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*Intangible Capital, Markups and Profits*

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# *Intangible Capital, Markups and Profits*

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# Intangible Capital, Markups and Profits\*

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## Abstract

Can an increasing importance of intangible capital explain increases in markups and profits? I use a heterogeneous firm model to show how intangible capital, characterized by fixed costs and uncertainty, is related to markups and profits at the industry level. The scalability and uncertainty properties of intangible capital imply that firms which succeed in their intangible capital investment can charge high markups relative to other firms whereas firms that fail will exit. However, these high markups do not imply any economic profits in the industry if they only serve to cover the total fixed costs of intangible capital. To empirically examine the relationship between intangible capital, markups and profits, I study average markups and profit shares in a panel of Swedish industries. There is evidence of a positive relationship between intangible capital and average industry markups. However, the evidence of the relationship between intangible capital and profits is less conclusive.

**Keywords:** Intangible capital, Markups, Profits, Labor share, Market Power.

**JEL:** E2, D2, L1, L2

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# 1 Introduction

This paper addresses the possible relationship between three documented macroeconomic trends; rising intangible capital, increasing markups and increasing economic profits. Can an increasing importance of intangible capital explain increases in markups and profits?

Regarding markups, De Loecker et al. (2020) find a substantial increase in firm markups over marginal costs in the US economy between the 1980s and the present day. De Loecker and Eeckhout, 2018 also find similar increases in other countries. At the same time, there is evidence that the labor share of income is declining (Karabarbounis and Neiman, 2013) and that a growing share of US income cannot be attributed to any production factor using standard methods (Karabarbounis and Neiman, 2018). Barkai (2016) interprets this income as economic profit. Taken at face value, these findings point to a rise in firm market power and to consumers being worse off. In parallel, there is evidence of an increasing importance of intangible capital in the economy. According to official statistics, investments in intangible capital in the form of R&D, software, and artistic originals amount to about one-third of business investments in the US and Sweden. Including a broader set of intangibles, Corrado et al. (2009) estimate this investment share to be as high as 50 percent.

This paper proposes that the scalability and uncertainty features associated with intangible capital can lead to higher markups but not necessarily higher economic profits.<sup>1</sup> First, since intangible capital does not take a physical form, it can be used in many locations simultaneously. For example, a pharmaceutical firm can use the same patent as a basis for production in several plants. This means that intangible capital is scalable and has the properties of fixed costs. Second, an investment in intangible capital is likely to be uncertain since it typically involves some element of innovation. For example, the outcome of a research and development project is hard to know beforehand. Third, an investment in intangible capital is more likely to be a sunk cost as compared to an investment in physical capital since it tends to be more firm-specific. For example, investments in marketing and advertising may not have any value to other firms whereas machines and buildings can yield a substantial value on the secondary market. An implication of uncertainty and scalability is that production based on a successful investment in intangible capital can be expanded at a low marginal cost. For example, a piece of software can potentially be installed on thousands of computers at almost zero marginal cost. Hence, a firm that succeeds in its intangible capital invest-

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<sup>1</sup>See Haskel and Westlake (2017) for a discussion of the properties of intangible capital.

ment can scale up its production or charge high markups relative to other firms. These arguments suggest that firms investing in intangible capital will charge high markups for at least two reasons; 1) to cover the fixed costs of intangible capital, and 2) if they succeed and obtain a low marginal cost relative to other firms. In addition, firms that fail in their intangible capital investment will not produce at a loss but the downside is always limited by the possibility of exit. Therefore, if intangible capital is creating a greater dispersion in firm outcomes and we only observe firms that survive, we are likely to observe higher markups in industries where intangible capital is more important in the production technology. However, these high markups are not necessarily associated with economic profit in the industry as a whole. To determine the presence of economic profit, we need to all firms that invest in the industry, not only those that succeed but also of those that fail.

To analyze theoretically how intangible capital is related to markups and profits, I use a model in which firms pay a fixed cost of investment in intangible capital, which results in an uncertain outcome for the marginal cost in line with Melitz and Ottaviano (2008). There is free entry into the industry and firms that fail in their intangible capital investment can exit. I model a higher importance of intangible capital in the industry technology as a higher level of the fixed cost  $f$  and a higher variation in terms of firm marginal costs. The model shows that the average industry markup generally depends on both the level of the fixed cost and the distribution of the marginal costs of production. It is commonly assumed that firm productivity follows a Pareto distribution, such that firm marginal costs are distributed inverse Pareto. In this case, the model predicts that industries in which intangible capital is more important in the production technology will be characterized by;

- i a higher fixed cost of intangible capital relative to the variable cost (a higher intangible capital-intensity),
- ii higher average industry markups,
- iii a lower share of income paid to labor,
- iv zero profit in the industry as a whole considering all firms that invest in the industry.

I test these predictions empirically using data on Swedish firms and industries for the period 1997 to 2016. In particular, I study the empirical relationship between i) intangible capital-intensity on the one hand and ii) average industry markups, iii) industry labor shares and iv) industry profit shares on the other hand. Specifically, I use national

accounts data on intangible capital relative to the labor cost at the industry level as a measure of intangible capital-intensity. The Swedish microdata allows me to estimate markups for all firms in the economy, except financial firms, and hence calculate the average industry markups for all non-financial industries. Sweden is an interesting case since it is one of the most intangibles-intensive economies in the world (Haskel and Westlake, 2017). It is the country of origin of many new software-intensive service providers such as Spotify, Skype, Mojang (Minecraft), and King (Candy Crush), as well as the base of older R&D-intensive manufacturing firms such as Ericsson, Volvo, Scania, ABB, and AtlasCopco.

Firm markups are estimated according to the method proposed by De Loecker and Warzynski (2012) based on a production function estimated in line with Akerberg et al. (2015). In accordance with the theoretical predictions, there is evidence of a positive relationship between intangible capital-intensity and average industry markups. When studying the variation in the two variables within industries over time, an increase in intangible capital-intensity by one standard deviation is associated with about 15 percentage points higher markups. The magnitude of this relationship is similar for unweighted markups and sales-weighted markups. However, I do not find any increasing aggregate markups in the Swedish economy between 1998 and 2016. Although some increasingly intangibles-intensive industries have experienced a substantial increase in markups, other industries have seen a decline. The sales-weighted average markup is generally below 20 percent of the marginal cost.

Economic profit is measured as the residual income after payments to labor and capital owners have been accounted for. I calculate the industry factor shares of income based on the national accounts data but, whereas the cost of labor is directly observed in the data, the cost of capital is unobservable. To estimate the cost of capital, I make use of the rental rate formula developed by Hall and Jorgenson (1967) and assume the required return on capital to be a weighted average between the cost of debt and equity capital. In accordance with the model predictions, high intangible capital-intensity is associated with a low share of income paid to labor. When studying the variation in the two variables within industries over time, an increase in intangible capital-intensity by one standard deviation is associated with a 5 percentage point lower labor share. However, the aggregate labor share in the business sector has remained roughly constant between 1997 and 2016.

If we successfully account for all factor payments, the profit shares are comparable across industries. When comparing observations across industries, I find that an increase in intangible capital-intensity by one standard deviation is associated with an increase

in the profit share by 5 percentage points. However, a positive relationship between intangible capital and profit shares is not necessarily present when studying the variation in the two variables over time within a given industry. Moreover, a robustness exercise shows that if the true stock of intangible capital was on average 17 percent higher than the measured stock, the positive relationship would disappear. In summary, the results on the relationship between intangible capital and economic profit are not entirely conclusive. The measured economic profit share in the Swedish economy has remained low, mostly below 5 percent of value added. Hence, there is evidence that Swedish firms are acting on relatively competitive markets with low profits.

This paper is related to three strands of the literature. First, this paper is related to the literature on superstar firms pioneered by Autor et al. (2020) by proposing that the scalability and uncertainty properties of intangible capital induce a high variation in firm marginal costs which results in big winners with high markups and profits. Ayyagari et al. (2019) find that star firms in the US economy are indeed related to high levels of intangible capital investment. Second, the paper relates to the literature on the role of intangible capital in firm production more broadly. The idea of scalability of intangible capital is also adopted by McGrattan and Prescott (2010) and De Ridder (2019). While De Ridder (2019) assumes that firms are heterogeneous in their use of intangible capital, which results in competitive advantages for productive firms, this paper assumes that firm heterogeneity is an outcome of intangible capital investment. Crouzet and Eberly (2019) also relate intangible capital to markups and find a positive relationship, in particular in the healthcare sector. Third, this paper contributes to the macro literature on the evolution of markups and factor shares of income by more granular measurement. Compared to De Loecker et al. (2020), I use data on a wider set of firms and separate between labor and intermediate inputs in the markup estimation. Compared to Barkai (2016), I use industry-level data to compute industry profit shares.

The rest of the paper is structured as follows. Section 2 describes the theoretical framework and Section 3 describes the data used to test model predictions. Section 4 presents the empirical analysis of intangible capital and markups, and Section 5 presents the empirical analysis of intangible capital and factor shares of income. Section 6 concludes the paper.

## 2 Theoretical framework

In this section, I use a conceptual framework following Melitz and Ottaviano (2008) to analyze the relationship between intangible capital, markups and factor shares of income.



I assume that the production technology is characterized by a fixed cost of intangible capital which is sunk and a degree of uncertainty in terms of the firm marginal cost. De Ridder (2019) provides evidence that software capital is indeed associated with fixed cost properties. Data on Swedish industries shows that the revenue dispersion is greater in intangible capital-intensive industries which is in line with a large cost variation in such industries, see Appendix B.2.

## 2.1 Industry model

There is a large pool of potential entrants that can freely enter into the industry. To enter, each firm must incur a fixed cost  $f$  of investment in intangible capital. The cost  $f$  is sunk and cannot be recovered at a later stage. The investment results in an uncertain outcome for the firm-specific marginal cost of production  $c_i$ , which is drawn from a known distribution  $G(c)$  with support  $[0, c_M]$ . After observing the cost draw, firms decide whether to produce or exit from the industry. From the total set of firms  $I$ , there is a continuum of firms of measure  $N_E$  that enters and invests and a measure  $N$  that eventually produces output. Each firm produces a distinct variety  $i$  of the industry good.

Consumers have preferences over a numeraire good  $y$  and industry varieties. The representative consumer's utility function is given by

$$U = y + \alpha \int_{i \in I} q_i di - \frac{1}{2} \eta \left( \int_{i \in I} q_i di \right)^2 - \frac{1}{2} \gamma \int_{i \in I} q_i^2 di \quad (1)$$

where the parameters  $\alpha$  and  $\eta$  shift the demand for the industry good relative to the numeraire good. The parameter  $\gamma$  determines the degree of substitutability between industry varieties. When  $\gamma = 0$  products are perfect substitutes and consumers care only about total consumption of the industry good.

