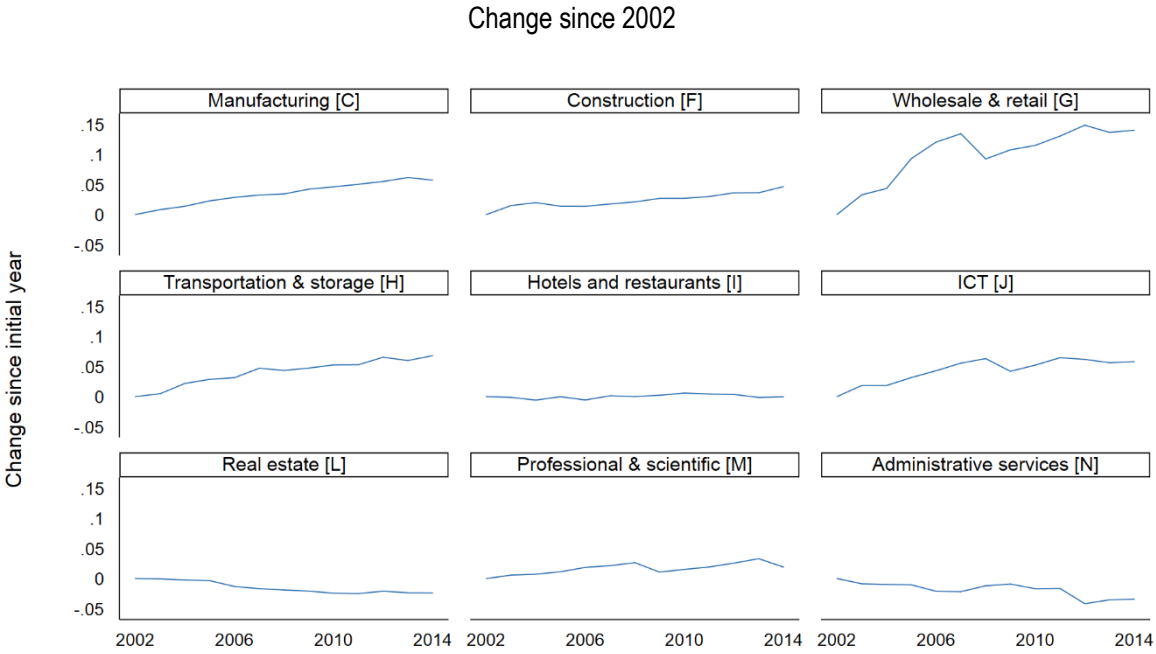


Note: The countries include BEL, DEU, DNK, ESP, FIN, FRA, GBR, GRE, FRA, JPN, PRT, SWE and USA. Included industries cover 2-digit manufacturing and non-financial market services. Concentration is measured by the share of top 8 business groups in the sales of each industry in each country. The figure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

[23] To make the results for top 4, top 8 and top 20 groups comparable, Figure A.1 shows proportional rather than absolute changes in concentration.

[24] Calculated as unweighted mean values.

Figure 2. Top 8 concentration by industry



Note: The countries include BEL, DEU, DNK, ESP, FIN, FRA, GBR, GRE, FRA, JPN, PRT, SWE and USA. Included industries cover 2-digit manufacturing and non-financial market services. Concentration is measured by the share of top 8 business groups in the sales of each industry in each country. For each A21 industry, the figure shows changes in the (unweighted) mean concentration across country-industry pairs compared to the base year 2002.

Next, we turn to the question whether the observed concentration increase was correlated with any suspected concentration drivers.

Intangible investment is an important candidate because most intangible assets (e.g. R&D, proprietary software) are easily scalable: they can be repeatedly applied at a large scale with little marginal costs. This makes them more valuable for large firms, which can also more often afford to invest in them. One could, therefore, expect that in countries and industries with a lot of intangible investment, market shares of large firms will grow relative to those of small firms. Indeed, the increase in concentration has been much stronger in countries and industries with high investment in intangible assets. Panel A of Figure 3 splits country-industry pairs into two groups of the same size by their average intensity of intangible investment over the sample period. For country-industries with above-median intensity of intangible investment, concentration increased about twice as fast as for the below-median country-industries.

The sustained integration of international markets (at least until recently) is another potential explanation for the increasing concentration as observed in our data. It allows the most productive firms to access larger markets, to expand through exports and benefit from a wide range of imported inputs.[25] In line with this explanation, Panel B of Figure 3 shows that the increase in concentration was stronger for country-industries with above-median intensity of international trade.

Digital technologies represent another commonly cited reason behind the increasing concentration (see Bessen, 2017). They can have similar scalability properties as intangible assets, of which software and

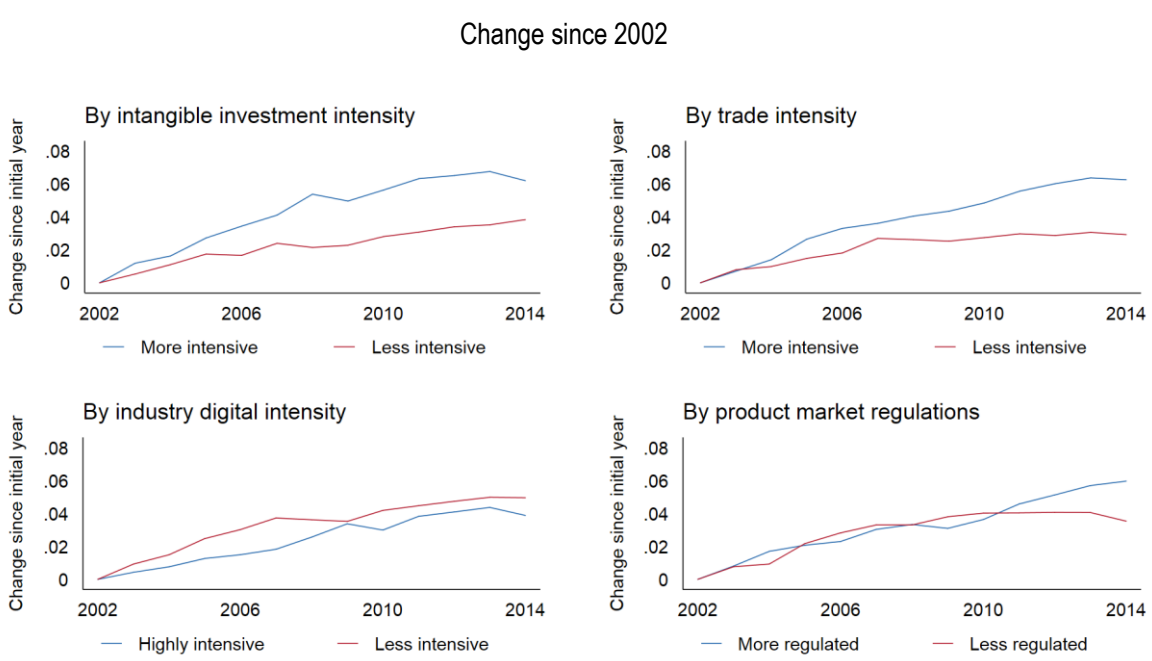
[25] Note that our data does not allow us to separate domestic sales from exports, and it also does not contain any information on firm-specific imports. The observed concentration, thus, reflects a concentration of domestic production rather than of sales in the domestic markets.

databases represent important components. Panel C of Figure 3 compares concentration trends in industries which are characterised by a high or medium-high digital intensity according to an OECD taxonomy (Calvino et al., 2018) with trends in less digital-intensive industries. It shows very similar trends for both groups of country-industries, giving little support to the idea that the increasing concentration is directly linked to digital technologies.

