Market Concentration and the Relative Demand for College-Educated Labor*

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Abstract: If large firms employ relatively more educated workers than small firms do, will an increase in market concentration increase income inequality by raising the relative demand for skill? I use detailed employer-employee data for Sweden between 1997 and 2016 and find a strong correlation between a firm's size and its share of workers that are college educated ("skilled"). Firms in the top size percentile are by far the most skill intensive. I also find that an increase in a sector's market concentration is correlated with a higher skilled wage premium and a rise in the relative employment of skilled workers. To analyze whether the rise in the relative employment of skilled workers is due to reallocation of workers across firms or a general skill upgrading within firms, I decompose the change in a sector's relative employment of skilled workers into between-firm and within-firm components. Increases in market concentration are strongly linked to increases in the between-firm component but not to changes in the within-firm component, suggesting that the reallocation of production from less skill intensive small firms to more skill intensive large firms is the primary mechanism. I demonstrate how the empirical results can be explained by a standard model of heterogeneous firms where production functions differ in productivity and skill intensity, and where productivity and factor intensity are positively correlated. A rise in concentration due to, for example, a rise in the elasticity of substitution thus increases the relative aggregate output elasticity of skilled workers, even though no within-firm change in technology occurs.

Keywords: Relative Skill Demand; Market Concentration; Superstar Firms; Income Inequality

JEL codes: D33; D43; F14; F62; J24; J31; L13; L40

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1 Introduction

An often mentioned potential cause for the rise in income inequality over recent decades is the rise in market concentration. One noteworthy example of market concentration is the emergence of so-called “superstar firms” (Autor et al., 2020; Barkai, 2016; Rossi-Hansberg et al., 2019), and another is the alleged global rise in firm markups (De Loecker and Eeckhout, 2020). Moreover, several studies have found evidence of between-firm variation in income being more important than within-firm variation in driving inequality, suggesting that the reallocation of workers across firms that market concentration causes may play an important role (Card et al., 2013, 2018; Song et al., 2019). Wolf (2019) discusses the phenomena of rising market concentration and markups as potential explanations for “why rigged capitalism is damaging liberal democracy” and why “economies are not delivering for most citizens”. The link between market concentration and income inequality therefore lies at the heart of the public debate about an important economic phenomenon in modern society. Establishing whether such a link exists is thus important for understanding income inequality. Little evidence on this matter exist, however.[1]

This paper studies whether increases in market concentration are linked to increases in the relative income and employment of college-educated (henceforth “skilled”) workers. The so-called college wage premium is an important measure in the literature on income inequality. The specific hypothesis that I analyze builds on the assumption that differences in technology across firms mean that large firms employ relatively more skilled workers than smaller firms do. Specifically, I want to analyze whether this difference in worker composition between large and small firms means that a rise in market concentration that reallocates market shares and employment from small to large firms in an industry, also raises the relative demand and relative income for skilled workers in that industry. The reallocation may in this way affect the aggregate technology of the economy even though no firm-level change has occurred.

Several explanations have been proposed in the literature for why larger firms employ relatively more skilled workers. More productive firms can for example produce goods of higher quality (Manova and Zhang, 2012), or require communication with a wider set of colleagues (Garicano, 2000), including foreign ones, both of which may require more education. It could also be because larger firms are more ICT intensive and that ICT is complementary to skill (Akerman et al., 2015), or that education is a signal of ability and that matching between workers and firms is assortative (Abowd et al., 1999; Eeckhout, 2018; Eeckhout and Kircher, 2018).

[1]The fact that several recent books on the topic of income inequality, for example by Atkinson (2015), Piketty (2014), Stiglitz (2013), and Taibbi (2014), all have become international bestsellers is an indication of strong public interest in the determinants and nature of income inequality.