Consumers maximize the utility given by (1) subject to the budget constraint<sup>2</sup>

$$\int_{i \in I} p_i q_i di + y = w_i. \quad (2)$$

This utility maximization results in the following linear demand for each variety of the industry good

$$q_i = \frac{\alpha}{\eta N + \gamma} - \frac{1}{\gamma} p_i + \frac{\eta N}{\eta N + \gamma} \frac{1}{\gamma} \bar{p} \quad (3)$$

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<sup>2</sup>There is a unit wage determined by the numeraire good sector.

where  $p_i$  is the price of variety  $i$ . The average price for industry varieties is given by  $\bar{p} \equiv \frac{\int p_i d_i}{N}$ . Demand falls to zero if  $p_i = \frac{1}{\eta N + \gamma}(\gamma\alpha + \eta N \bar{p})$  so this is the maximum price,  $p_{max}$ , that firms can charge and still sell a nonnegative quantity. After learning its marginal cost of production, a firm finds its optimal price by solving

$$\max_{p_i} [p_i - c_i] q_i(p_i) \quad (4)$$

subject to  $q_i$  given by (3) and taking  $N$  and  $\bar{p}$  as given. Thus, the industry is monopolistically competitive. The price that maximizes a firm's profit is

$$p_i = \frac{1}{2} \frac{\gamma\alpha}{\eta N + \gamma} + \frac{1}{2} \frac{\gamma\eta N}{\eta N + \gamma} \frac{\bar{p}}{\gamma} + \frac{1}{2} c_i. \quad (5)$$

Inserting (5) into (3), we have the operational profit function

$$\pi_i = \frac{1}{4\gamma} \left( \frac{\alpha\gamma}{\eta N + \gamma} + \frac{\eta N}{\eta N + \gamma} \bar{p} - c_i \right)^2. \quad (6)$$

Firms whose optimal price in (5) exceeds their marginal cost will decide to produce whereas firms that cannot cover their marginal cost will exit the industry. The marginal producer is a firm which can make zero profit by charging the highest possible price,  $p_{max}$ . We denote this cost by  $c_D$  and note from (6) that it is given by

$$c_D = \frac{\alpha\gamma}{\eta N + \gamma} + \frac{\eta N}{\eta N + \gamma} \bar{p}. \quad (7)$$

All performance measures of a producing firm can be expressed as functions of the cutoff cost  $c_D$ . In particular, the firm's net markup relative to the marginal cost is given by

$$\mu(c_i) = \frac{p_i - c_i}{c_i} = \frac{c_D - c_i}{2c_i} \quad (8)$$

so firms with lower cost draws charge higher markups.

The average industry markup is given by the integral of firm markups from the lowest cost level to the cutoff cost  $c_D$

$$\bar{\mu} = \int_0^{c_D} \frac{(c_D - c)}{2c} dG(c)/G(c_D). \quad (9)$$

By substituting (7) into (6), the operating profit of a producing firm is given by

$$\pi(c_i) = (p_i - c_i) q_i - f = \frac{1}{4\gamma} (c_D - c_i)^2. \quad (10)$$

Before entry, a firm compares the expected operational profit from entering to the fixed cost of investment in intangible capital,  $f$ . With free entry, firms will enter the industry until the expected operational profit is equal to the fixed cost

$$E(\pi) = \int_0^{c_D} \pi(c) dG(c) = \int_0^{c_D} \frac{1}{4\gamma} (c_D - c)^2 dG(c) = f. \quad (11)$$

Using (11), we can solve for the cutoff cost level  $c_D$ . This free entry condition has an important economic implication summarized in the following proposition.

**Proposition 1:** *The total fixed cost of entrant firms is exactly equal to the total operating profits of surviving firms.*

Proof: The relationship between entering firms and producing firms is given by

$$N_E = \frac{N}{G(c_D)}. \quad (12)$$

From (11) we have that the total expected operational profit in the industry is equal to the total fixed cost

$$N_E \int_0^{c_D} \pi(c) dG(c) = N_E f. \quad (13)$$

By substituting (12) into (13) it follows that the total expected operational profit is equal to the operational profit of producing firms

$$N_E \int_0^{c_D} \pi(c) dG(c) = N \int_0^{c_D} \pi(c) dG(c) / G(c_D). \quad (14)$$

Hence, the total fixed cost of entering firms is equal to the total operating profit of producing firms

$$N_E f = N \int_0^{c_D} \pi(c) dG(c) / G(c_D) \quad (15)$$

Q.E.D.

This result holds irrespective of the underlying distribution of the firm marginal cost. It is important for the analysis of factor shares below.

## 2.2 The importance of intangible capital and markups

This section studies what happens to average industry markups when intangible capital becomes more important in the production technology. I model a higher importance of

intangible capital in the industry technology as a higher level of the fixed cost  $f$  and a higher variation in terms of firm marginal costs.

### 2.2.1 General distribution

What happens to markups when the fixed cost  $f$  of intangible capital increases? From (11), we see that  $f$  is positively related to the cutoff cost-level  $c_D$ . The logic behind this result is that if we consider an industry with a fixed number of potential entrants, a higher fixed cost will lead to fewer firms attempting to enter the industry.<sup>3</sup> With a lower number of competitors, the demand curve for an individual firm will shift out and less productive firms will be able to survive. Applying Leibniz' integral rule to the average industry net markup in (9), we get

$$\frac{\partial \bar{\mu}}{\partial c_D} = \int_0^{c_D} \frac{1}{2c} dG(c)/G(c_D) - \int_0^{c_D} \frac{(c_D - c)}{2c} \frac{dG(c)G'(c_D)}{G(c_D)^2}. \quad (16)$$

The first term captures a positive effect on average markups because firms that have sufficiently low costs to survive under the initial  $c_D$  will raise their markups. The second term captures a negative effect on average markups from the survival of less productive firms. Which of these two effects that dominates depends on the underlying distribution of firms' marginal costs. When the effect of an increase in the cutoff cost  $c_D$  on survival is small (the second term is small), the average markups will increase with the fixed cost. Autor et al. (2020) show that if the distribution of firm productivity  $1/c$  is log-concave in  $\log(c_D)$ , then an increase in  $c_D$  will lead to higher average industry markups.<sup>4</sup>

What happens to markups when a higher importance of intangible capital in the industry technology results in a greater variation in firms' marginal cost of production? Let us consider a cost distribution  $F(c)$  which is a mean-preserving spread of the distribution  $G(c)$ . A firm's markup  $\mu(c)$  is a convex function of its marginal cost. Hence, for a given cutoff cost level  $c_D$ , the average industry markup under the more dispersed distribution  $F(c)$  is greater to or equal to the average industry markup under  $G(c)$ :

$$\int_0^{c_D} \mu(c) dF(c) \geq \int_0^{c_D} \mu(c) dG(c). \quad (17)$$

The intuition behind this result is that with an increased cost dispersion, firms that draw a low cost will be further away from the cutoff and will therefore enjoy higher

<sup>3</sup>This reasoning is borrowed from Syverson (2004).

<sup>4</sup>This is a local condition, see Appendix A1 of Autor et al. (2020) building on work by Arnaud Costinot.

markups. At the same time, firms that obtain high cost draws will exit and do not affect the average industry markup. However, the increase in markups and operating profits will attract more firms to enter the industry and this will be a force putting downward pressure on  $c_D$ . From above, we know that a change in  $c_D$  can imply higher or lower markups.<sup>5</sup> To obtain sharp predictions for how an increased cost dispersion affects the average industry markups, we need to know the underlying distribution of the firms' marginal costs.

### 2.2.2 Pareto distribution

Firm productivity is typically found to be right-skewed, with a large number of firms with low productivity and a smaller number of highly productive firms. Commonly found distributions are either a Pareto distribution or a log-normal distribution; see for example Head et al. (2014) and Amand and Pelgrin (2016). Let us assume that firm productivity draws  $1/c$  follow a Pareto distribution with the lower bound  $1/c_M$  and shape parameter  $k \geq 1$ .<sup>6</sup> This is equivalent to assuming that marginal cost draws are distributed inverse Pareto. With free entry, the equilibrium condition (11) now results in the cutoff cost level

$$c_D = (2(k+1)(k+2)\gamma c_M^k f)^{\frac{1}{k+2}}. \quad (18)$$

The assumption that a higher importance of intangible capital in the industry technology results in more variation in terms of firm marginal costs translates into the shape parameter  $k$  decreasing with the importance of intangible capital. The coefficient of variation of the firm marginal cost

$$\frac{\sigma_c^2}{E(c)} = \frac{c_M}{(k+1)(k+2)} \quad (19)$$

does indeed increase when  $k$  is decreasing for a given  $c_M$ .

**Proposition 2:** *When firm marginal costs follow an inverse Pareto distribution, average industry markups are higher in industries with a greater cost dispersion.*

Proof: By substituting (18) into (9), we get the average industry markup

$$\bar{\mu} = \int_0^{c_D} \mu(c) dG(c)/G(c_D) = \frac{1}{2} \frac{1}{k-1} \quad (20)$$

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<sup>5</sup>It can be noted that in a Cournot model with a fixed number of firms, a larger cost variation will lead to a higher markup (and profit); see Tirole (1988) page 223.

<sup>6</sup>The Pareto distribution also encompasses the uniform distribution when  $k = 1$ .

which increases when  $k$  falls and the dispersion of the marginal cost increases.<sup>7</sup> Q.E.D.

Why does  $k$ , reflecting the marginal cost dispersion, determine average industry markups? A firm's markup depends on its cost advantage relative to the firm with the cost  $c_D$ . With a Pareto distribution, the fraction of firms having a certain cost advantage is fixed and determined by  $k$ . A lower  $k$  implies a greater expected distance from the cutoff cost  $c_D$  which results in a higher average markup.

Interestingly, the industry markup does not depend on the cutoff cost  $c_D$  and thus, not on the level of the cost  $f$  of intangible assets. To understand this result, consider the case when  $f$  and  $c_D$  increase from (16). Firms that were already productive enough to survive given the initial  $c_D$  can now charge higher markups but a mass of less productive firms charging relatively low markups will survive. With a Pareto distribution, the net effect of these two forces exactly cancel out and the average markup is unaffected. According to Autor et al. (2020), the Pareto distribution of firm productivity is log-linear in  $\log(c_D)$ , which implies that a change in  $c_D$  will leave the average industry markups unaffected.

## 2.3 The importance of intangible capital and factor shares

### 2.3.1 Pareto distribution

Although average industry markups do not depend on the level of the fixed cost of investment in intangible capital,  $f$ , paid by an individual firm, there is still a relationship between intangible capital and the ratio of aggregate fixed costs to variable costs in the industry.

**Proposition 3** *When firm marginal costs follow an inverse Pareto distribution, there will be a higher ratio of fixed costs to variable cost in industries with a greater cost dispersion.*

Proof: We know from (15) that the total fixed cost is equal to the total operating profit in the industry. Hence, the total fixed cost to the total variable cost

$$\frac{N_E f}{N \int_0^{c_D} q(c) c dG(c) / G(c_D)} = \frac{N \int_0^{c_D} \pi dG(c) / G(c_D)}{N \int_0^{c_D} q c dG(c) / G(c_D)} = \frac{1}{k} \quad (22)$$

is also only determined by  $k$  and this ratio increases when  $k$  falls. Q.E.D.

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<sup>7</sup>This is also true for the revenue-weighted markup

$$\bar{\mu}_w = \int_0^{c_D} r(c) \mu_2(c) dG(c) / \int_0^{c_D} r(c) dG(c) = \frac{1}{2} \frac{2k+1}{k^2-1}. \quad (21)$$

The intuition behind this result is that when  $k$  falls and the dispersion increases, there is an increase in the markups and profits of surviving firms which attracts more firms to invest in the industry. However, firms that survive in this environment are very productive, requiring relatively little variable inputs to produce output. This results in a high fraction of fixed costs paid in proportion to the variable costs paid considering all firms that invest in the industry.

It follows from (22) that the fraction of income paid as compensation to variable production factors is lower in industries with a greater cost dispersion. Assuming that variable production factors mainly consist of labor, the fraction of income paid to labor will be lower. Another way of seeing this relationship is that high markups over variable costs among surviving firms translate into high operational profits paid to capital owners. This reasoning results in the following proposition:

**Proposition 4:** *When firm marginal costs follow an inverse Pareto distribution, the labor share will be lower in industries with a greater cost dispersion.*

Do higher average markups in industries with greater cost dispersion result in higher economic profits? The average operating profit share of revenue among producing firms

$$s_\pi = \frac{\int_0^{c_D} \pi(c) dG(c)/G(c_D)}{\int_0^{c_D} p(c)q(c) dG(c)/G(c_D)} = \frac{1}{k+1} \quad (23)$$

is positive and increases with a higher cost dispersion. However, to assess the presence of economic profit, we need to consider the revenue relative to the opportunity cost. When investment is risky, it is misleading to only examine the firms that succeed and end up producing in equilibrium. Instead, it is relevant to compare the total revenue to total costs of all firms that invest in the industry, including those that fail. It follows from (15) that the aggregate operational profit is equal to the aggregate fixed cost. Hence, the total industry profit, that is the aggregate operational profit net of fixed cost,

$$N \int_0^{c_D} \pi(c) dG(c)/G(c_D) - N_E f = 0 \quad (24)$$

is zero in the industry as a whole. This reasoning results in the following proposition:

**Proposition 5.** *A higher fixed cost  $f$  or a greater cost dispersion are not associated with any economic profit.*

In fact, this result follows by construction from the assumption of free entry into the industry.