Finally, it has been argued that the observed increase in concentration, especially in the US, could be partly due to regulations, especially those related to firm entry. As a first indication of whether this might be the case, Panel D of Figure 3 compares concentration trends for countries with above- and below-average values of the OECD Product Market Regulations index. It reveals very similar trends for both groups of countries with the exception of the last three years, when concentration increases in the more regulated countries but remains flat in the less regulated ones.[26]

The descriptive evidence in this section suggests that intangible investment, globalisation and digital technologies may be linked to the increasing concentration. The subsequent sections turn to regression analysis to discriminate between these explanations and test them more formally.

Figure 3. Top 8 concentration by potential concentration drivers



Note: The countries include BEL, DEU, DNK, ESP, FIN, FRA, GBR, GRE, FRA, JPN, PRT, SWE and USA. Included industries cover 2-digit manufacturing and non-financial market services. Concentration is measured by the share of top 8 business groups in the sales of each industry in each country. The figure shows changes in the (unweighted) mean concentration across country-industry pairs. Panels A-D show concentration separately for country-industries with above- and below-median intensity of intangible investment (Panel A), country-industries with above- and below-median ratio of exports and imports to value added (Panel B), high-digital intensity industries and less digital industries (Panel C) and countries with above- and below-median values of the product market regulations index (Panel D). The interaction variables are calculated as means over the period 2002-2014 with the exception of digitalisation, which refers to years 2001-2003.

[26] Note that the PMR index does not vary across industries, so it may fail to capture regulations that are relevant in some industries but not in others.

4 Empirical Framework

To test the relationship between intangible investment and industry concentration, we estimate the following equation:

$$\Delta CR^{8}_{ci(t+k,t-1)} = \alpha_1 Intan_{cit} + \alpha_2 \Delta \log S_{ci(t+k,t-1)} + \alpha_3 Tan_{cit} + \alpha_4 Driver_{cit} + \delta_c + \delta_i + \delta_t + \varepsilon_{cit}. \quad [3]$$

$\Delta CR^{8}_{ci(t+k,t-1)}$ designates the change in the top 8 industry concentration in country c and industry i between years t-1 and t+k. We set $k = 3$ by default, so we examine 4 year changes in concentration, but test robustness of results to using shorter and longer concentration changes. $Intan_{cit}$ denotes the intensity of intangible investment between t and t-1. An alternative approach would be to use changes in intangible capital stocks over the 4 year period, however stock data is not available for many countries. The specification controls for output growth in country c and industry i over the same period over which concentration is measured ($\Delta \log S_{ci(t+k,t-1)}$). It further controls for the intensity of tangible investment (Tan_{cit}); this is important given that intangible and tangible investment intensities are strongly positively correlated. Country and industry fixed effects (δ_c, δ_i) ensure that the observed correlations are not driven purely by country-specific trends or general characteristics of particular industries, and the specification also controls for overall year effects (δ_t). Finally, the specification allows including other candidate drivers of concentration ($Driver_{cit}$) such as trade openness and digital intensity.

If intangibles give an inherent advantage to large firms, the advantage can be expected to be greater if large firms have big markets in which to grow, if large firms are larger relative to other firms in their industry, if the firms operate in industries where digitalisation facilitates fast expansion or if regulations shield them from smaller competitors. To examine such complementarities, we interact intangible investment respectively with trade and FDI intensity, with initial concentration, with industry digital intensity and with the PMR index, estimating equation

$$\Delta CR^{8}_{ci(t+k,t-1)} = \alpha_1 Intan_{cit} + \alpha_2 \Delta \log S_{ci(t+k,t-1)} + \alpha_3 Tan_{cit} + \alpha_4 Intan_{cit} * Compl_{ci2002} + \alpha_5 Compl_{ci2002} + \delta_c + \delta_i + \delta_t + \varepsilon_{cit}, \quad [4]$$

where $Compl_{cit-1}$ denotes the factor complementary to intangible investment.

We subsequently investigate mechanisms beneath the level of the industry, by estimating regressions on the underlying business groups. The first estimating equation is closely related to equations [3] and [4], using industry-level intangibles, but instead examines market shares at the business group-level:

$$\Delta s_{gci(t+k,t-1)} = \beta_1 Intan_{cit} + \beta_2 Intan_{cit} * s_{gcit-1} + \beta_3 s_{gcit-1} + \beta_4 \Delta \log S_{ci(t+k,t-1)} + \beta_5 Tan_{cit} + \theta_c + \theta_i + \theta_t + \epsilon_{gcit}, \quad [5]$$

where $\Delta s_{gci(t+k,t-1)}$ denotes the change in the business groups' market share in country c and industry i between years t-1 and t+k. We set $k = 3$ by default and again test robustness of results to using shorter and longer concentration changes. $Intan_{cit}$ reflects industry-level intangible investment between time t and t-1 as above. s_{git-1} reflects the initial size of the business group to allow for differential correlations between larger and smaller firms.

Finally, we examine the role of intangibles at the business-group-level, thus examining the link between changes in market shares on one hand and patent stock growth and R&D investment intensity on the other:

$$\begin{aligned}\Delta s_{gci(t+k,t-1)} = {} & \gamma_1 \Delta ln(Patent)_{gci(t+k,t-1)} + \gamma_2 \Delta ln(Patent)_{gci(t+k,t-1)} * s_{git-1} \\ & + \gamma_3 RD_{gcit} + \gamma_4 RD_{gcit} * s_{gcit-1} + \gamma_5 s_{gcit-1} \\ & + \gamma_6 \Delta Positive\_Patents_{gci(t+k,t-1)} + \gamma_7 \Delta \log S_{ci(t+k,t-1)} + \mu_c + \mu_i \\ & + \mu_t + \omega_{gcit},\end{aligned} \quad [6]$$

$\Delta ln(Patent)_{gcit(t+k,t-1)}$ reflects the growth in business-group level patent stock between t-1 and t+k (patent stock construction is outlined in section 2). We add one to the patent stock to avoid dropping firms with zero patents, and include a dummy variable $\Delta Positive\_Patents_{gci(t+k,t-1)}$ to reflect business-groups that have positive patents at t+k for the first time. Again we interact the patent stock growth with a measure of initial firm size.

Equations [3]-[6] are estimated with linear regressions. Robust standard errors are clustered for each country-A21 industry pair in industry-level intangible regressions ([3] to [5]), reflecting the variation in the intangible measure. For business-group-level patent regressions (equation [6]), clustering is at the group-country-industry-level.