I first analyze the hypothesis theoretically through the lens of a standard model with monopolistically competitive heterogeneous firms which differ in the factor intensity and productivity of their production functions. I follow Autor et al. (2020) and Cortes and Tschopp (2020) in modeling the increase in market concentration as caused by a rise in the elasticity of substitution across goods, although other causes of a rise in concentration would yield similar outcomes.[2] If productivity and the skill intensity of firms (i.e. how important skilled workers are in a firm's production function) are sufficiently positively correlated in the joint distribution function of these two variables, then a rise in the demand elasticity will induce a reallocation of production from less productive firms to more productive firms, and thus also from less skill-intensive to more skill-intensive firms. Less skill-intensive firms contract or exit, and more skill-intensive firms expand, since the latter are on average more productive than the former. This reallocation of production increases the aggregate demand for skilled workers, even in the absence of within-firm changes in skill intensities, and leads to a rise in the relative income of skilled workers.

I use employer-employee linked data for Sweden during 1997–2016 to evaluate this hypothesis. I focus both on the economy as a whole and specifically on the manufacturing sector, since manufacturing has traditionally been the most important sector in the Swedish wage-bargaining process.

The evidence supports the hypothesis that an increase in market concentration is closely linked to a rise in both the relative income and the relative employment of skilled workers. Larger firms employ significantly more skilled workers in relative terms than smaller firms do. And the by far most skill-intensive firms are the so-called "superstar" firms, i.e. the firms in the top bracket of the size and productivity distribution.[3] Moreover, following an empirical strategy similar to that by Autor et al. (2020), I find that sectors which became more concentrated, for example because the leading four firms increased their share of total sales or employment or that the Herfindahl-Hirschman index (henceforth "Herfindahl index") increased, also increased their use of skilled workers relatively more than other sectors. These sectors also experienced a rise in the relative income of skilled workers, suggesting that increases in market concentration may be linked to a widening of the

[2]As pointed out by Autor et al. (2020), evidence of a positive causal effect of new technology on the elasticity of demand is provided by Akerman et al. (forthcoming) who study the impact of broadband internet adoption in Norway on the trade patterns of Norwegian firms.

[3]Some previous evidence points at a correlation between size and skill-intensity, but whether so-called superstar firms hire relatively more or fewer skilled workers than other firms has not been known. While Apple, Microsoft or Google are highly skill-intensive, Amazon, Walmart or McDonald's are famous large-scale employers of unskilled workers. Examples specific to the Swedish setting are Spotify, Ericsson or Volvo as likely more skill intensive firms, while IKEA or H&M may be more unskilled. For earlier evidence on the link between the productivity and size of firms and the educational composition of the workforce, see for example Haltiwanger et al. (1999) or Oi and Idson (1999). I also show that the relationship holds across the entire support of firm size and that the slope is the largest among the top quantiles of firm size, i.e. the quantiles where the superstar firms are located.

income gap between skilled and unskilled workers.

The results also support the mechanism in my hypothesis, i.e. that it is the reallocation of workers across firms that is linked to the rise in the relative employment of skilled workers. When aggregate changes in the relative employment of skilled workers are decomposed into between-firm and within-firm variation, as well as changes due to entry and exit, I find that the between-firm component is strongly correlated with changes in market concentration while the within-firm component appears unaffected. This suggests that the mechanism through which market concentration is linked to the skill intensity of a sector is that market concentration reallocates production away from firms using relatively fewer skilled workers to firms using relatively more of them. It also indicates that increases in market concentration are not linked to a general skill upgrading of an industry.[4]

I conduct a series of robustness checks. An advantage of my empirical strategy is that exploiting within-sector variation means that one also controls for all time-invariant differences across sectors. But to further challenge the results, I add sector-specific linear trends which means that the estimates are identified from accelerations and decelerations relative to sector-specific trends in market concentration within sectors. The estimates barely move leaving little cause for worry. When I divide the sample period into two I find that the estimates are significant and relatively similar in both periods. Some argue that increases in market concentration can be due to a rise in import competition and that this pushes out weaker domestic firms. However, controlling for import competition and how imports affect the levels of market concentration does not change the estimates.[5]

The contribution of this paper to the literature can be viewed as four-fold. First, it offers a new potential explanation for why income inequality has increased in most countries in recent decades. All measures of income and wealth inequality that for example Atkinson et al. (2017) report for Sweden during the most recent decades, including the sample period used in this paper, increase substantially.[6] In the vast literature on this issue the two most important drivers of rising income inequality typically mentioned are skill-biased technological change (that recent technologies are complementary to skill)[7] and globalization (that increasing trade with or outsourcing to relatively low-skill

[4]See for example Card et al. (2018) or Song et al. (2019) for more evidence on the importance of firms in determining the wage distribution. For analyses of this phenomenon in a Swedish setting, see for example Nordström Skans et al. (2009) or Akerman et al. (2013).