## 2.4 Theoretical predictions

We have assumed that the industry production technology is characterized by a fixed cost of intangible capital, which is sunk, and a degree of uncertainty in terms of the firm marginal costs. In particular, we have modeled industries where intangible capital is more important in the production technology as having a higher level of fixed cost  $f$  paid by each firm and a higher variation in firm marginal costs. The prediction for the relationship between intangible capital and markups depends on the underlying distribution of the firm marginal costs. In the case of an inverse Pareto distribution, average industry markups will increase only because of a greater dispersion in the firm marginal cost and not because the firm level fixed cost is higher. With a high cost dispersion, the industry will be dominated by very productive firms which implies a high ratio of aggregate fixed costs to variable costs and a low labor share at the aggregate industry level.

The prediction for the relationship between intangible capital and economic profit does not depend on the underlying marginal cost distribution. Whereas higher cost dispersion implies greater profits among firms that succeed, many firms will be attracted to invest but fail. With free entry, there is no economic profit considering all firms that invest in the industry. In summary, when firm productivity follows a Pareto distribution, such that the firm marginal costs are distributed inverse Pareto, the model predicts that industries in which intangible capital is more important in the production technology will be characterized by;

- i higher fixed costs of intangible capital relative to the variable costs (a higher intangible capital-intensity),
- ii higher average industry markups,
- iii a lower share of income paid to labor,
- iv zero profit in the industry as a whole considering all firms that invest in the industry.

The purpose of the empirical analysis below is to test these predictions. In particular, I will study the empirical relationship between i) intangible capital-intensity on the one hand and ii) average industry markups, iii) industry labor shares and iv) industry profit shares on the other hand.



## 3 Data

### 3.1 Measuring intangible capital

The principle of recognizing firm expenditure on intangibles as capital investment has been established in the national accounting over the past three decades.<sup>8</sup> Today, three types of intangibles are included in the national capital stock; R&D, software and artistic originals. This is what I use as measures of intangible capital at the industry level.

The national accounts principle is that expenditures that are expected to yield an income at least one year into the future are counted as an investment. Information on investment in intangible capital is mainly based on surveys of a sample of firms which are used to impute values for the wider population. Details on the data sources are found in Appendix A.1. The national accounts measures have the advantage of providing consistent definitions as well as covering the entire economy. However, intangibles such as brand value, which can be very important from a firm-perspective, are omitted.

Alternatively, measures of intangible capital can be based on intangible capital reported in firm financial statements such as in Peters and Taylor (2017). The treatment of intangible capital in corporate accounting varies across countries and across time. Swedish firms have the option but not the obligation to treat expenditure on internally developed intangibles as capital investment. There are reasons to believe that start-up firms that are not yet profitable find it optimal to account for this expenditure as investment in order to support equity values. In contrast, more profitable firms may find it optimal to keep profits and thus taxes low by accounting for this expenditure as cost. In fact, for the median industry observation, aggregate intangible capital reported in firm accounts is only one-fifth of the median intangible capital reported in the national accounts, see Appendix A.2 for further details.

Another option would be to measure intangible capital based on the difference between the book value and the market value of publicly listed firms as in Hall (2001) and Brynjolfsson et al. (2018). This method is limited to publicly listed firms, however.

### 3.2 Industry data

Data at the industry level is used to calculate measures of intangible capital-intensity and factor shares of income. I obtain data from Statistics Sweden for the time period 1997 to 2016. The underlying industry unit is the 2-digit SNI/ISIC industry, but smaller industries are grouped together. In total, there are 52 industries spanning the entire

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<sup>8</sup>In Sweden, software capital was recognized in 1999 and R&D capital in 2013.

private sector from agriculture and manufacturing to services.

Data on capital stocks, labor cost, and value added at the industry level are obtained from the national accounts. Four types of capital are considered; machines, buildings, R&D capital, and software capital.<sup>9</sup> When calculating capital stocks, Statistics Sweden does not consider whether a firm that invested in capital in the past still exists. This means that capital stocks reflect the total historical investment of all firms in the industry, not only of firms that survive. This absence of selection effects is important to measure the economic profit in an industry.

To calculate the user cost of capital, I use estimates of price inflation rates and depreciation rates for capital goods from Statistics Sweden. Inflation rates vary across time and industries but depreciation rates are constant over time. The depreciation rates for intangible capital are also constant across industries. The rate is 16.5 percent for R&D capital and 40 percent for software.<sup>10</sup>

### 3.3 Firm data

Data at the firm level is used to estimate markups at the firm level. Firm financial statement data is obtained from administrative records covering all non-financial Swedish firms between 1997 and 2016. The observed firm unit is most often the legal unit but sometimes several legal units are grouped into an economic unit.

The variables of interest for the markup estimation are firm sales, cost of labor, cost of intermediate inputs and book values of capital. The variables are deflated for production function estimation. More detailed variable definitions are found in Appendix A.3.

### 3.4 A measure of intangible capital-intensity

The model in Section 2 predicts that the higher is the importance of intangible capital in the industry technology, the higher will be the ratio of total fixed costs of intangible capital relative to variable costs. As a proxy for this ratio, I use the stock of intangible capital relative to the cost of labor.<sup>11</sup> I call this measure intangible capital-intensity.

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<sup>9</sup>I ignore the capital type "artistic originals" which is a minor capital item in most industries.

<sup>10</sup>The depreciation rates are 40 percent for externally acquired software and 20 percent for internally developed software. However, I do not know to what extent software is internally developed in each industry.

<sup>11</sup>An alternative would be to use the approximated cost of intangible capital relative to the cost of labor and the approximated cost of capital. However, the cost of capital is subject to several assumptions as discussed in Section 5.

Hence, the intangible capital-intensity in industry  $j$  at time  $t$  is given by

$$\frac{IC_{jt}}{wL_{jt}} \tag{25}$$

where  $IC_{jt}$  corresponds to the measure of intangible capital from the national accounts and  $wL_{jt}$  corresponds to the labor cost from the national accounts. The aggregate intangible capital-intensity has increased somewhat, from 0.43 in 1997 to 0.48 in 2016, but there is a large variation across industries, see Figure B.2. In particular, there has been a strong increase in the chemical and pharmaceutical industry and the industry for other transportation equipment. Somewhat surprisingly, I measure a decline in the sector for R&D services, see Figure B.3.

A potential drawback of relating a capital stock to a variable production factor is that when shocks hit the economy, the capital stock may adjust at a slower rate than the variable cost. Hence, the intangible capital-intensity measure may vary for other reasons than variation in production technologies. As a robustness check, I use intangible capital as a proportion of total capital.

## 4 Markups and intangible capital

This section tests the model prediction that a higher intangible capital-intensity is positively related to higher average industry markups. I estimate firm markups according to the method proposed by De Loecker and Warzynski (2012) building on work by Hall (1988). This method is based on firm cost-minimization and relies on that we observe the cost of a variable production factor and can identify its output elasticity. The theoretical model in Section 2 does not distinguish between the different variable production factors. However, to identify markups, I model the variable costs of capital, labor and other intermediate inputs separately.<sup>12</sup>

### 4.1 Empirical model

In order to produce, firms need to pay a fixed cost  $f$  for intangible capital.  $f$  can either be paid once as in the theoretical model in Section 2 or more frequently as firms need to make investments in intangible capital to develop new products and services. The production technology is Leontief in intermediate inputs which can be considered as a

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<sup>12</sup>Introducing capital in the Melitz-Ottaviano model does not change its insights as long as capital is owned by workers, each of them holding a balanced portfolio so that they are only interested in the expected returns as pointed out by Bellone et al. (2009) and Corcos et al. (2007).

short-run technology for which there is no substitutability between capital or labor and intermediate inputs, respectively. For example, a certain amount of metal is needed to produce one mobile phone.<sup>13</sup> For firm  $i$  at time  $t$ , we have

$$Y_{it} = \min[e^{\beta_0} K_{it}^{\beta_1} L_{it}^{\beta_2} e^{\omega_{it}}, \beta_3 M_{it}] e^{\epsilon_{it}} \quad (26)$$

where  $Y_{it}$  corresponds to gross output,  $L_{it}$  is labor input,  $K_{it}$  is a measure of (physical) capital input and  $M_{it}$  are intermediate inputs. Persistent productivity denoted by  $\omega_{it}$  is known by the firm when it makes time  $t$  input decisions whereas  $\epsilon_{it}$  is an unknown temporary productivity shock. I consider both labor and intermediate inputs to be flexible inputs, that is, they are chosen after firms observe persistent productivity  $\omega_{it}$ .

The firm's problem is to minimize the costs given a target expected output level  $Y_{it}$  and can be expressed as

$$\begin{aligned} \mathcal{L}_{it}(L_{it}, M_{it}, K_{it}, \Lambda_{it}^1, \Lambda_{it}^2) &= f + r_{it} K_{it} + w_{it} L_{it} + p_{it}^M M_{it} \\ &\quad - \Lambda_{it}^1 E(e^{\beta_0} K_{it}^{\beta_1} L_{it}^{\beta_2} e^{\omega_{it}} e^{\epsilon_{it}} - Y_{it}) \\ &\quad - \Lambda_{it}^2 E(\beta_3 M_{it} e^{\epsilon_{it}} - Y_{it}) \end{aligned} \quad (27)$$

where  $\Lambda_{it}^1$  and  $\Lambda_{it}^2$  are the Lagrange multipliers and the first-order conditions with respect to labor and the intermediate inputs are

$$w_{it} = \Lambda_{it}^1 \beta_2 \frac{E(Y_{it})}{L_{it}} \quad (28)$$

and

$$p_{it}^M = \Lambda_{it}^2 \beta_3 E(e^{\epsilon_{it}}). \quad (29)$$

The marginal cost of production is given by

$$MC_{it} = \Lambda_{it}^1 + \Lambda_{it}^2 = \frac{w_{it} L_{it}}{\beta_2 E(Y_{it})} + \frac{p_{it}^M}{\beta_3 E(e^{\epsilon_{it}})} \quad (30)$$

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<sup>13</sup>The Leontief production function allows for the identification of the output elasticity as pointed out by Gandhi et al. (2011). This is also the production function used by De Loecker et al. (2020) when separating between labor and intermediate inputs.

where

$$\beta_3 = \frac{E(Y_{it})}{M_{it}E(e^{\epsilon_{it}})}. \quad (31)$$

which implies

$$\Lambda_{it}^1 + \Lambda_{it}^2 = \frac{w_{it}L_{it}}{\beta_2 E(Y_{it})} + \frac{p_{it}^M M_{it}}{E(Y_{it})} = \frac{w_{it}L_{it} + \beta_2 p_{it}^M M_{it}}{\beta_2 E(Y_{it})}. \quad (32)$$

The gross firm markup, the price over the marginal cost, is

$$1 + \mu_{it} = \frac{P_{it}^Y}{MC_{it}} = \beta_2 \frac{P_{it}^Y E(Y_{it})}{w_{it}L_{it} + \beta_2 p_{it}^M M_{it}}. \quad (33)$$

The costs of labor and intermediate inputs can be directly observed in the data but expected output  $E(Y_{it})$  and the output elasticity  $\beta_2$  need to be estimated.