5 Findings

5.1. Intangibles vs. Other Explanations

Intangibles are an increasingly important part of leading firms' business models and for several economies aggregate intangible investment now dwarfs that in tangible assets (see Haskel and Westlake, 2017). Intangibles are scalable – for instance, new innovation, branding or management practices can be leveraged throughout the organisation, meaning intangibles can lead to increasing returns to scale and allow intangible-rich leading firms to scale-up. These returns can be further amplified since intangibles can have synergies between themselves, for instance, between organisational investments and digital technologies (Brynjolfsson and Hitt, 2000; Bresnahan et al., 2002; Brynjolfsson et al., 2002).

Consistent with this narrative, we find intangible investment to be strongly correlated with changes in country-industry concentration (see Table 3). A specification where year fixed effects represent the only control shows a positive and highly statistically significant association between intangible investment intensity and 4-year changes in concentration (column 1). The coefficient on intangibles increases by more than half when we control for country-specific and industry-specific trends (column 2), and controlling for the real growth in industry output has little impact on the result (column 3). 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 4). Thus, in our sample of countries we do not find evidence of a link between increasing concentration and tangible investment – as suggested for the US by Gutiérrez and Philippon (2017).

The association between changes in concentration and intangible intensity is economically meaningful. The specification controlling for country- and industry-specific trends, output growth and tangible investment (column 4) implies that industries with a 10 percentage point higher intangible investment (as a share of value-added) on average have 1.8 percentage point higher increase in industry concentration over the next four years.[27]

Although intangibles are one possible candidate, there are a myriad of potential factors that could explain changes in industry concentration. We examine a primary set of candidates in columns 5-8 of Table 3. We show both results without country and industry fixed effects (columns 5 and 7) and with these effects included (columns 6 and 8). Columns 7 and 8 include an FDI intensity variable, which is available only for a smaller number of observations.[28]

An important alternative explanation of increasing concentration could be that globalisation and increasing openness to trade and FDI flows gives leading firms increased scope to scale-up, with Global Value Chains driven by a minority of leading multinational firms. We find some evidence that trade openness (in final

[27] A 10 percentage point higher intangible investment share is roughly equivalent to moving from the median to the 90th percentile country-industry, or from the 10th percentile to the median.

[28] We include all variables jointly. Including them one by one gives virtually identical results.

goods) is positively related to increases in concentration, but this relationship is not robust to inclusion of country and industry dummies. We find no link of concentration with FDI intensity.

Table 3. Industry Concentration Changes and Intangible Investment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	4 Year Change in CR8 Concentration							
Intangible Investment	0.087***	0.146***	0.138***	0.181***	0.094***	0.188***	0.092**	0.189**
	(0.029)	(0.043)	(0.043)	(0.049)	(0.030)	(0.049)	(0.037)	(0.074)
4 Year Growth in Real Output			-0.069***	-0.069***	-0.061***	-0.069***	-0.054***	-0.057***
			(0.011)	(0.011)	(0.011)	(0.011)	(0.010)	(0.010)
Tangible investment				-0.055	0.014	-0.056	0.008	-0.046
				(0.037)	(0.023)	(0.036)	(0.024)	(0.038)
Trade Openness					0.012***	0.009	0.014***	0.008
					(0.003)	(0.006)	(0.003)	(0.006)
FDI Intensity							-0.003	-0.001
							(0.002)	(0.002)
High Digital Intensity					-0.002		-0.004	
					(0.006)		(0.007)	
4 Year Change in Product Market Regulation					-0.014	-0.047	0.000	-0.011
					(0.017)	(0.037)	(0.020)	(0.027)
Country and Industry FE		Y	Y	Y		Y		Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
N	3703	3703	3703	3703	3703	3703	2693	2693

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 explanatory variables are a share of value added, with the exception of the industry high digital intensity dummy and level of product market regulations, as explained in Section 2.

Digital technologies have been cited as having the potential for "winner takes most" dynamics, which may be amplified by network effects of some types of technologies (Brynjolfsson and McAfee, 2011; Bessen, 2017). To reflect this, we include an indicator of each sector's digital intensity measured in the period 2001-3, constructed by Calvino et al (2018). It does not vary over time or across countries, so its effect can only be estimated when industry fixed effects are not included. We find no evidence that digital-intensive sectors have differential concentration trends.

Finally, increasing concentration trends may reflect weakening competition and increasing barriers to entry (Covarrubias et al., 2019). As a proxy for competition, we include 4-year changes in the OECD's measure of Product Market Regulation. We do not find that industries with differential changes in the degree of regulations have significantly different concentration trends.

In the Appendix Table A.1, we show alternative measures of the candidate concentration drivers and confirm the results shown in Table 3. These include trade openness measured in terms of intermediates, Global Value Chain participation, changes in components of the Product Market Regulation index and employment protection legislation. We find a weak evidence of a link between concentration changes on one hand and GVC participation and employment protection legislation on the other, but these are not robust across different specifications.

Our choice to focus on 4-year changes in CR8 concentration in the baseline specification is driven by the trade-off between explaining in medium-term concentration developments (rather than short-run volatility) and having sufficiently large number of observations for the estimation (firms appearing, disappearing and changing identifiers mean that the number of observations decreases for longer changes). In the Appendix

Table A.2, we repeat our baseline specification for the top 4 and top 20 concentration metrics (CR4 and CR20) and also for 2 and 6 year changes. We consistently find a robust positive correlation between

intangible investment and any of these concentration trends. As expected, the correlations strengthen in longer time windows and are somewhat larger for a larger group of firms, such as the top 20 than the top 4.

In sum, we find a consistently strong correlation between industry intangible investment and concentration growth, which is not apparent for the other candidate drivers included here. However, this does not rule out the possibility of complementarities between intangibles and these other factors, which we examine in the next subsection.

5.2. Complementary Factors

The ability of firms to leverage intangibles to scale up – and therefore impact industry concentration – is likely to depend upon complementary factors. For instance, since intangibles are scalable, access to larger markets abroad may amplify their impact. In addition, the impact of digital technologies on firms has also been found to be stronger for those that make intangible investments in managerial capital, skills and innovative business models (Draca et al., 2009). Finally, intangibles may depend upon the initial share of large firms in an industry – since large firms are likely have a suite of complementary competencies, they are more likely to benefit from intangible investments.

To account for these potential complementarities and differential exposure of industries to intangible investments, we supplement the baseline estimations by interacting intangible investment with an exposure variable. We examine, in turn, trade openness, FDI, sector digital intensity indicator, Product Market Regulations and initial concentration. All exposure variables are demeaned and defined in 2002 (the start of our sample period), with the exception of the digital intensity dummy which uses cross-sectional data from 2001-2003 (see Calvino et al., 2018). The results are presented in Table **4**.