[5]See Amiti and Heise (2021) for a deeper discussion on how imports have affected measures of US market concentration in recent decades.

[6]The variables reported by Atkinson et al. (2017) include the Gini coefficient of disposable income, earnings of the top decile and top percent relative to the median, share of the top 1 percent in wealth as well as the population share living in relative poverty. See Fredriksson and Topel (2010), Roine and Waldenström (2015) and Nordström Skans et al. (2009) for further descriptions of the Swedish labor market and its institutions as well as the evolution of income inequality over time in Sweden.

[7]See Acemoglu (1998; 2002) and Hornstein et al. (2005) for a theoretical background and overviews on skill-biased technological change, and Goldin and Katz (1998) for a history covering a longer time period.

abundant countries increases the relative demand for skill at home)[8] or complementarities between these two effects such as in Bustos (2011).[9] The finding that the rise in market concentration can be linked to the rise in the relative employment and income of skilled workers provides a new potential explanation for why income inequality has increased in recent decades. Second, I identify a new potential consequence for labor markets of the rise in market concentration. Knowledge of these issues is arguably important in an era of rising markups and the emergence of superstar firms. In the rapidly expanding literature on these issues, my methodology is closest to Autor et al. (2020). They show, among other things, that the share of GDP that is paid to workers, the labor share, has dropped in industries and countries where market concentration has increased. Market concentration thus appears to increase income inequality between labor and other production factors.[10] Similarly, Azar et al. (2020) and Qiu and Sojourner (2019) find that higher market concentration in the US has reduced wage growth. In my paper I instead show that changes in market concentration are not only correlated with the inequality between labor and other production factors, but also with changes in inequality between different types of workers.[11] Third, a rapidly growing literature focuses on how firms affect the wage distribution. For example, Song et al. (2019) show that virtually all of the increase in wage dispersion in the United States between 1978 to 2012 can be accounted for by differences in average wages between firms rather than wage dispersion within firms. My paper suggests a potentially economically important alternative role of firms in determining labor market outcomes: that the mean productivity of workers of different types changes when employment is reallocated across firms that have systematically different production technologies.[12] Cortes and Tschopp

Akerman et al. (2015), Autor et al. (1998) and Beaudry et al. (2010) provide specific examples of the effects of broadband internet and the personal computer.

[8]See Krugman (2008) and Helpman (2018) for a summary of the subject and a literature overview. Autor et al. (2013) and Feenstra and Hanson (1999) provide specific estimates of effects of import exposure to China and outsourcing, respectively. Helpman et al. (2017) show how the interaction between firm heterogeneity and trade participation creates a link between unemployment and globalization under more realistic labor market assumptions than in original trade models on the topic. Michaels (2008) uses variation in trade access for rural counties due to exogenous components in how the US interstate highway system was expanded and analyzes the effect on relative skill demand.

[9]Other factors, such as changes in the minimum wage, the decline in unionization rates, or deregulation of labor markets, have generally not been found to contribute much to the rising college wage premium. See Bourguignon (2015) for a review of evidence concerning these factors.

[10]See also Barkai (2016) and Kehrig and Vincent (2018).

[11]The issue of rising market concentration is by no means new. The usage of the term "superstar" workers or firms was introduced by Rosen (1981) who argued that already in the late 1970s it was obvious that "winner-takes-it-all" forces were becoming rapidly more important over time. In fact, as he points out, one can read about similar observations already in Marshall (1890) who notes that the best oil-painters and opera-singers in the late 19th century grabbed an increasingly large share of the market and the returns. The technological process favoring superstar firms therefore seems to have been operating for a long time and there appears to be little reason to question that it will continue. Understanding its effects on key economic variables is therefore important.