## 4.2 Estimation

To find a measure of the output elasticity on labor input,  $\beta_2$ , I estimate the Cobb-Douglas production function in log form

$$y_{it} = \beta_0 + \beta_1 k_{it} + \beta_2 l_{it} + \omega_{it} + \epsilon_{it} \quad (34)$$

where,  $y_{it}$  is given by sales,  $k_{it}$  is the book value of firm capital and  $l_{it}$  is the cost of labor aimed at capturing a quality-adjusted measure of labor input. Moreover, I assume that persistent productivity evolves according to an AR(1) process

$$\omega_{it} = \rho \omega_{it-1} + \xi_{it} \quad (35)$$

where  $\xi_{it}$  can be interpreted as the unanticipated innovation to the firm's persistent productivity in period  $t$ .

The estimation procedure closely follows Akerberg et al. (2015) and relies on assumptions on the relationship between persistent productivity  $\omega_{it}$  and intermediate inputs  $m_{it}$ . The necessary conditions are that  $\omega_{it}$  is the only unobservable entering the firms' intermediate input demand function  $m_{it} = f_t(k_{it}, l_{it}, \omega_{it})$  and that this function is strictly increasing in  $\omega$  meaning that, conditional on capital, more productive firms use more intermediate inputs. This allows us to invert  $f_t$  and write

$$y_{it} = \beta_0 + \beta_1 k_{it} + \beta_2 l_{it} + f_t^{-1}(k_{it}, l_{it}, m_{it}) + \epsilon_{it}. \quad (36)$$

As pointed out by Gandhi et al. (2011), the output elasticity for the flexible labor input will not be identified if labor also fulfills these two conditions. Therefore, I assume that there are persistent unobserved wage shocks that break this relationship.

In a first step, expected output  $E(y_{it})$  is separated from the unexpected productivity shock,  $\epsilon_{it}$ . The functional form of  $f_t^{-1}$  is treated non-parametrically as a second-order polynomial of  $k_{it}$ ,  $l_{it}$  and  $m_{it}$  such that

$$\begin{aligned} y_{it} &= (\beta_0 + \gamma_0) + (\beta_1 + \gamma_1)k_{it} + (\beta_2 + \gamma_2)l_{it} + \gamma_3 m_{it} \\ &+ \gamma_4 k_{it}^2 + \gamma_5 l_{it}^2 + \gamma_6 m_{it}^2 + \epsilon_{it} \\ &= \tilde{\Phi}_t(k_{it}, l_{it}, m_{it}) + \epsilon_{it}. \end{aligned} \quad (37)$$

Using OLS regression we obtain an estimate of  $\tilde{\Phi}_t(k_{it}, l_{it}, m_{it})$  which corresponds to expected output  $E(y_{it})$ . It follows that productivity is given by

$$\omega_{it} = \tilde{\Phi}_t(k_{it}, l_{it}, m_{it}) - (\beta_0 + \beta_1 k_{it} + \beta_2 l_{it}). \quad (38)$$

In a second step, I estimate the parameters based on moment conditions on the shock to persistent productivity  $\xi_{it}$ . By assuming that capital responds with a lag to productivity shocks, we get the moment conditions

$$\begin{aligned} E \left[ \xi_{it}(\beta) \otimes \begin{pmatrix} l_{it-1} \\ k_{it} \\ \tilde{\Phi}_{t-1} \end{pmatrix} \right] &= E \left[ \omega_{it}(\beta) - \rho \omega_{it-1}(\beta) \otimes \begin{pmatrix} l_{it-1} \\ k_{it} \\ \tilde{\Phi}_{t-1} \end{pmatrix} \right] \\ &= E[(y_{it} - \beta_0 - \beta_1 k_{it} - \beta_2 l_{it} - \rho(\tilde{\Phi}_{t-1} - \beta_0 - \beta_1 k_{it-1} - \beta_2 l_{it-1})) \\ &\otimes \begin{pmatrix} l_{it-1} \\ k_{it} \\ \tilde{\Phi}_{t-1} \end{pmatrix}] = 0 \end{aligned} \quad (39)$$

where, in practice,  $\xi_{it}(\beta)$  is obtained by regressing productivity  $\omega_{it}(\beta)$  given by (38) on its own lag  $\omega_{it-1}(\beta)$  using the estimate of  $\tilde{\Phi}_t(k_{it}, l_{it}, m_{it})$  from the first stage. I estimate these moment conditions by GMM using the procedure of "concentrating out" parameters that depend linearly on other parameters as proposed by Akerberg et al. (2015).

Output elasticities are assumed to differ across industries, reflecting the considerable variation in production technologies, but remain constant over time. I estimate separate

production functions for each industry at the ISIC 2-digit level with at least 30 firm-year observations. In total, this amounts to 67 industries.<sup>14</sup> The log specification implies that only firm observations with positive sales, capital, and labor inputs are included. In my main specification, I restrict the estimation and calculation of markups to firms with at least ten employees since this is the cutoff size for firms being included in the survey on R&D.

#### 4.2.1 Calculation of markups

I calculate firm markups according to (33) where the expected sales  $P_{it}^Y E(Y_{it})$ , the labor cost  $wL_{ijt}$  and the intermediate input cost  $p_M M_{ijt}$  are undeflated to reflect the fact that the markup is a nominal concept.<sup>15</sup> The weighted average of firm markups is calculated for each industry  $j$  and year  $t$  as

$$\bar{\mu}_{jt} = \sum_i (1 + \mu_{ijt}) weight_{ijt} - 1 \quad (40)$$

where  $weight_{ijt}$  denotes the weight of firm  $i$  at time  $t$  in industry  $j$ . I calculate both the arithmetic average markup with all firms given equal weight (henceforth called unweighted average) and a markup where  $weight_{ijt}$  is given by the share of each firm's sales in total industry sales. This sales-weighted markup gives greater weight to larger firms and better reflects the economy as a whole. In the main specification, I exclude the bottom 0.5 percent and the top 0.5 percent of individual firm markups.

### 4.3 Results

Table 1 shows summary statistics for the sample of industry data used for the analysis.<sup>16</sup> The median estimated output elasticity with respect to labor,  $\beta_2$ , is 0.97 and several industries exhibit economies of scale. The median unweighted average industry markup is 0.04 and the median weighted average markup is 0.11 indicating that larger firms on average charge higher markups. For some industries, observed markups are below zero, implying that the price is lower than the marginal cost. Very low markups are primarily found in the agriculture and forestry sectors. The median intangible capital-intensity (IC/wL) is 0.20 with a standard deviation of 0.60. It is thus significantly lower than the

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<sup>14</sup>The estimation results in unreasonable estimates for industry 16 and this industry will be excluded in the following. In fact, this industry consists of disparate sub-industries such as marketing and veterinary services.

<sup>15</sup>In practice, expected sales is given by  $P_j e^{E(y_{ijt})}$ .

<sup>16</sup>Details on the full sample are found in Appendix A.4.

Table 1: Summary statistics for industry-level panel data

	p5	median	mean	p95	st. dev	No.
Output elasticity on labor, $\beta_2$	0.65	0.97	0.96	1.19	0.14	831
Markup unweighted	-0.25	0.04	0.05	0.44	0.21	831
Markup weighted	-0.24	0.11	0.13	0.55	0.24	831
Intangible capital-intensity, $IC/wL$	0.02	0.20	0.42	1.57	0.60	950
Physical capital-intensity, $K/wL$	0.36	1.83	6.36	30.84	15.23	950

*Notes:*  $\beta_2$  varies across industries only. Weighted markup refers to sales-weighted markup. Data on markups between 1998 and 2016. Data on capital intensities between 1997 and 2016.

median physical capital-intensity ( $K/wL$ ) of 1.83.

To examine the relationship between intangible capital and markups, I regress average industry markups on intangible capital-intensity. Physical capital is generally considered as a semi-fixed cost and it is plausible that markups over marginal costs are also positively related to physical capital. This motivates the inclusion of physical capital-intensity (physical capital-to-labor cost) in the regressions. It is likely that markups vary across industries for reasons other than intangible capital-intensity, for example due to the competitive situation. This motivates the study of changes in markups within industries over time. The basic specification of interest is

$$\mu_{jt} = \zeta_0 + \zeta_1(IC/wL)_{jt} + \zeta_2(K/wL)_{jt} + \tau_t + \psi_j + u_{jt} \quad (41)$$

where  $\tau_t$  denotes year fixed effects and  $\psi_j$  denotes industry fixed effects. The results for unweighted average markups are shown in Table 2. In line with the theoretical predictions, there is a positive and statistically significant relationship between intangible capital-intensity and unweighted average markups over time within a given industry. The results in column 2 show that an increase in intangible capital-intensity by one unit is associated with an increase in unweighted industry markups by 14 percentage points when controlling for year and industry fixed effects. This implies that an increase in intangible capital-intensity by one standard deviation (0.60) is associated with an increase in the unweighted average industry markup by 8 percentage points.

In addition, it is likely that the level of industry markups varies over time due to underlying trends in technology and the competitive environment that are independent of intangible capital. The specifications reported in columns 3 and 4 aim at controlling for such general trends at the broad 1-digit sector level. Column 3 includes a linear time-trend and column 4 includes sector-year fixed effects which is a more flexible spe-



Table 2: Regression - Unweighted average markups and intangible capital-intensity

	(1)	(2)	(3)	(4)
Intangible capital-intensity, IC/wL	0.0190 (0.0118)	0.140** (0.0541)	0.252*** (0.0480)	0.256*** (0.0495)
Physical capital-intensity, K/wL	0.00185*** (0.000547)	-0.0140** (0.00498)	-0.0175*** (0.00447)	-0.0200*** (0.00523)
Observations	831	831	831	831
$R^2$	0.023	0.282	0.494	0.613
year fe	yes	yes	yes	no
industry fe	no	yes	yes	yes
sector trends	no	no	yes	no
sector-year fe	no	no	no	yes

*Notes:* The dependent variable is the unweighted average industry markup. Coefficients refer to a one unit increase in the explanatory variables. Industry refers to the 2-digit ISIC sector level but smaller industries are grouped together. Sector refers to the 1-digit ISIC sector level. Standard errors in parenthesis. Panel data on industries between 1998 and 2016.

cification.<sup>17</sup> The results imply that an increase in intangible capital-intensity by one standard deviation is associated with an increase in the average industry markups of about 15 percentage points, that is 15 percent of marginal cost. For example, when comparing the industry for electricity production with an intangibles-intensity of 0.6 to the telecommunications sector with an intangibles-intensity of 1.2, we would expect the latter to have 15 percentage points higher markups.

The results from the regressions of weighted average industry markups on intangible capital-intensity are reported in Table 3. Interestingly, a positive and statistically significant relationship between intangible capital-intensity and weighted average markups is present even when we compare observations across industries (column 1). This result indicates that intangible capital is indeed strongly related to weighted average markups. The correlation between intangible capital-intensity and weighted average markups is of similar magnitude as the results for unweighted average markups. Column 4 implies that an increase in the intangible capital-intensity by one standard deviation is also associated with a 15 percentage point increase in weighted average markups when controlling for industry fixed effects and sector-year fixed effects. The magnitude of this relationship is large considering that the median industry markup is 13 percentage points of the marginal cost. A somewhat counterintuitive result is that there is evidence of a negative relationship between physical-capital intensity and markups. For example, column 4 suggests that an increase in the physical capital-intensity ratio from 0 to the

<sup>17</sup>When controlling for linear trends at the industry level there is no longer a statistically significant relationship between industry markups and intangible capital-intensity. This indicates that intangible capital-intensity evolves smoothly over time at the 2-digit industry level.