Table **4**. Intangible Investment Complementarities

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	4 Year Change in CR8 Concentration									
Exposure Variable:	Initial Trade Openness		Initial FDI Intensity		Initial High Digital Intensity		Initial Product Market Reg.		Initial Concentration	
Intangible Investment	0.099***	0.184***	0.124***	0.205***	0.034	0.117**	0.099***	0.188***	0.103***	0.203***
	(0.028)	(0.049)	(0.028)	(0.061)	(0.036)	(0.052)	(0.029)	(0.048)	(0.030)	(0.046)
* Exposure Variable	0.108**	0.132***	0.073***	0.060**	0.121**	0.080*	-0.097	-0.149*	0.286	0.204
	(0.044)	(0.035)	(0.026)	(0.025)	(0.048)	(0.047)	(0.092)	(0.077)	(0.173)	(0.158)
Exposure Variable	-0.004	-0.012	-0.013***	-0.010***	-0.020**		0.015		-0.067***	-0.106***
	(0.009)	(0.011)	(0.004)	(0.004)	(0.009)		(0.014)		(0.025)	(0.023)
Cou. and Ind. FE		Y		Y		Y		Y		Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	3717	3717	3429	3429	3717	3717	3717	3717	3717	3717

Note: Regressions are 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.

Intangible investment is more strongly correlated with concentration growth in country-industries that are open to international markets through trade or FDI (columns 1-4). Based on the more restrictive specifications, a 10 percentage point increase in initial trade or FDI openness strengthens the estimated association between intangibles and concentration respectively by 13 percentage points and 6 percentage points. around 5%-10% (columns 1 to 4). For the mean level of trade or FDI openness (reflected in the

non-interacted intangible investment term), the correlation between intangibles and concentration is broadly similar to the baseline.

The relationship between intangibles and concentration changes also seems stronger in digital intensive sectors, although this appears to depend somewhat upon the specification, perhaps reflecting the limited (only sectoral) variation in the digital measure. With only year fixed effects included, the correlation between intangibles and concentration appears to be driven entirely by digital intensive sectors (column 5). However, with country and industry fixed effects included, there is some evidence of a role for intangibles in less-digital sectors, and some evidence this is stronger in digital sectors (column 6).

In contrast, the relationship appears to be, if anything, *weaker* in industries with more restrictive product-market regulations (columns 7 and 8), but this result is only statistically significant at the 10% level and only with country and industry fixed effects included. Finally, there is no statistically significant relationship between the effect of intangibles and initial concentration of an industry (columns 9 and 10), although this may be because the relationship with initial concentration is rather noisily estimated.

5.3. Which Intangibles?

Intangibles encompass a broad range of investments that may have differing impacts and policy implications. The previous sections have used total intangible investment, here we decompose into three subcategories as defined in section 2: innovative property (R&D, design…); computer and software and economic competencies (advertising, marketing, training...). Table 5 repeats the baseline estimation for these three components individually.

The results for total intangible investment appear to be mostly driven by investments in innovative property. They turn out as statistically significant with and without country and industry fixed effects, and both when they are included alone (columns 1 and 2) or together with the other types of intangible investment (columns 7 and 8). Based on the more restrictive specification, 10 percentage point higher innovative property investment is correlated with a 3 percentage point higher concentration growth.

There is also some evidence of computerised information being positively associated with concentration changes, but the coefficient is only statistically significant when it is included alone in the less restrictive specification. We find little evidence of investment in economic competencies being associated with the concentration changes, possibly because such competencies (e.g. training) may be less scalable than other intangibles (e.g. innovations, software).

Table 5. Decomposing Total Intangible Investment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	4 Year Change in CR8 Concentration							
Innovative Property Investment	0.133***	0.308***					0.117**	0.303***
	(0.048)	(0.073)					(0.054)	(0.076)
Computer and Software Investment			0.231**	0.306			0.072	0.209
			(0.106)	(0.226)			(0.112)	(0.242)
Economic Competencies Investment					0.140	-0.037	0.053	-0.088
					(0.088)	(0.132)	(0.087)	(0.119)
Country and Industry FE		Y		Y		Y		Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
N	3570	3570	3570	3570	3570	3570	3570	3570

Note: Regressions are 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.

Until now, the regressions have examined concentration at the country-industry level. Next we examine market share of the underlying largest business groups. Specifically, we examine whether the changes in the market shares of the largest business groups is linked to innovative property investment at the industry-level – this specification was given by equation [5] earlier. Our sample reflects the 100 largest groups in each country-industry (since Orbis has poorer coverage of smaller firms), and we examine differentially the correlations for the (initial) top 20, top 8 and top 4 firms. The results are presented in Table 6.

Industries with higher investment in innovative property intangibles show faster market share growth of the top firms. Overall, a 10 percentage point higher innovative property investment (as a share of value added) is correlated with 0.04 percentage point increase in market share over the next four years for an average top 100 group (see columns 1 and 2). As we are considering business groups and within-group changes, the coefficients are obviously much smaller than the earlier industry level analysis that are both more aggregate and also encompass churning of the largest groups. Importantly, these coefficients strengthen with size. A 10 percentage point increase in innovative property investment corresponds to a roughly 0.1 percentage point market share increase for (initial) top 20 groups, 0.3 percentage point increase for the top 8 and 0.5 percentage point increase for the top 4 groups (compared to the rest of the top 100). Note that in the Appendix

Table A.3 we document similar results for total intangible investment.

Table 6. Innovation Intangibles & Top Business Group Market Share

	(1)	(2)	(3)	(4)	(5)	(6)
	4 Year Change in Group Market Share					
Innovative Property Investment	0.004**	0.005***	0.001	0.001	0.002	0.001
	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
* Group Market Share		0.690***				
		(0.228)				
* Top 20 Group			0.012***			0.001
			(0.004)			(0.001)
* Top 8 Group				0.027***		0.006
				(0.009)		(0.006)
* Top 4 Group					0.046***	0.039***
					(0.015)	(0.014)
Country and Industry FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
N	294327	294327	294327	294327	294327	294327

Note: Regressions are at the business group–year level and reflect 100 largest business groups in each country-A64 industry-year. All regressions include (4 year) growth in industry sales and tangible investment intensity as control variables, which are omitted for parsimony. Non-interacted top business group dummies or group market share are also included but not reported. Robust standard errors clustered at the country–A21 industry level in parentheses. ***, **, * represent significance at the 1%, 5% and 10% level respectively.

Since large groups are themselves likely to account for a larger share of industry intangible investment, the link between industry intangible investment and the market share of large groups is perhaps unsurprising. Using group-level measures of patents allows us to distinguish whether the impact of intangible investment is larger for larger groups, or larger groups simply account for a larger share of intangible investment with the impact being similar across groups of all sizes. As noted in the empirical framework, to be consistent with the market share measure, we collapse subsidiaries of the same business group in the same country-industry, summing the subsidiaries' patent stocks. We examine the correlation with changes in group market share and (4-year) growth in these group patent stocks, within a country-industry – given by equation [6] earlier.