[12]Card et al. (2013) find that an increase in plant-level heterogeneity and a rise in the assortativity in

(2020), Rinz (forthcoming) and Webber (2015) study the interaction between labor market concentration and wage inequality but study the effects within groups of similar workers rather than the differences in outcomes between different types of workers. A related paper by Ma et al. (2019) find that mergers and acquisitions in the early 2000s led to post-merger establishments which were more skill-intensive than the initial firms. I view this finding as supportive of the fact that larger firms operate with technologies that are more skill intensive and that a reallocation of labor from smaller to larger firms thus leads to an increase in the aggregate relative employment of skilled workers, and ultimately also to an increase in income inequality. Finally, the paper adds to the theoretical understanding of the mechanisms through which skill biased technological change raises the output elasticity of skilled workers (see for example the canonical models by Acemoglu and Autor, 2011). In my model, the aggregate output elasticity of skilled workers increases even though no firm-specific changes in the output elasticity occurs. New technology reallocates workers away from smaller firms with low output elasticities of skilled workers towards larger firms with higher output elasticities. Thereby, the mean output elasticity of skilled workers rises but the effect is due to a reallocation of workers rather than within-firm changes in technology.

Section 2 outlines a theoretical framework which illustrates how a rise in market concentration can cause a rise in the relative employment and income of skilled workers. Section 3 discusses the data sources used and presents summary statistics. Section 4 shows a strong correlation between firm size and the share of employment of skilled workers. Section 5.1 analyzes whether the changes in skill shares are systematically linked to changes in market concentration, while Section 5.2 conducts a similar analysis for relative wages. Section 6 focuses on the mechanism outlined above and analyzes the role played by reallocation of production across firms. It decomposes the change in the aggregate relative employment of skilled workers and analyzes which components vary systematically with market concentration. Section 7 concludes.

2 Theory

I first develop a theoretical model to better understand the hypothesis that underlies the empirical analysis. The main components of the model are the following: i) both unskilled and skilled workers are used in production, ii) firms are heterogeneous and differ in both productivity and the skill intensity of their workforce, and iii) the joint distribution of

the allocation of workers across plants account for a large share of the rise in wage inequality between occupations, industries and groups of workers in Germany between 1985 and 2009. Mueller et al. (2017ab) find that wage dispersion increases in firm size among UK firms for the years 2004 to 2013. In a cross-country regression, they also find a correlation between the growth in size of the largest 50 and 100 firms and aggregate wage inequality.

productivity and skill intensity is such that higher productivity firms also tend to be more skill intensive. The model can thus be used to analyze how technological shocks that change the relative size of firms affect the aggregate relative demand of unskilled and skilled workers and their relative returns.

The specific technological shock that I focus on is an increase in the elasticity of substitution between varieties. Autor et al. (2020) discuss such a change as a potential cause of the increase in market concentration (see for example Syverson, 2019 for a broader discussion on the potential causes of the rise in market concentration). Autor et al. (2020) point out how consumers become more price-sensitive as they use the Internet to learn more about the distribution of prices across markets (see Akerman et al., forthcoming, for evidence on this phenomenon) or when the liberalisation of international trade increases competition across borders (see Melitz and Ottaviano, 2008). Cortes and Tschopp (2020) follow a similar strategy in terms of modeling the cause of the rise in concentration. An increase in the elasticity of substitution, as I will show, reallocates output and labor demand from firms with low productivity towards firms with high productivity.

While Autor et al. (2020) study a competitive labor market with only one type of worker, I instead focus on a setting where firms employ both unskilled and skilled workers to study wage inequalities between the two types of workers. Cortes and Tschopp (2020) build a model that focuses on wage differences between homogenous workers across heterogeneous firms, where labor market frictions give rise to wage differences across firms. My analysis is thus new in the sense that I focus on the skill premium specifically, and that I analyze income inequalities in a competitive labor market with heterogeneous firms, where it is the reallocation of production across firms that drives the increase in the skill premium. The model I use builds on a closed-economy version of the model by Harrigan and Reshef (2015), who study the effect of trade liberalization on an economy with firms that differ in productivity and skill intensity. While they analyze trade liberalization I instead focus on an increase in the elasticity of substitution and a rise in market concentration.