Table 3: Regression - Weighted average markups and intangible capital-intensity

	(1)	(2)	(3)	(4)
Intangible capital-intensity, IC/wL	0.0810*** (0.0133)	0.127* (0.0554)	0.197*** (0.0490)	0.245*** (0.0493)
Physical capital-intensity, K/wL	0.00234*** (0.000617)	-0.00737 (0.00498)	-0.0212*** (0.00450)	-0.0160** (0.00521)
Observations	831	831	831	831
$R^2$	0.063	0.424	0.590	0.710
year fe	yes	yes	yes	no
industry fe	no	yes	yes	yes
sector trends	no	no	yes	no
sector-year fe	no	no	no	yes

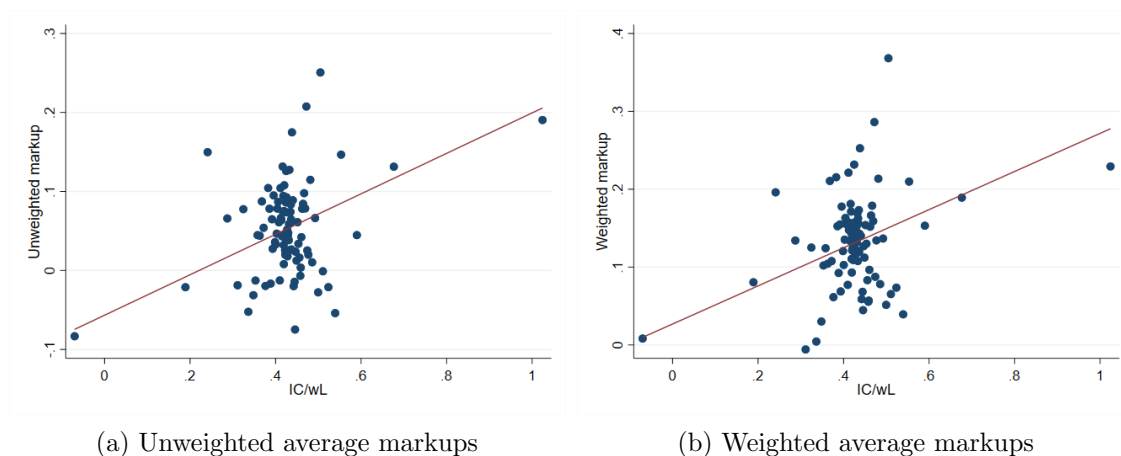
*Notes:* The dependent variable is the sales-weighted average industry markup. Coefficients refer to a one unit increase in the explanatory variables. Industry refers to the 2-digit ISIC sector level but smaller industries are grouped together. Sector refers to the 1-digit ISIC sector level. Standard errors in parenthesis. Panel data on industries between 1998 and 2016.

median level (1.83) is associated with a decrease in the average industry markups by 3 percentage points when including industry fixed effects and sector-year fixed effects.

The relationship between intangible capital-intensity and average industry markups is displayed in Figure 1. The figure depicts the correlation between the two variables when industry averages and sector-year averages are removed, corresponding to the regression results in column 4 of Tables 2 and 3. Data points that represent a very high intangible capital-intensity are related to high markups and, vice versa, data points that represent a very low intangible capital-intensity are associated with low markups. The main result is clearly determined by the observations with a very high or a very low intangible capital-intensity. Excluding these observations, the graph reveals a steeper relationship between intangible capital-intensity and markups, especially in panel (b).

Focusing on the evolution of markups in individual industries, we see that some industries that have experienced an increase in intangible capital have also seen a rise in the markups. This is, for example, the case in the industries for other transportation equipment and the industry for electricity generation, see Figure B.4. In contrast, I measure a decline in markups in the pharmaceutical industry. Throughout this time period, there is also a decline in markups in the retail and telecommunications industries. In the industry for technical and R&D services, the measured markups are variable and generally below zero, meaning that the price is lower than the marginal cost. This industry partly consists of firms that are in the early stages of research and do not yet produce any actual sales. The very low observed markup in this industry illustrates some of the challenges of the markup estimation when marginal costs and output are

Figure 1: Markups and intangible capital-intensity



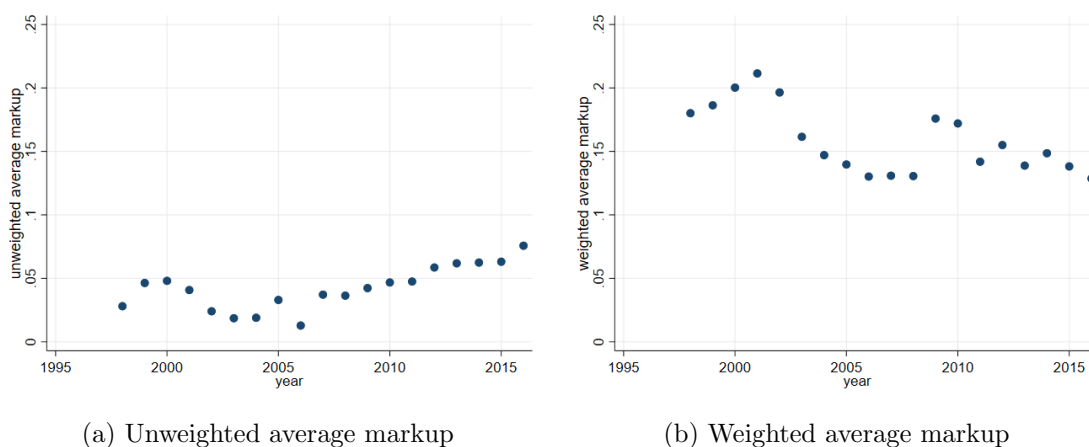
*Notes:* Bin scatter plots of intangible capital-intensity against unweighted and weighted average markups. The data corresponds to the residuals from the regressions reported in column 4 of Tables 2 and 3 including physical capital-intensity, industry fixed effects and sector-year fixed effects. The data is grouped into 100 equally sized bins. Each data point in the graph represents the average of the x-axis and the y-axis variables within each bin. The regression line is displayed in red. Panel data on industries between 1998 and 2016.

hard to measure.

#### 4.4 Aggregate economy markups

According to De Loecker et al. (2020), the markups among publicly listed firms in the US have increased by 40 percentage points of marginal cost between 1980 and the present day. The increase has been particularly strong over the last two decades. In contrast, I find no significant increase in aggregate markups in Sweden. Figure 2 shows aggregate markups among all firms with more than ten employees. While there is a slight upward trend in unweighted average markups, the increase is only in the order of magnitude of 5 percentage points. The trend in weighted average markups is rather going downward, suggesting that firms with large market shares are reducing their markups over time. Somewhat surprisingly, there is an increase in the weighted aggregate markup during the recession year of 2009. Since the unweighted markup does not change, this must be due to a relatively higher market share of firms with high markups. In addition, I find a lower level of aggregate markups compared to what has been found among publicly listed firms in the US. For example, De Loecker et al. (2020) and Traina (2018) estimate current aggregate markups to 61 percent and 50 percent of the marginal cost. In the Swedish

Figure 2: Time series of aggregate markups



*Notes:* Weighted average markup refers to sales-weighted average markup. Averages across Swedish firms with more than ten employees. Excluding observations in the bottom 0.5 and top 0.5 percentiles of the markup distribution.

data, I find that the unweighted average markup is below 10 percentage points and the weighted average markup is generally below 20 percent of marginal cost. However, in line with previous findings for the US economy, I find that weighted average markups are higher than unweighted average markups.

#### 4.5 Robustness

The main results are based on markups estimated for firms with more than ten employees excluding the top 0.5 and the bottom 0.5 percent of individual firm markups. Observations with an extremely high intangible capital-intensity following the dotcom bubble are also excluded, as discussed in Appendix A.4. The results using alternative measures of intangible capital-intensity and average industry markups are presented in Table B.3. When including all firms in terms of the markup distribution, the slope coefficient is almost twice as large, 0.48, as seen in column 1. This result indicates that firms with very high markups are most prevalent in intangibles-intensive sectors and vice versa. Column 2 shows that, compared to the main result, the slope coefficient is unchanged when also including all firms with more than three employees in the markup calculation. It indicates that the relationship between intangible capital-intensity and markups is also prevalent among smaller firms. The results of a regression of average industry markups on an alternative measure of intangible capital-intensity, intangibles

as a share of total capital ( $IC/(IC+K)$ ), are displayed in column 3. They imply that an increase in the intangible share by one standard deviation (0.20) around its mean value of 0.20 is associated with an increase in markups of 29 percentage points. However, when including the observations with extremely high intangible capital-to-labor cost ratios, there is no longer any positive relationship between intangible capital and average industry markups (column 4).

## 5 Factor shares of income and intangible capital

This section tests the model predictions of a negative relationship between intangible capital-intensity and the labor share of income, as well as zero profit in the industry as a whole. For this purpose, I first present a method for measuring the factor shares of income.

### 5.1 Accounting for value added

In general, value added can be accounted for by the cost of labor ( $wL$ ), the user cost of capital ( $RK$ ) and economic profit ( $\Pi$ ). For each industry  $j$  and time  $t$ , we have

$$VA_{jt} = wL_{jt} + \sum_{n=1}^N R_{jtn}K_{jtn} + \Pi_{jt} \quad (42)$$

where  $n$  denotes the type of capital. The categories of capital considered are two types of physical capital, machines and buildings, and two types of intangible capital, R&D and software. Unlike the cost of labor, the user cost of capital, and hence the economic profit, cannot be directly observed in the data. The main reason is that the market rental rates for capital are rarely observable since many firms own, rather than rent, their capital. Instead, a rental rate of capital is commonly constructed using the formula developed by Hall and Jorgenson (1967) based on a no-arbitrage condition between renting and owning capital. This is the approach taken by Karabarounis and Neiman (2018) and Barkai (2016), which I also follow here. For each capital type  $n$  we have

$$R_{jtn} = \delta_{jtn} - i_{jtn} + r_{jt} \quad (43)$$

where  $\delta_{jtn}$  is the depreciation rate,  $i_{jtn}$  is the inflation rate for the price of capital goods  $\frac{\Delta p_{j,tn}}{p_{j,t-1,n}}$  and  $r_{jt}$  is the required return on capital. Depreciation rates and capital inflation rates are obtained from Statistics Sweden. I assume that the required return on capital

is given by a weighted average of the cost of debt and equity capital

$$r_{tj} = r_{D,tj} \frac{D_{tj}}{D_{tj} + E_{tj}} + r_{E,tj} \frac{E_{tj}}{D_{tj} + E_{tj}} \quad (44)$$

where  $r_{D,t}$  is the average corporate borrowing rate on bank loans and  $r_{E,t}$  corresponds to  $r_{D,t}$  plus a risk premium of 5 percentage points. This required return on capital does not differ across capital types. However, if a larger share of equity financing for certain types of capital implies higher financing costs, these higher financing costs are reflected in the required return measure.

Given the calibration of the rental rate, the user cost of capital and factor shares of value added can be calculated. The average user cost of intangible capital across industries is 29 percent. For each industry  $j$  and time period  $t$ , the labor share, the capital share and the profit share are given by

$$s_{L,tj} = \frac{wL_{tj}}{VA_{tj}}, \quad (45)$$

$$s_{K,tj} = \frac{\sum_{n=1}^N R_{tjN} K_{tjN}}{VA_{tj}}, \quad (46)$$

and

$$s_{\Pi,tj} = \frac{\Pi_j}{VA_{jt}} = 1 - s_{L,tj} - s_{K,tj}. \quad (47)$$

## 5.2 Results

Table 4 shows the distribution of industry factor shares of value added in the sample used for analysis.<sup>18</sup> The median labor share is 70 percent but there are observations with a labor share above one implying that income does not cover the cost of labor. The median physical capital share is 17 percent and the median intangible capital share 4 percent of value added. Economic profit in the median Swedish industry only is 2 percent of value added but there are industry observations with significantly positive and significantly negative profits.<sup>19</sup> Unfortunately, missing data on capital price inflation leads to a loss of observations on the user cost of capital and capital shares.