Group patents show broadly similar results to industry-level investments in innovation intangibles. Changes in market share of the top 100 groups are significantly related to growth in the number of patents over the same 4 year period (see Table 7). The estimated coefficients are again quite small, and suggest a 10% growth in the group patent stock is associated with a 0.03 percentage point increase in firm market share (of an average top 100 firm). Importantly, the coefficients still strengthen with initial size, with the estimated coefficient approximately 3 fold, 5 fold and 6 fold stronger for the (initial) top 20, top 8 and top 4 largest groups compared to the rest of the top 100. Thus, changes in patent stock are more strongly correlated with market share growth for initially larger groups. Similar results are obtained using citation-weighted patents in Appendix Table A.5. Big firms seem to be able to better leverage innovation intangibles to further scale up.

Our baseline estimates consider 4 year changes group market share, mirroring the earlier industry-level concentration metrics. In the Appendix Table A.4 we consider 2 or 6 year changes in market share. We find very similar results to the baseline, that is, the correlation between group patents and market share

strengthens with initial size. The correlations are somewhat larger for 6 year differences than 2 year differences, which likely reflects an adjustment period for realising the scale effects of intangibles.[29]

Table 7. Business Group Patents & Top Business Group Market Share

	(1)	(2)	(3)	(4)	(5)	(6)
	4 Year Change in Group Market Share					
Group Patent Growth	0.002***	0.001***	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
* Group Market Share		0.037***				
		(0.007)				
* Top 20 Group			0.003***			0.001*
			(0.001)			(0.000)
* Top 8 Group				0.005***		0.002***
				(0.001)		(0.001)
* Top 4 Group					0.006***	0.004**
					(0.002)	(0.002)
Country and Industry FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
N	294327	294327	294327	294327	294327	294327

Note: Regressions are at the business group–year level and reflect 100 largest business groups in each country-A64 industry-year. All regressions include growth in industry sales as a control variable, which is omitted for parsimony. Non-interacted top business group dummies or group market share are also included but not reported. Robust standard errors clustered at the firm-level in parentheses. ***, **, * represent significance at the 1%, 5% and 10% level respectively. Group patent growth reflects 4 year changes in log (1 + patent stock), adding one to avoid dropping zeros. A (4-year change) positive group patent dummy is added to reflect changes from zero to non-zero patent stock.

Patent stock as a measure of innovation suffers from well-known limitations. It is more relevant in manufacturing than in services, and a large part of innovation activity is not patentable. Furthermore, in the context of the present analysis, it is not clear if patenting captures actual innovative activity or rather an effort by large firms to exclude their competitors from the market. To shed some light on this question, we re-run the estimation using R&D investment intensity rather than growth of patent stock.

The results are broadly similar to those for patents (see Table 8). While we do not observe any correlation between R&D and changes in market share for an average top 100 group (column 1), there is a significant positive correlation for top 20, top 8 and, in particular, top 4 groups (columns 3 to 6). Importantly, we show in Appendix Table A.6 that the patent growth and R&D intensity do not simply capture the same variation. When they are included at the same regression, both innovation measures remain significantly correlated with changes in market shares. This could be seen as indicating that large business groups further increase their market shares partly through productive innovative investment and partly through strategic use of patents.

Table 8. Business Group R&D Investment Intensity & Top Business Group Market Share

	(1)	(2)	(3)	(4)	(5)	(6)
	4 Year Change in Group Market Share					
Group R&D Intensity	0.001	0.004***	-0.001	-0.001	-0.000	-0.001
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)

[29] There may also be changes in the composition of firms by using 2 or 6 year changes. Examining 6 year changes in market share implicitly conditions on groups that survive for the subsequent 6 years, which are likely to be larger and more productive.

* Group Market Share		0.972***				
		(0.267)				
* Top 20 Group			0.011**			0.002
			(0.005)			(0.002)
* Top 8 Group				0.026**		0.002
				(0.013)		(0.006)
* Top 4 Group					0.044*	0.040*
					(0.023)	(0.024)
Country and Industry FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
N	70551	70551	70551	70551	70551	70551

Note: Regressions are at the business group–year level and reflect 100 largest business groups in each country-A64 industry-year. All regressions include growth in industry sales as a control variable, which is omitted for parsimony. Non-interacted top business group dummies or group market share are also included but not reported. Robust standard errors clustered at the firm-level in parentheses. ***, **, * represent significance at the 1%, 5% and 10% level respectively. R&D intensity is defined at a group consolidated-level and as a share of consolidated GO, dropping observations with missing R&D.

5.4. Supersize, Superstars or Superpowers?

The transition to an intangible economy appears to have gone hand-in-hand with big firms getting bigger. Earlier results showed this holds at the industry-level, with larger increases in industry concentration (due to intangibles) for initially concentrated sectors, and at the business group-level, with larger increases in market share for initially large groups. Of course, this does not necessarily mean size is the relevant dimension. Autor et al. (2019) and Ayyagari et al. (2019) have argued that we are in a world of superstars, i.e. firms with high productivity or profits, and intangibles may allow these frontier firms to expand further. Others have demonstrated that mark-ups have been rising over recent decades, particularly for firms with the highest mark-ups (Calligaris et al., 2018; De Loecker and Eckhout, 2018). Since productivity and often mark-ups tend to be correlated with size, we may be conflating size with these other factors.

To contrast these three explanations is not straightforward because they are interrelated. To get a sense of which story is likely to dominate, we examine whether the link between group market share and patents is stronger for those groups that are initially large, initially productive or have initially high mark-ups. To obtain a consistent sample of countries, we drop the US and Japan for this part of the analysis due to more limited data availability for multi-factor productivity (MFP) and mark-ups. Again, we conduct business-group level analysis, consistent with the measure of market shares in earlier sections, and so collapse multiple subsidiaries in the same country-industry to a single observation. For MFP and mark-ups, we calculate the group-level measure as a weighted average of the underlying subsidiaries' MFP or mark-ups using initial sales as weights. We use either the initial level of these variables, or a dummy reflecting the group is initially in the top 8 for market share, MFP or mark-ups in that country-industry. We report the results using top 8 dummies in Table 9 and the continuous levels in the Appendix Table A.4.

The results indicate that initial size matters most. After excluding Japan and the US due to limited firm productivity data, we confirm firm patent growth remains positively correlated with changes in group market shares as in the previous section (see column 1 of Table 9). The initially 8 largest groups have significantly stronger correlations between patent growth and market share changes – with a roughly 7 fold higher coefficient than the rest of the top 100 (column 2). Similarly, the initially 8 most productive groups have significantly stronger correlations between patent and market share growth – an approximately 2 fold higher coefficient than the rest of the top 100 (column 3), while the estimate on the interaction with an indicator for the 8 groups with the highest initial mark-ups goes in a similar direction but is not statistically significant. A horse race amongst these competing explanations strongly suggests that size dominates – MFP and mark-ups appear to be precisely estimated but not statistically different from zero (see 9 and 10). In the Appendix Table A.4 we find similar results using continuous measures of initial size, productivity or

mark-ups, rather than top 8 dummies. Patent growth strongly predicts market share growth of initially large groups rather than those initially productive or with higher mark-ups.