2.1 Assumptions

I make the following set of assumptions in order the create a model with the features outlined above. There are L_U unskilled workers and L_S skilled workers in the economy. Workers are homogenous within skill category, supply their labor inelastically, and are paid the same skill-specific wages, w_U and w_S. Wages are used to buy consumption goods, where c_i denotes the consumption of good i, and consumers maximize a CES utility function characterized by $U = \left(\int c_i^{\frac{\sigma-1}{\sigma}} di \right)^{\frac{\sigma}{\sigma-1}}$ where the elasticity of substitution across goods, σ, is greater than one.

The model is dynamic and firms incur a sunk cost in order to enter and discover their marginal cost

$$c_i^v(\beta_i, \varphi_i, w_U, w_S) \equiv \frac{w_U^{1-\beta_i} w_S^{\beta_i}}{\varphi_i}$$

which is indexed by a firm identifier i in order to indicate that firms differ in total factor productivity (henceforth "productivity"), $\varphi_i > 0$, and relative factor intensity of unskilled and skilled workers, $\beta_i \in (0,1)$. In other words, both φ_i and β_i differ across firms.

It follows from Shephard's Lemma that a firm i will demand the following number of workers to produce q_i units of output:

$$\begin{aligned} L_{Ui}(\beta_i, \varphi_i, w_U, w_S, q_i) &= (1-\beta_i)\left(\frac{w_S}{w_U}\right)^{\beta_i} \varphi_i^{-1} q_i \\ L_{Si}(\beta_i, \varphi_i, w_U, w_S, q_i) &= \beta_i \left(\frac{w_U}{w_S}\right)^{1-\beta_i} \varphi_i^{-1} q_i \end{aligned}$$

and a firm's relative demand for skilled workers is

$$\frac{L_{Si}}{L_{Ui}} = \frac{\beta_i}{1-\beta_i}\left(\frac{w_U}{w_S}\right).$$

The relative demand for skilled workers is independent of φ_i. But if skill intensities β_i are positively correlated with productivity, more productive firms will still demand more skilled workers. More specifically, I assume that firms upon entry draw their productivity and skill intensity from a joint cumulative distribution function $G(\beta, \varphi)$. As will be shown in Section 4, there is a very clear link between the size and skill intensity of firms in my data: larger firms are more skill intensive. I therefore assume that $G(\beta, \varphi)$ features a positive correlation between β and φ such that more productive firms have more skill-intensive production functions. Moreover, I assume that parameters are such that skilled workers are paid more than unskilled workers. This means, however, that firms with larger draws of β_i have higher marginal costs conditional on φ_i. The stylized fact that these firms are nevertheless larger makes me also assume that the joint distribution between β_i and φ_i in $G(\beta, \varphi)$ is such that there is a positive correlation also between q_i and β_i in equilibrium.

Firms have to pay two fixed costs, one to enter the market and one to produce each period. These cost functions, c^{f_e} and c^f, are

$$\begin{aligned} c^{f_e} &= \left(\frac{L_S}{L_U + L_S} w_S + \frac{L_U}{L_U + L_S} w_U\right) f_e \\ c^f &= \left(\frac{L_S}{L_U + L_S} w_S + \frac{L_U}{L_U + L_S} w_U\right) f \end{aligned}$$

where f_e and f denote the fixed costs of entry and per-period production, respectively, and $\frac{L_S}{L_U+L_S}w_S + \frac{L_U}{L_U+L_S}w_U$ denotes the factor cost term which is the same for all firms and all fixed cost activities. This means that the average relative employment of skilled workers in the production of the fixed cost component is the same as the relative endowment of skilled workers in the economy. This means that variation in the number of firms that enter does not affect the relative demand for workers.[13] In addition, there is a constant per-period risk of forced exit with a probability δ, which keeps the present discounted value upon entry finite.