<sup>18</sup>Details on the full sample are found in Appendix A.5.

<sup>19</sup>It is not necessarily the same industry which represents the median of all factor shares. Therefore, the median factor shares are not summing to 1 but mean factor shares do.

Table 4: Summary statistics for industry-level factor shares

	p5	median	mean	p95	st.dev	No.
Labor	0.27	0.71	0.67	1.02	0.21	878
Physical capital	0.06	0.17	0.25	0.76	0.25	835
Intangible capital	0.00	0.04	0.07	0.20	0.07	800
Profit	-0.35	0.02	0.01	0.32	0.19	757

*Notes:* Factor shares of value added. Panel data of industry observations 1997-2016.

### 5.2.1 Intangible capital-intensity and the labor share

While the labor share is not the main focus of this paper, evidence on the relationship between intangible capital and the labor share still provides information on whether the model in Section 2 is reasonable. The model predicts a negative relationship between intangible capital-intensity and the labor share. To test this relationship, I regress the labor share on intangible capital-intensity. The labor share is also determined by the presence of physical capital which is included as a control variable. A basic specification is

$$s_{L,jt} = \theta_0 + \theta_1(IC/wL)_{jt} + \theta_2(K/wL)_{jt} + \tau_t + \psi_j + u_{jt} \quad (48)$$

where  $\tau_t$  denotes year fixed effects and  $\psi_j$  denotes industry fixed effects.

The results in Table 5 point to an economically and statistically significant negative relationship between intangible capital-intensity and the labor share both across and within industries over time. Column 1 implies that an increase in intangible capital-intensity by one standard deviation (0.60) is associated with an 8 percentage point lower labor share when comparing observations across industries. The magnitude of this correlation is somewhat smaller within industries over time. For example, column 4 suggests that the corresponding result is a 5 percentage point lower labor share when also including for industry fixed effects and sector-year fixed effects. This correlation is depicted in Figure 3. It is clear that a very high intangible capital-intensity is associated with a low labor share and, vice versa, a very low intangible capital-intensity is associated with a high labor share. Without these most extreme observations in terms of intangible-capital intensity, the figure reveals an even stronger negative relationship between intangible capital and labor shares. The coefficient on the physical-capital intensity in Table 5 is also negative and mostly statistically significant. Intuitively, when relatively more capital is used in production, a larger share of income is paid to capital owners.

Table 5: Regression - Labor shares and intangible capital-intensity

	(1)	(2)	(3)	(4)
Intangible capital-intensity, IC/wL	-0.142*** (0.00918)	-0.103*** (0.0227)	-0.105*** (0.0211)	-0.0807*** (0.0212)
Physical capital-intensity, K/wL	-0.00772*** (0.000446)	-0.0143*** (0.00270)	-0.0116*** (0.00249)	-0.00328 (0.00299)
Observations	878	878	878	878
$R^2$	0.379	0.861	0.892	0.922
year fe	yes	yes	yes	no
industry fe	no	yes	yes	yes
sector trends	no	no	yes	no
sector-year fe	no	no	no	yes

*Notes:* The dependent variable is the labor share of value added at industry level. Coefficients refer to a one unit increase in the explanatory variables. Industry refers to the 2-digit ISIC sector level but smaller industries are grouped together. Sector refers to the 1-digit ISIC sector level. Standard errors in parenthesis. Panel data of industry observations 1997-2016.

### 5.2.2 Intangible capital-intensity and the profit share

When there is free entry into an industry, we expect zero economic profits in the long run.<sup>20</sup> This means that if we successfully take all factor payments into account, the presence of long-run economic profit is always an indication of barriers to entry. Hence, in theory, economic profit shares are comparable across industries and a relevant regression specification is:

$$s_{\Pi,tj} = \nu_0 + \nu_1(IC/wL)_{jt} + \tau_t + u_{jt} \quad (49)$$

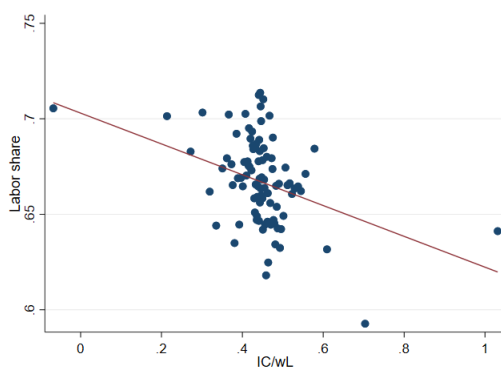
where  $\tau_t$  denotes time fixed effects.

The regression results are displayed in Table 6. When comparing observations across industries, there is a positive and statistically significant relationship between intangible capital-intensity and profits. An increase in intangible capital-intensity by one standard deviation (0.60) is associated with a 5 percentage point higher profit share of value added as seen in column 1. This correlation is further depicted in Figure 4. The figure shows a clear positive relationship between intangible capital-intensity and the measured profit share. However, when focusing on changes within industries over time, there is not necessarily any statistically significant relationship between the profit share and intangible capital-intensity (columns 2, 3 and 4). In addition, in Section 5.4, I investigate whether the positive correlation found in column 1 could be due to measurement error in the cost of intangible capital. In summary, the results on the relationship between

<sup>20</sup>In the short run economic profits can be positive or negative; see Carlton et al. (1990) for a discussion.



Figure 3: Labor shares and intangible capital-intensity



*Notes:* Bin scatter plot of intangible capital-intensity and labor share. The data corresponds to the residuals from the regression reported in column 4 of Table 5 including physical capital-intensity, industry fixed effects and sector-year fixed effects. The data is grouped into 100 equally sized bins. Each data point in the graph represents the average of the x-axis and the y-axis variables within each bin. The regression line is displayed in red. Panel data of industry observations 1997-2016.

intangible capital-intensity and economic profits are not entirely conclusive.

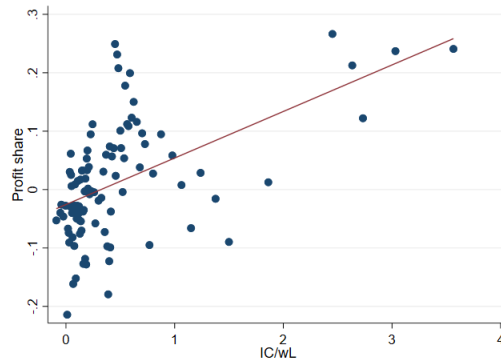
Focusing on the evolution of the profit share in individual industries, consistently positive profits are seen in the chemical and pharmaceutical industry and the industry for other transportation equipment. These industries typically include multinational firms that apply transfer pricing to allocate profits across countries. Since intangible capital does not take a physical form, there has been a potential for multinational firms to transfer intangible capital and associated profit flows to countries with relatively low

Table 6: Regression - Profit shares and intangible capital-intensity

	(1)	(2)	(3)	(4)
Intangible capital-intensity, IC/wL	0.0797*** (0.0104)	0.0518 (0.0304)	0.0788** (0.0301)	0.0486 (0.0305)
Observations	757	757	757	757
$R^2$	0.096	0.716	0.746	0.824
year fe	yes	yes	yes	no
industry fe	no	yes	yes	yes
sector-year fe	no	no	no	yes

*Notes:* The dependent variable is the profit share of value added at industry level. Coefficients refer to a one unit increase in the explanatory variables. Industry refers to the 2-digit ISIC sector level but smaller industries are grouped together. Sector refers to the 1-digit ISIC sector level. Standard errors in parenthesis. Panel data of industry observations 1997-2016.

Figure 4: Profit shares and intangible capital-intensity



*Notes:* Bin scatter plot of intangible capital-intensity and profit share. The data corresponds to the residuals from the regression reported in column 1 of Table 6 including year fixed effects. The data is grouped into 100 equally sized bins. Each data point in the graph represents the average of the x-axis and the y-axis variables within each bin. The regression line is displayed in red. Panel data of industry observations 1997-2016.

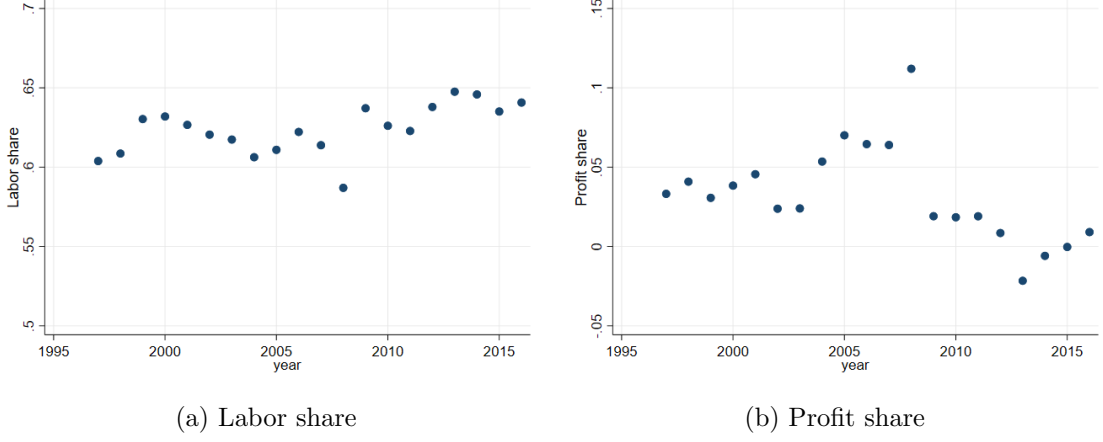
corporate taxes.<sup>21</sup> This phenomenon illustrates the challenge of correctly measuring the economic profit in individual industries and countries. In some industries, the profit shares are close to or even below zero. For example, I calculate a negative profit share for the retail industry throughout the whole time period, see B.5.

### 5.3 Aggregate labor share and profit share

Figure 5 shows the labor share and the profit share in the Swedish private sector between 1997 and 2016. In contrast to the findings by Karabarbounis and Neiman (2018) and Barkai (2016) for the US, there is no evidence of a declining labor share and an increasing profit share in the Swedish economy. The labor share is stable, around 0.6 and, with few exceptions, the profit share is mostly below five percent of value added. If anything, there is a downward trend in the profit share. Sweden is a small open economy and about half of its GDP is exported, mostly to other European countries. Hence, these results do not give rise to any concerns that Swedish firms do not act on competitive markets. This result is in line with the finding of Gutiérrez and Philippon (2018) that EU markets are more competitive than US markets.

<sup>21</sup>See for example Guvenen et al. (2017).

Figure 5: Private sector labor share and profit share over time



*Notes:* Shares of value added. Aggregates of private sector industry-level data from the national accounts.

## 5.4 Robustness

In this section, I investigate whether the observed positive correlation between intangible capital and economic profit in column 1 of Table 6 can be due to a measurement error in the user cost of intangible capital.

### 5.4.1 Stock of intangible capital

First, consider the case in which the rental rate of intangible capital is correctly measured, but there is measurement error in the stock of intangible capital. If the observed intangible capital is positively correlated with some unobserved capital stock, we will attribute the missing capital to higher rates of economic profit in intangibles-intensive industries. It is informative to ask what size of the unmeasured intangible capital stock that would imply a zero correlation between intangible capital and economic profit in column 1 of Table 6. To this end, consider the equation

$$VA_{jt} - wL_{jt} - R_{Ph,jt}K_{Ph,jt} = \bar{\Pi} + R_{IC,jt}K_{IC,jt}(1 + \Delta) + \Pi_{jt} \quad (50)$$

where  $K_{Ph,jt}$  denotes the physical capital stock,  $K_{IC,jt}$  denotes the intangible capital stock,  $\bar{\Pi}$  represents average industry profit and  $\Pi_{jt}$  is the residual profit uncorrelated with other variables. The unmeasured capital stock is given by  $\Delta$ . I normalize all variables by value added and estimate this equation in the panel of industries. The results give  $\hat{\Delta}=0.17$  saying that if the intangible capital stock on average was 17 percent

higher, there would be no positive relationship between intangible capital and economic profit. Such a difference between actual and measured intangible capital is not very large and possibly within the range of plausible measurement error. Hence, it cannot be excluded that the observed positive correlation between intangible capital-intensity and economic profit shares is due to an undermeasurement of intangible capital stocks.