Table 9. Group Patents & Group Market Share –Size, Productivity or Mark-ups

	(1)	(2)	(3)	(4)	(5)
Group Patent Growth	0.003***	0.001**	0.002***	0.002***	0.001**
	(0.001)	(0.000)	(0.000)	(0.001)	(0.000)
* Top 8 Group Market Share		0.007***			0.006***
		(0.002)			(0.002)
* Top 8 Group MFP			0.004**		0.001
			(0.002)		(0.001)
* Top 8 Group Mark-ups				0.003	0.001
				(0.002)	(0.002)
Positive Group Patent Dummy	-0.001	-0.000	-0.001	-0.001	-0.000
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Country and Industry FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
N	138135	138135	138135	138135	138135

Note: Regressions are estimated at the business group–year level and reflect 100 largest business group in each country-A64 industry-year, requiring that at least 20 business group within each country-A64 industry-year have market share, MFP or mark-up data. The regressions exclude Japan and the US due to limited firm productivity data. All regressions include growth in industry sales as a control variable, which is omitted for parsimony. Non-interacted top 8 business group market share, MFP, or mark-up dummy variables are also not reported. Robust standard errors clustered at the group-level in parentheses. ***, **, * represent significance at the 1%, 5% and 10% level respectively. Group patent growth reflects 4 year changes in log (1 + patent stock), adding one to avoid dropping zeros. A (4-year change) positive group patent dummy is added to reflect changes from zero to non-zero patent stock.

5.5. “Good” or “Bad” Concentration?

The analysis so far indicates that the observed increases in industry concentration are related to investment in innovative intangible assets, which helps large business groups further scale up and capture ever increasing market shares. An important open question is whether the correlation between innovative intangibles and large firm market shares is driven by productive innovation (that can benefit the economy) or rather by anti-competitive efforts using patents and other intangibles (e.g. trademarks) to preclude competition. Whilst this is not straightforward to discern, the result above showing a positive association between R&D investment and market share of large groups suggests that anti-competitive patenting is not the entire story, but it by no means closes the question. This subsection offers additional evidence by relating changes in concentration to changes in additional proxy measures of competitive environment: prices, mark-ups, churning on the top and entry rates.

If increasing concentration is a symptom of weak competition, one would expect it to be positively correlated with prices. To see if this the case, we regress 4-year growth in industry price indices to 4-year changes in top 8 industry concentration. We find a strong negative correlation, implying that a 10 percentage point increase in concentration corresponds to a 1.5% reduction in industry prices (see column 1 of

Table 10). In line with a central role of intangible investment, the negative association between concentration changes and price changes is about twice as large in country-industries with above-median intensity of intangible investment compared to those below-median (columns 2 and 3). At the same time, changes in industry concentration are strongly *positively* associated with changes in average markups of the 8 largest groups in each country-industry, and this relationship seems almost entirely driven by country-industries with above-median intensity of intangible investment. Taken together, the results for prices and top firm mark-ups are consistent with a story where large business groups incur the fixed costs of investing in intangible assets and are rewarded by reduced marginal costs. Prices decline but marginal costs decline even more, leading to an increase in markups.[30]

Reduced prices, taken at face value, represent good news. However, even if intangible investment is associated with static gains for consumers, it might have dynamic anti-competitive effects if the largest firms manage to preclude competition and become increasingly entrenched at the top. We find evidence that increases in concentration are correlated with lower churning of top 8 firms (see columns 7 to 9). The increasing persistence of the same top firms is only evident in industries with above median intangible intensity. In contrast we see no evidence of increasing concentration linked to a more general decline in business entry rates across country industries, admittedly with a lower sample size due to the A38 industry level of aggregation and the availability of the OECD Dynemp data (see columns 10 to 12).

[30] See De Ridder (2019) for a theoretical model consistent with these findings.

Table 10.Industry Concentration and Other Measures of Competitive Environment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	4 Year Change in Industry Price Index			4-year Growth in Markups of Top 8 Firms			4-year Change in Share of New Top 8 Firms			4-year Change in Entry Rate		
	All	High Intan.	Low Intan.	All	High Intan.	Low Intan.	All	High Intan.	Low Intan.	All	High Intan.	Low Intan.
4 Year Change in CR8 Concentration	-0.149***	-0.179***	-0.083*	0.168***	0.256***	0.105	-0.090*	-0.135**	-0.028	0.002	0.000	0.001
	(0.040)	(0.063)	(0.047)	(0.059)	(0.077)	(0.087)	(0.048)	(0.058)	(0.077)	(0.005)	(0.005)	(0.009)
4-year Growth in Output	-0.258***	-0.285***	-0.248***	0.034	0.035	0.051	-0.011	-0.005	-0.017	-0.002	-0.002	-0.002
	(0.029)	(0.037)	(0.038)	(0.030)	(0.038)	(0.048)	(0.019)	(0.031)	(0.022)	(0.003)	(0.003)	(0.006)
Tangible Investment	0.016	-0.197	0.089*	-0.139	-0.240	-0.135	0.075	-0.166	0.127	-0.027*	0.016	-0.045**
	(0.044)	(0.147)	(0.049)	(0.096)	(0.204)	(0.110)	(0.066)	(0.131)	(0.105)	(0.016)	(0.026)	(0.017)
Country and Ind. FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	3642	1818	1824	2953	1458	1494	2891	1462	1428	1091	548	542

Note: Regressions in columns 1-9 are are at the country–A64 industry–year level, and regressions in columns 10-12 are at the country-A38 industry-year level. Robust standard errors are clustered at the country–A64 industry level (country-A38 industry in columns 10-12) in parentheses. ***, **, * represent significance at the 1%, 5% and 10% level respectively. High and low intangible investment observations are respectively defined as those with above and below median intangible investment intensity. Industry price index is defined at the country-A64 industry level and comes from OECD STAN. The share of new top 8 firms is given by the share of top 8 firms which were not in the top 8 in the previous year. Entry rates are taken from OECD Dynemp for each country-A38 industry and year.

6 Discussion

Since the early 2000s, industry concentration has increased in a number of OECD economies and in many, but not all, industries. The analysis above indicates that intangible investment has played a significant role in this increase. Intangibles disproportionately benefit large firms, which are able to leverage them in greater sales and are also better placed to invest in them. It appears that intangibles, and in particular innovative assets such as patents, have allowed large firms to further increase their market shares. This effect is especially pronounced in globalised, concentrated and highly digital-intensive industries and countries.

These results are still preliminary and may change with additional cleaning, methodological improvements or inclusion of additional countries and industries in the sample.

The findings shed new light on the debate about "good vs. bad" concentration increase in the United States (Covarrubias et al., 2019). To begin with, they show that the recent increase in concentration is not unique to the United States and has taken place also in other OECD economies. Taken at face value, they further suggest that this increase may be mostly of the "good" variety in the sense that it was associated with investment in innovative assets and new intangible business models rather than anti-competitive forces. Whilst further research is needed, evidence that both innovation expenditure via R&D, as well as patents, predict increases in scale is consistent with this narrative. Furthermore, whilst markups appear to have risen for the largest firms, costs appear to have fallen more, reflected in lower consumer prices.