2.2 Equilibrium

The specified demand system means that firms charge a fixed markup over their marginal cost such that

$$p_i = \frac{\sigma}{\sigma-1}c_i^v \tag{1}$$

which generates the following sales revenues and profits each period:

$$\begin{aligned} r\left(c_i^v\right) &= \frac{\left(w_U L_U + w_S L_S\right)}{P^{1-\sigma}}\left(\frac{\sigma-1}{\sigma}\frac{1}{c_i^v}\right)^{\sigma-1} \\ \pi\left(c_i^v\right) &= \frac{r\left(c_i^v\right)}{\sigma} - c^f. \end{aligned} \tag{2}$$

The definition of profit in equation (2) can be used to define the highest level of marginal cost in the economy on which a firm can survive:

$$r\left(c^{v*}\right) = \sigma c^f$$

where it is important to note that survival does thus not only depend on productivity φ_i but also on the relative factor intensity of a firm, β_i. I define the set of combinations of β and φ that generate $c_i^v \leq c^{v*}$ as Φ. The probability for a new entrant firm, who does not yet know its productivity and factor intensity, to survive is thus

$$\chi = \iint_{(\beta,\varphi)\in\Phi} g\left(\beta,\varphi\right) d\beta d\varphi$$

where $g\left(\right)$ is the density function of $G\left(\right)$.

Free entry means that the cost of entry has to equal the expected discounted flow of

[13] This modeling assumption is due to Harrigan and Reshef (2015).

future profits after entry. The weighted average marginal cost of all active firms is

$$\tilde{c}^v(c^{v*}) = \left(\iint\limits_{(\beta,\varphi)\in\Phi} \chi^{-1}(c_i^v)^{1-\sigma} g(\beta,\varphi)\,d\beta d\varphi\right)^{\frac{1}{1-\sigma}}$$

which means that I can specify the following free entry condition

$$\chi\frac{\pi(\tilde{c}^v)}{\delta} = c^{f_e}$$

or

$$\iint\limits_{(\beta,\varphi)\in\Phi}\left(\left(\frac{c^{v*}}{c_i^v}\right)^{\sigma-1}-1\right)g(\beta,\varphi)\,d\beta d\varphi = \delta\frac{f^e}{f}. \tag{3}$$

To close the model, I turn to the labor market equilibrium. Given the demand structure and the price strategy of firms in (1), the output of a firm will be

$$q_i = (w_U L_U + w_S L_S)P^{\sigma-1}\left(\frac{\sigma}{\sigma-1}c_i^v\right)^{-\sigma} \tag{4}$$

and the aggregate relative labor demand from variable cost activities is thus

$$\frac{L_S^v}{L_U^v} = \frac{w_U}{w_S}\frac{\iint\limits_{(\beta,\varphi)\in\Phi}\beta_i\left(\frac{1}{c_i^v}\right)^{\sigma-1}g(\beta,\varphi)\,d\beta d\varphi}{\iint\limits_{(\beta,\varphi)\in\Phi}(1-\beta_i)\left(\frac{1}{c_i^v}\right)^{\sigma-1}g(\beta,\varphi)\,d\beta d\varphi}. \tag{5}$$

The total fixed costs in the economy depends on the mass of firms and the mass of entrants. If I let the mass of entrants be M_e, then a fraction χ of those will successfully enter. These have to equal the share of active firms, M, that die each period such that $\chi M_e = \delta M$ and I thus conclude that there are $\frac{\delta}{\chi}$ entrants for each active firm. This means that each active firm pays $\left(\frac{L_S}{L_U+L_S}w_S + \frac{L_U}{L_U+L_S}w_U\right)\left(\frac{\delta}{\chi}f_e + f\right)$ in fixed costs. Moreover, the relative labor demand in the fixed cost activities of firm i is equal to the aggregate relative endowment of skilled workers:

$$\frac{L_{Si}^f}{L_{Ui}^f} = \frac{L_S}{L_U}$$

which means that dynamics relating to fixed costs do not affect aggregate relative demand.

Finally, using the fact that aggregate revenues equals total wages and that the free entry condition states that $\frac{\bar{r}}{\sigma} = c^f$, where $\bar{r}$ is the mean level of revenues conditional on entry, we know that

$$M = \frac{R}{\bar{r}} = \frac{L_U + L_S}{\sigma\left(\frac{\delta f_e}{\chi} + f\right)}$$

and that the CES price index is thus

$$P = \frac{\sigma}{\sigma - 1} M^{\frac{1}{1-\sigma}} \tilde{c}^v.$$

The equilibrium is characterized by the free entry condition in equation (3) and labor market equilibrium condition in equation (5).