#### 5.4.2 Rental rate of capital

Second, consider the case when the intangible capital stock is correctly measured, but the rental rate of intangible capital is measured with error. For example, there are reasons to believe that the required return on intangible capital is higher than the required return on physical capital, for example since intangible capital is not collateralizable.<sup>22</sup> The objective is to find the average rental rate of intangible capital that is consistent with a zero correlation between economic profit and intangible capital in column 1 of Table 6. For this purpose, consider the equation

$$VA_{jt} - wL_{jt} - R_{Ph,jt}K_{Ph,jt} = \bar{\Pi} + K_{IC,jt}R_{IC} + \Pi_{jt} \quad (51)$$

where  $R_{IC}$  is the average rental rate of intangible capital consistent with zero correlation between intangible capital and economic profit. Again, I estimate this equation in the panel of industries normalizing all variables by value added. The estimated user cost of capital,  $\hat{R}_{IC}$ , is 0.28, which is almost the same as the average user cost of capital calculated based on the formula of Hall and Jorgenson (1967) (0.29). Hence, it does not seem as if a different user cost of capital would help explain the observed positive relationship between intangible capital and measured economic profit.

## 6 Concluding discussion

This paper proposes that the scalability and uncertainty properties of intangible capital will be associated with higher average industry markups but not necessarily a higher economic profit at the industry level. I find empirical support for a positive relationship between intangible capital-intensity and average industry markups. I also find evidence of a negative relationship between intangible capital-intensity and labor shares whereas the evidence on the relationship between intangible capital and the profit share is less conclusive.

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<sup>22</sup>See, for example, Hall (2002).

To reach firm conclusions, we need further evidence. First, the estimation of the firm productivity distribution for various industries can provide sharper theoretical predictions of the role of intangible capital for markups. Second, a correct attribution of output across firms and countries is important for the measurement of markups and profits. Further work on this topic may be needed, especially in open economies with a large presence of (intangibles-intensive) multinational firms. Third, additional questions on the role of intangible capital in firm production call for an answer. How do we measure the importance of intangible capital in various industry technologies? Can we measure the uncertainty of intangible capital investment? Is it possible to disentangle whether the industry-level results of this paper are due to the fixed costs-properties or to the variation in the firms' marginal costs?

To draw policy conclusions, it is important to understand the driving forces behind the rise of intangible capital. There are several candidates but technology is likely to be a major force.<sup>23</sup> In general, the reduction of trade costs over the past century has expanded the market size and increased the potential return on investment in scalable production factors. More specifically, the revolution in information and communication technologies (ICT) and the exponential increase in computing power have laid the foundation for widespread use of software in all domains of life. But if the technology is the main driver behind the rise of intangible capital, and this is important for markups and profits, why do the Swedish patterns deviate from the US trends? Nevertheless, if the mechanism proposed in this paper is valid, a rise in the markups due to the increased importance of intangible capital need not be a sign of rising entry barriers. In such a case, an increase in the markups should not be a major concern for anti-trust authorities.

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<sup>23</sup>See the discussions in Brynjolfsson et al. (2018), Corrado and Hulten (2010) and Haskel and Westlake (2017).

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## Appendix A: Data

### A.1 Survey data on intangible assets

The intangible capital stocks in the national accounts are mainly based on survey data on firm expenditure on intangible capital. The principle is that expenditure which is expected to yield an income at least one year into the future is counted as an investment. The survey on R&D expenditure takes place every other year. Since 1995 it covers the entire economy and since 2005 all firms with more than ten employees are included in the survey population. Firms that have more than 200 employees or firms that are R&D-intensive are asked to answer the survey each time. Among other firms, a sample is collected. In total, 7705 firms were sampled for the survey in 2015. The survey provides information on both in-house and outsourced R&D activities. In addition to spending money on developing intangible capital, firms can also acquire R&D assets, such as patents, on the market. Information on acquired R&D capital is mainly derived as a residual item based on surveys of large firms.

The survey on software spending takes place every year starting in 2005. It includes acquired software such as purchased standard programs, licenses, cloud services as well as the development of customized software solutions. However, it does not include expenditure on developing software in-house. Firms with more than 250 employees are asked to answer the survey each year whereas a sample is collected among firms with between 10 and 249. In total, 4495 firms were sampled for the survey in 2015. Information on internally developed software is based on the number of workers in IT-occupations multiplied by the average wage and an estimated fraction of time allocated to own-account software development. The measurement on investment in artistic originals is based on royalty income. For all capital, adjustments are made to arrive at a market value equivalent.

### A.2 Intangible capital in firm accounting

The firm accounting framework covers a broader set of intangible capital as compared to the national accounts. According to the international accounting standards (IAS), intangible capital assets include computer software, licences, trademarks, patents, films, copyrights and import quotas. It also includes goodwill acquired in a business combination. However, the treatment of intangible capital in corporate accounting varies across countries and time. For example, in the US, firms are allowed to recognize acquired but not internally developed intangible capital on their balance sheet. In Sweden, firms

have the option, but not the obligation, to treat expenditure on internally developed intangibles as capital investment. However, small firms that have opted for a simplified accounting framework do not have the right to recognize internally developed intangible capital.<sup>24</sup> Moreover, at the time of a business combination, firms have significant freedom in whether to account for acquired intangible capital as goodwill or whether to identify specific intangible assets. In 2008, the 259 major publicly listed Swedish firms reported SEK 613 billion in goodwill and SEK 334 billion in other intangible capital (Gauffin and Thörnsten, 2010). There can be strategic advantages from accounting for acquired intangible capital as goodwill rather than recognising specific underlying assets. Primarily, goodwill is not subject to continuous depreciation but should undergo yearly impairment tests. (Gauffin and Thörnsten (2010)) show that Swedish firms perform little write-down of the value of goodwill, even after the global financial crisis.

The main principle behind the recognition of intangible assets other than goodwill is that it should be valued at historical cost and subject to yearly depreciation. However, the degrees of freedom in the framework imply that firms can account for this expenditure according to their strategic objectives. For example, start-up firms that have large expenditures on intangible assets but low sales have an interest in bolstering profits and equity values by reporting the expenditures on intangible assets as an investment. However, profitable firms that want to reduce taxes may have an interest in reporting expenditure on intangible assets as a cost. As a consequence of this freedom, firm accounting data does most likely neither provide a consistent measurement of the presence of intangible capital nor a comparable measurement across firms. Table A.2 shows a comparison between intangible capital at the industry level in the national accounts compared to intangible capital at the industry level derived from firm accounting data. We see that for the median industry observation, intangible capital according to the firm accounting rules is only one-fifth of the median observation in the national accounts. Moreover, the median intangible capital-intensity is only 0.04 as compared to 0.20 in the national accounts. This is likely due to the fact that many firms choose to account for expenditure on intangible assets as a cost rather than capitalizing it on their balance sheet. Further calculations show that there is a low correlation between these measures across industries and time. I do not observe any relationship between intangible assets reported in firm accounts and markups in micro data.

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<sup>24</sup>The simplified framework K2 came into place in 2008.

Table A.2: Intangible capital in the national accounts and firm accounting

	p1	median	p99	mean	st.dev.	No.
National accounts IC	78	3,767	1.7e+05	11622	26052	965
Firm accounting IC	0	724.44	21678	2,666	7,716	1,062
National accounts IC/wL	.00905	.2032	11.252	.58882	1.4798	965
Firm accounting IC/wL	0	.04487	.95768	.11379	.20643	1,020

*Notes:* Intangible capital in firm financial statements summed to the same industry level as in intangible capital in the national accounts (2-digit level with some exceptions). Panel data of industry observations 1997-2016.

### A.3 Variable definitions

**Industry capital stocks:** Capital stocks refer to capital stocks on January 1 each year. The capital types considered are buildings and land, machines and equipment, R&D capital and software capital.

**Industry debt:** The book values of debt capital at the firm level are aggregated to a measure of industry debt.

**Industry equity:** The book values of equity capital at the firm level are aggregated to a measure of industry equity. Equity refers to total equity that is total assets - debt.

**Capital inflation rates:** Capital inflation rates are obtained for each industry, capital type, and year, from the national accounts.

**Depreciation rates:** For each industry and capital type, I obtain estimated capital depreciation rates directly from Statistics Sweden. The depreciation rates are constant across time.

**Cost of debt capital:** The corporate borrowing rate refers to the average rate on all loans from monetary financial institutions to non-financial firms.

**Firm sales:** Sales net of VAT. I only consider firms with nonnegative sales. For purposes of production function estimation, sales are deflated by the GDP deflator for the respective industry.

**Firm labor cost:** It includes contributions to social security systems. I consider firms with nonpositive cost. For production function estimation, the labor cost is deflated by the general GDP-deflator. Deflating the labor costs by the GDP deflator is meant not to only remove changes in the labor input which are due to price inflation and not due to changes in labor productivity.

**Firm physical capital:** This measure includes machines and buildings (including land). I consider firms with nonnegative capital values. For production function estimation, the end of year capital stock in year  $t-1$  is used as a measure of capital input in year  $t$ .

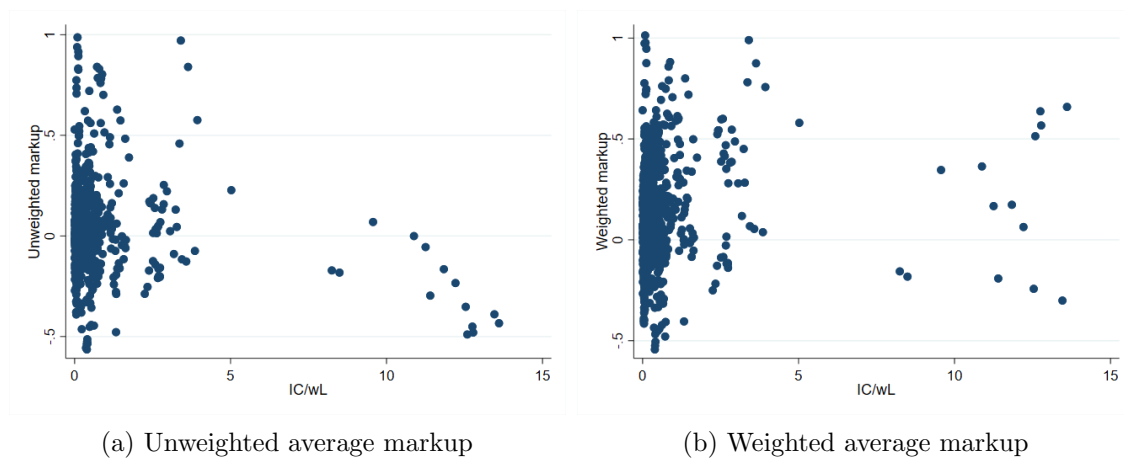
Therefore, in practice, the data ranges from 1998 to 2016. Capital stocks are deflated by industry-specific capital deflators. Land is not deflated in the national accounts but it is deflated here since it cannot be separated from buildings.

**Firm cost of intermediate inputs:** Intermediate inputs correspond to the value of raw materials, merchandise and other external costs that belong to the normal operations of the firm. I consider firms with nonpositive costs of intermediate inputs. For the production function estimation, intermediate inputs are deflated by the general GDP-deflator.