However, three qualifications are in place. Firstly, country-level Product Market Regulation indices are an admittedly coarse proxy for anti-competitive regulations and barriers to entry. More indicators and analysis would be needed to tell if market power contributed to the concentration increase. Secondly, while many intangibles create economic value, some may have as their sole or primary purpose to shield their owners from competition (e.g. patent thickets).[31] Thirdly, even if the top firms grew their market shares thanks to productive innovative efforts, they may try to entrench their enhanced position by raising barriers to entry, for example through lobbying for regulations that disproportionately hit young and small firms.[32] That we see declining churning of the top firms in each industry raises similar dynamic competition considerations. Finally, the rise in concentration need not have the same roots in all countries. For example, the difference between results on the role of regulations found in this paper and those found, for example, by Covarrubias et al. (2019) and Gutiérrez and Philippon (2019), may be due to data and measurement but also due to genuine differences between concentration drivers in the United States and in Europe or Japan.

For policy makers, the findings highlight the growing importance of intangible assets in shaping business dynamics. They may amplify existing differences in market conditions facing different firms, for example in terms of access to finance or skills. Recent research points to a break down in knowledge diffusion from frontier firms to the rest of the economy as a source of the slow-down in aggregate productivity observed in many countries (Andrews et al., 2016; Akcigit and Ates, 2019a,b; Berlingieri et al., forthcoming). In this context, it will be important for policies to ensure that a broader set of firms are able to invest in intangible

[31] Crouzet and Eberly's (2019) results for the United States suggest that intangible investments are associated with increasing market power of the leaders in some industries but not in others.

[32] Van Reenen (2018) and Ayyagari et al. (2019), among others, make a similar point.

assets and find the right balance between protecting intellectual property and allowing knowledge to flow between firms.

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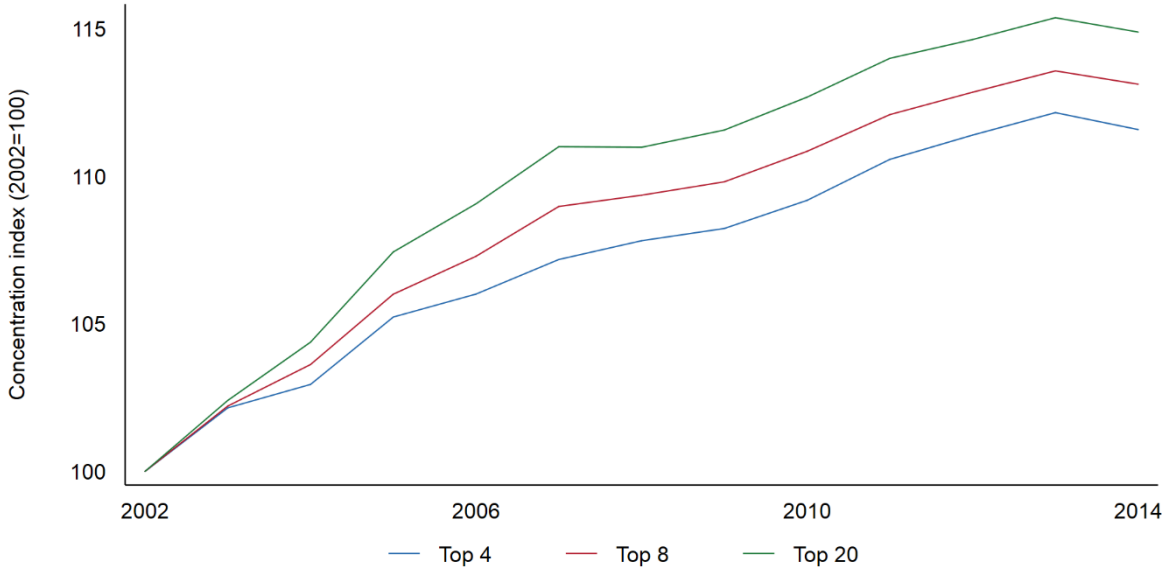
Annex A. Additional results

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

Normalised to 2002



Note: The countries include BEL, DEU, DNK, ESP, FIN, FRA, GBR, GRE, FRA, JPN, PRT, SWE and USA. Included industries cover 2-digit manufacturing 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.1. Correlation Industry Concentration Changes and Intangible Investment – Alternative Explanations

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	4 Year Change in CR8 Concentration											
Intangible Investment	0.095***	0.192***	0.095***	0.185***	0.099***	0.175***	0.099***	0.176***	0.100***	0.180***	0.092***	0.173***
	(0.029)	(0.050)	(0.029)	(0.050)	(0.029)	(0.049)	(0.029)	(0.049)	(0.029)	(0.050)	(0.029)	(0.048)
Trade Openness (Intermediates)	0.004	0.007										
	(0.004)	(0.007)										
GVC Participation			0.018	0.083*								
			(0.026)	(0.046)								
PMR Barriers to Investment					-0.027	-0.020						
					(0.020)	(0.025)						
PMR Barriers to Entrepreneurship							-0.018	-0.010				
							(0.016)	(0.027)				
PMR State Control									-0.003	-0.013		
									(0.009)	(0.017)		
Emp. Protection Legislation											0.010	0.024*
											(0.009)	(0.014)
Cou. and Ind. FE		Y		Y		Y		Y		Y		Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	3701	3701	3717	3717	3717	3717	3717	3717	3717	3717	3717	3717

Note: Regressions are at the country–A64 industry–year level. All regressions include growth in industry sales as a control variable, which is omitted for parsimony. Robust standard errors clustered at the country–A21 industry level in parentheses - all explanatory variables are at least at this level of disaggregation. ***, **, * represent significance at the 1%, 5% and 10% level respectively.

Table A.2. Robustness – Intangibles and Concentration for Different Concentration Measures and Difference Lengths

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	CR4 Concentration			CR8 Concentration			CR20 Concentration		
Concentr. change over	*2 Years*	*4 Years*	*6 Years*	*2 Years*	*4 Years*	*6 Years*	*2 Years*	*4 Years*	*6 Years*
Intangible Investment	0.084***	0.172***	0.212***	0.086***	0.176***	0.217***	0.102***	0.215***	0.263***
	(0.021)	(0.047)	(0.074)	(0.022)	(0.049)	(0.076)	(0.024)	(0.052)	(0.082)
Country and Industry FE		Y		Y		Y		Y	
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	4512	3717	2891	4512	3717	2891	4512	3717	2891

Note: Regressions are at the country–A64 industry–year level. All regressions include growth in industry sales as a control variable (defined in 2, 4 or 6 year changes), which is omitted for parsimony. Robust standard errors clustered at the country–A21 industry level in parentheses - all explanatory variables are at least at this level of disaggregation. ***, **, * represent significance at the 1%, 5% and 10% level respectively.

Table A.3. Total Intangible Investment & Top Firm Market Share

	(1)	(2)	(3)	(4)	(5)	(6)
	4 Year Change in Group Market Share					
Intangible Investment	0.004***	0.005***	0.002*	0.002**	0.003**	0.002*
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
* Group Market Share		0.521***				
		(0.157)				
* Top 20 Group			0.009***			0.002**
			(0.002)			(0.001)
* Top 8 Group				0.019***		0.003
				(0.005)		(0.004)
* Top 4 Group					0.032***	0.028***
					(0.008)	(0.008)
Country and Industry FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
N	294326	294326	294326	294326	294326	294326

Note: Regressions are at the business group–year level and reflect 100 largest business groups in each country-A64 industry-year. All regressions include (4 year) growth in industry sales and tangible investment intensity as control variables, which are omitted for parsimony. Non-interacted top business group dummies or group market share are also included but not reported. Robust standard errors clustered at the country–A21 industry level in parentheses. ***, **, * represent significance at the 1%, 5% and 10% level respectively.

Table A.4. Robustness – Business Group Patents & Top Business Group Market Share – Alternative Difference Lengths

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	2 Year Change in Group Market Share					6 Year Change in Group Market Share				
Group Patent Growth	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***	0.001***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
* Group Market Share	0.013					0.052***				
	(0.009)					(0.010)				
* Top 20 Group		0.002***			0.001***		0.004***			0.001
		(0.001)			(0.000)		(0.001)			(0.001)
* Top 8 Group			0.003**		0.001			0.006***		0.002**
			(0.001)		(0.001)			(0.002)		(0.001)
* Top 4 Group				0.003**	0.002				0.007***	0.004*
				(0.002)	(0.002)				(0.002)	(0.002)
Country and Industry FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	292778	292778	292778	292778	292778	199832	199832	199832	199832	199832

Note: Regressions are at the business group–year level and reflect 100 largest business groups in each country-A64 industry-year. All regressions include (2 or 6 year) growth in industry sales and tangible investment intensity as control variables, which are omitted for parsimony. Non-interacted top business group dummies or group market share are also included but not reported. Robust standard errors clustered at the firm-level in parentheses. ***, **, * represent significance at the 1%, 5% and 10% level respectively. Group patent growth reflects 4 year changes in log (1 + patent stock), adding one to avoid dropping zeros. A (4 year change) positive firm patent dummy is added to reflect changes from zero to non-zero patent stock.

Table A.5. Business Group Patents (Citation-Weighted) & Top Business Group Market Share

	(1)	(2)	(3)	(4)	(5)	(6)
	4 Year Change in Group Market Share					
Group Patent Growth (Citation Weighted)	0.004***	0.003***	0.001	0.001**	0.002***	0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
* Group Market Share		0.054***				
		(0.011)				
* Top 20 Group			0.006***			0.002*
			(0.001)			(0.001)
* Top 8 Group				0.008***		0.004**
				(0.002)		(0.002)
* Top 4 Group					0.009***	0.005
					(0.003)	(0.003)
Country and Industry FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
N	294327	294327	294327	294327	294327	294327

Note: Regressions are at the business group–year level and reflect 100 largest business groups in each country-A64 industry-year. All regressions include growth in industry sales as a control variable, which is omitted for parsimony. Non-interacted top business group dummies or group market share are also included but not reported. Robust standard errors clustered at the firm-level in parentheses. ***, **, * represent significance at the 1%, 5% and 10% level respectively. Group patent growth reflects 4 year changes in log (1 + patent stock), adding one to avoid dropping zeros. A (4-year change) positive group patent dummy is added to reflect changes from zero to non-zero patent stock.

Table A.6. Business Group Patents and R&D and Top Business Group Market Share

	(1)	(2)	(3)	(4)	(5)	(6)
	4 Year Change in Group Market Share					
Group Patent Growth	0.003***	0.002***	0.001***	0.001***	0.001***	0.001***
	(0.001)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
* Group Market Share		0.023***				
		(0.008)				
* Top 20 Group			0.003***			0.001
			(0.001)			(0.001)
* Top 8 Group				0.005***		0.002**
				(0.002)		(0.001)
* Top 4 Group					0.005**	0.003
					(0.002)	(0.002)
Group R&D Intensity	0.001	0.003**	-0.001	-0.001	-0.001	-0.001
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)
* Group Market Share		0.879***				
		(0.264)				
* Top 20 Group			0.011**			0.002
			(0.005)			(0.002)
* Top 8 Group				0.027**		0.003
				(0.013)		(0.006)
* Top 4 Group					0.043*	0.039
					(0.023)	(0.024)
Country and Industry FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
N	70551	70551	70551	70551	70551	70551

Note: Regressions are at the business group–year level and reflect 100 largest business groups in each country-A64 industry-year. All regressions include growth in industry sales as a control variable, which is omitted for parsimony. Non-interacted top business group dummies or group market share are also included but not reported. Robust standard errors clustered at the firm-level in parentheses. ***, **, * represent significance at the 1%, 5% and 10% level respectively. Group patent growth reflects 4 year changes in log (1 + patent stock), adding one to avoid dropping zeros. A (4-year change) positive group patent dummy is added to reflect changes from zero to non-zero patent stock. R&D intensity is defined at a group consolidated-level and as a share of consolidated GO, dropping observations with missing R&D.

Table A.7. Group Patents & Group Market Share –Size, Productivity or Mark-ups (Continuous Measures)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	4 Year Change in Group Market Share									
Group Patent Growth	0.004***	0.004***	0.001**	0.001**	0.002***	0.002***	0.003***	0.003***	0.001*	0.001*
	(0.001)	(0.001)	(0.000)	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.000)
* Group Market Share			0.080***	0.080***					0.080***	0.080***
			(0.010)	(0.010)					(0.015)	(0.015)
* Group MFP					0.004*	0.004*			-0.000	-0.000
					(0.002)	(0.002)			(0.001)	(0.001)
* Group Mark-ups							0.001	0.001	-0.002	-0.002
							(0.001)	(0.001)	(0.001)	(0.001)
Positive Group Patent Dummy	-0.001	-0.001	0.001	0.001	-0.000	-0.000	-0.000	-0.000	-0.001	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
Country and Industry FE		Y		Y		Y		Y		Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
N	116962	116962	116962	116962	116962	116962	107018	107018	107018	107018

Note: Regressions are at the business group–year level and reflect 100 largest business group in each country-A64 industry-year, where we require at least 20 business groups within each country-A64 industry-year to have market share, MFP or mark-up data. Regressions exclude the US and Japan due to limited firm productivity data. All regressions include growth in industry sales as a control variable, which is omitted for parsimony. Non-interacted group market share, MFP, or mark-up variables are not reported for parsimony. Robust standard errors clustered at the firm-level in parentheses. ***, **, * represent significance at the 1%, 5% and 10% level respectively. Group patent growth reflects 4 year changes in log (1 + patent stock), adding one to avoid dropping zeros. A (4 year change) positive firm patent dummy is added to reflect changes from zero to non-zero patent stock.