#### A.4 Sample selection for markup analysis

Figure A.2 plots the relationship between markups and intangible capital-intensity in the panel of industries between 1998 and 2016. There is a group of outliers with an intangible capital-intensity ( $IC/wL$ ) above 5 representing the industry for computers, electronics and optics post-2001. The very high intangible capital-intensity reflects the particular history of this industry in Sweden. In the late 1990's, it invested heavily in software and R&D. By the turn of the millennium, the firm Ericsson became the world's second largest mobile phone producer. However, after the bust of the dot-com bubble, the labor force in this industry shrank rapidly while the capital stock, measured based on historical costs, did not adjust as fast. This mismatch in the measured downsizing of the sector implied an intangible capital-to-labor cost ratio which is not reflecting the production technology. In the analysis, I exclude observations with an intangible capital-intensity above 5.

Figure A.2: Intangible capital-intensity and average industry markups



*Notes:* Weighted markup refers to the sales-weighted markup. Panel of industry observations between 1998 and 2016.

### A.5 Sample selection for factor share analysis

The distributions of factor shares of value added are characterized by large outliers as seen from Table A.3. For example, some industry observations show labor shares over 50 meaning that the labor cost is 50 times higher than the income. Correspondingly, a number of industry observations show negative profits of several multiples of value added. This can happen in an economic crisis and need not reflect a measurement error. However, to reduce the influence of extreme outliers, in the analysis I exclude observations in the bottom 5 and top 5 percentiles of the labor share and profit share distributions, respectively.

Table A.3: Summary statistics for industry-level factor shares

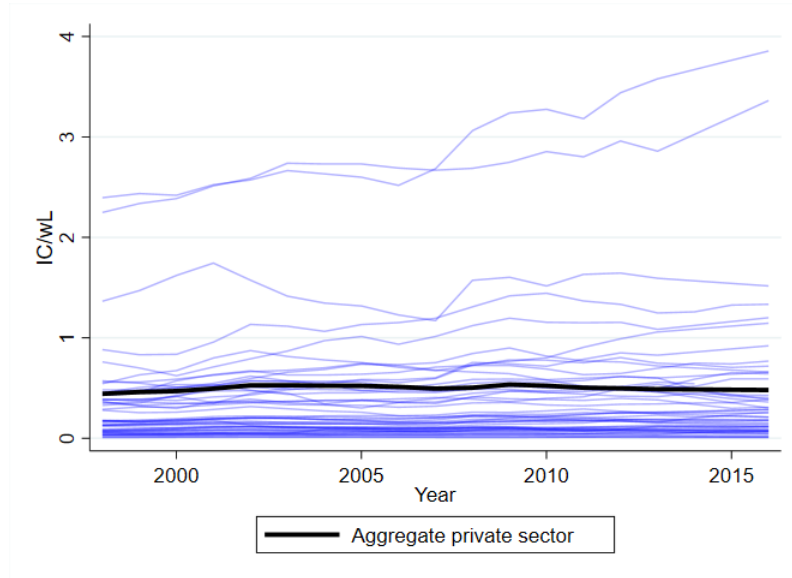
	p1	p5	median	mean	p95	p99	st.dev	No.
Labor	0.18	0.22	0.70	1.83	1.16	58.13	8.00	1020
Physical capital	0.03	0.06	0.17	0.26	0.75	1.16	0.24	942
Intangible capital	0.00	0.00	0.04	0.08	0.22	0.54	0.10	861
Profit	-3.22	-0.74	0.03	-0.07	0.46	0.66	0.65	858

*Notes:* Factor shares of value added. Panel data of industry observations 1997-2016.

## Appendix B: Empirical analysis

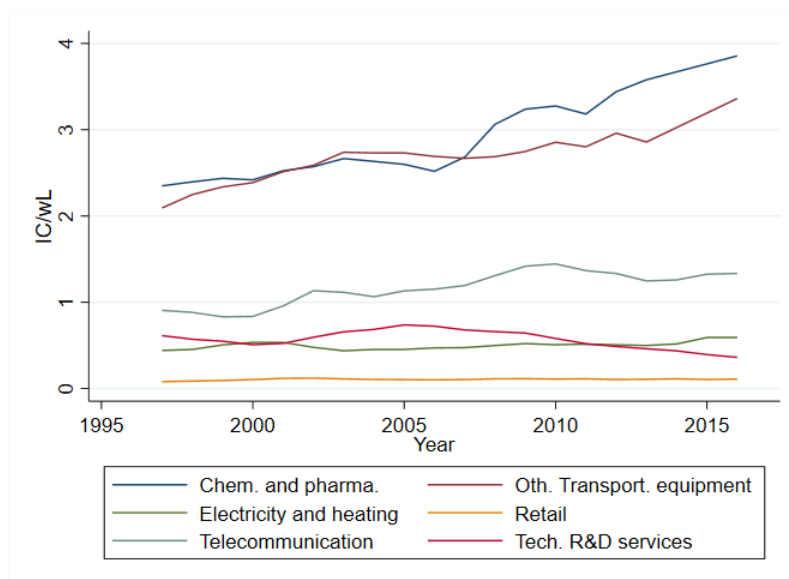
### B.1 Intangible capital-intensity

Figure B.2: Intangible capital-intensity in private sector



*Notes:* The measure of intangible capital-intensity is intangible capital (IC) over labor cost (wL). Aggregate private sector marked in black. Individual industries marked in blue. Data from the national accounts.

Figure B.3: Intangible capital-intensity in selected industries



Notes: The measure of intangible capital-intensity is intangible capital (IC) over labor cost (wL). Data from the national accounts.

## B.2 Uncertainty

A key assumption of the model in Section 2 is that a higher importance of intangible capital in an industry is associated with a greater variation in the firm marginal cost of production. In this section I analyze whether more intangible capital-intensive industries are associated with a greater revenue-dispersion. The measure of revenue dispersion is the ratio of the 90th percentile firm relative to the 10th percentile firm in the revenue distribution. All firms generating a positive revenue are included. This means that firms that are in the start-up phase and firms that are in the wind-down phase are included as long as they generate some positive revenue.

I regress the measure of revenue-dispersion on intangible capital-intensity at the industry level. Table B.2 shows that there is a positive and statistically significant relationship between intangible capital-intensity and revenue dispersion. Column 4 shows that an increase in intangible capital-intensity by one standard deviation is associated with the revenue ratio increasing 418 times when including industry fixed effects and sector-year fixed effects. This finding is in line with Caggese and Perez-Orive (2017) who find greater productivity dispersion in intangibles-intensive sectors.

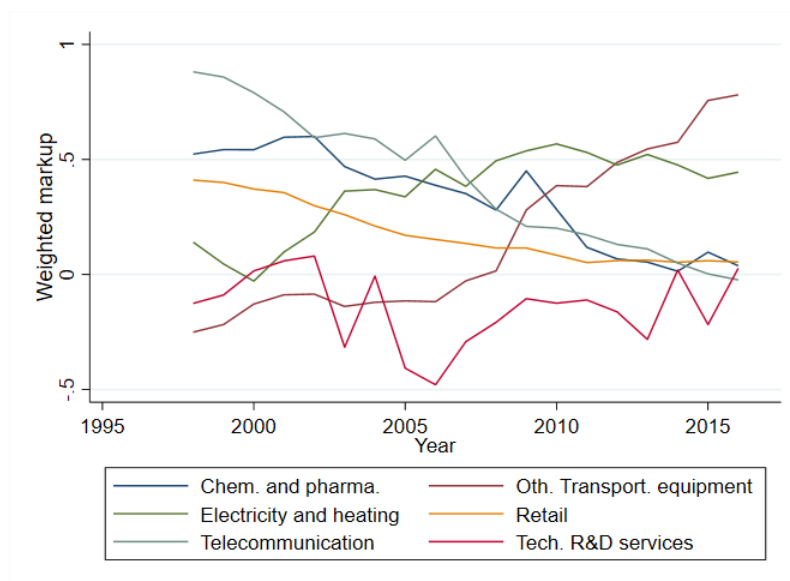
Table B.2: Regression: Revenue dispersion and intangible capital-intensity

	(1)	(2)	(3)	(4)
Intangible capital-intensity, IC/wL	566.1*** (74.94)	1098.0*** (270.1)	619.9* (277.2)	697.0* (318.7)
Physical capital-intensity, K/wL	21.06*** (3.473)	-0.693 (24.86)	-3.413 (25.76)	12.60 (34.70)
Observations	883	883	883	883
$R^2$	0.118	0.587	0.610	0.641
year fe	yes	yes	yes	no
industry fe	no	yes	yes	yes
sector trends	no	no	yes	no
sector-year fe	no	no	no	yes

*Notes:* The dependent variable is the ratio of the 90th percentile firm to the 10th percentile firm in terms of the revenue distribution. Coefficients refer to a one unit increase in the explanatory variables. Industry refers to the 2-digit ISIC sector level but smaller industries are grouped together. Sector refers to the 1-digit ISIC sector level. Standard errors in parenthesis. Panel of industry observations between 1997 and 2016.

### B.3 Markup results

Figure B.4: Weighted average markups in selected industries



*Notes:* Weighted markup refers to sales-weighted average markups.



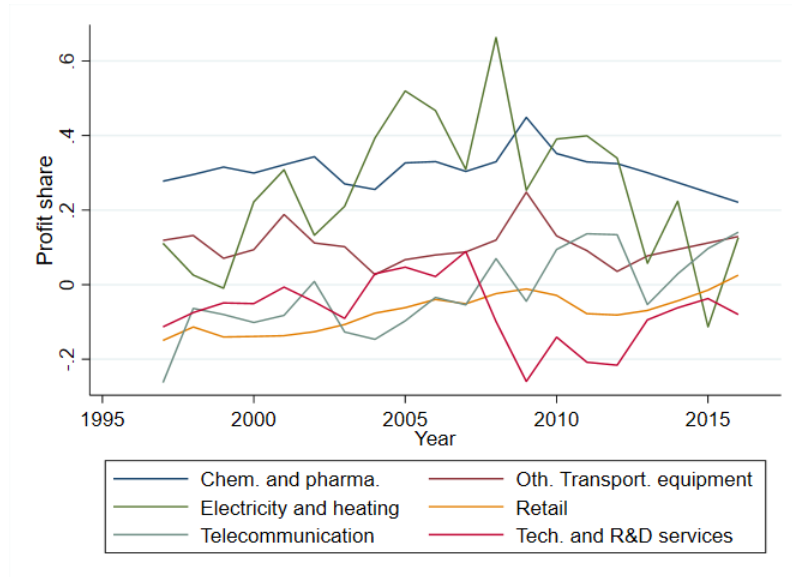
Table B.3: Alternative specifications

	(1)	(2)	(3)	(4)
IC/wL	0.480*** (0.0757)	0.254*** (0.0493)		-0.00489 (0.00899)
K/wL	-0.0318*** (0.00799)	-0.0149** (0.00520)	-0.0297*** (0.00737)	-0.0157** (0.00547)
IC/(IC+K)			1.430*** (0.305)	
Observations	832	832	756	846
$R^2$	0.742	0.644	0.556	0.682

*Notes:* The dependent variable is the weighted average industry markup. Coefficients refer to a one unit increase in the explanatory variables. The results are comparable to column 4 in Table 3 including physical capital-intensity, industry fixed effects and sector-year fixed effects. Standard errors in parenthesis. Column 1: Including all firms in terms of the markup distribution. Column 2: Including all firms with more than 3 employees. Column 3: Intangible capital-intensity measured as intangible capital in proportion to total capital. Column 4: Including observations with an intangible capital-intensity above 5. Panel data of industry observations 1998-2016.

#### B.4 Factor share results

Figure B.5: Profit share in selected industries



*Notes:* Profit share of value added.