2.3 Comparative statics from increasing the elasticity of substitution

I will analyze a rise in concentration and a reallocation of production towards large firms by calculating the comparative statics of increasing the elasticity of substitution σ.

I first turn to the free entry condition in equation (3) and conclude that c^{v*} must decrease when σ increases since $c^{v*} > c_i^v$ for all i by definition. Therefore, an increase in σ drives out the least competitive firms in the economy.

Proposition 1. *The highest marginal cost that an active firm can have decreases when the elasticity of substitution increases.*

Proof. Consider the free entry condition in equation (3). When σ increases no variable except c^{v*} can change. It must therefore be that c^{v*} decreases when σ increases since $c^{v*} > c_i^v$ for all i. □

Second, I note that the lower the marginal cost a firm has the more it will expand when the elasticity of substitution increases. This can be seen by using equation (4) to compare the proportional increase in size of two firms with different costs:

$$\frac{\partial}{\partial \sigma} \ln q\left(c_i^v\right) - \frac{\partial}{\partial \sigma} \ln q\left(c_{i'}^v\right) = \sigma\left(\ln c_{i'}^v - \ln c_i^v\right) \tag{6}$$

so that firm i increases in size more if firm i has a lower marginal cost than firm i'. There will thus be a reallocation of production away from small firms with high costs to large firms with low costs. And since firms with lower costs have a higher productivity φ and thus also a larger skill intensity β due to the positive correlation between φ and β in the density function $G(\beta, \varphi)$, this also means that production is reallocated from firms which are relatively less skill intensive to firms which are more skill intensive.

Proposition 2. *The change in output from an increase in the elasticity of substitution is larger for firms that have lower costs, are larger, and have more skill-intensive production functions.*

Proof. Equation (4) contains the expression for the output of a firm with a given cost c_i^v. Equation (6) calculates the derivative of output with respect to the elasticity of substitution and shows how the derivatives differ between two firms with different costs. One can note that if firm A has a higher cost than firm B, then the difference in the effect of the elasticity of substitution σ on output q is larger for firm B than firm A. □

It follows from Proposition 2 that firms that demand relatively more skilled workers expand relatively more than other firms as a consequence of the increase in the elasticity of substitution σ, and that this increases the relative demand for skilled workers.

One can therefore conclude that the two main effects from free entry and the labor market equilibrium both contribute to an increase in the relative demand for skilled workers. First, the highest cost firms are also the ones with the lowest skill intensity, and the exit of these firms means that that the remaining firms are of the lower cost type. And since firms with lower costs on average use relatively more skilled workers this increases the relative demand for skilled workers. Second, I show that there is also a reallocation of output and employment from smaller and less skill-intensive firms with higher cost to larger and more skill-intensive firms with lower costs. The only change in the endogenous variables that can rebalance the excess demand for skilled workers is a rise in the relative wage of skilled workers, $\frac{w_S}{w_U}$.

Proposition 3. *The increase in the elasticity of substitution increases the relative wage of skilled workers.*

Proof. Consider the expression in equation (5). Two things affect the relative excess demand for skilled workers. First, the cutoff marginal cost c^{v*} decreases and the least skill intensive firms thus disappear (Proposition 1). This increases the numerator in equation (5) relative to the denominator. Second, the increase in σ causes a change in the relative size of the weights $\left(\frac{1}{c_i^v}\right)^{\sigma-1}$ since differences in output across firms become more responsive to differences in marginal costs (Proposition 2). This means that firms with low marginal costs gain market share. In the numerator these firms have a higher β_i (skill intensity) which increases the numerator. In the denominator, however, these weights are multiplied with $1-\beta_i$ which is instead low for firms with low marginal costs. This means that the numerator increases and the denominator decreases. The only way to counteract these changes and reduce the excess demand for skilled workers is to increase w_S/w_U. □

It is therefore the case that a standard model with monopolistically competitive firms that are heterogeneous both in productivity as well as factor intensity predicts that the relative income of skilled workers increases when the elasticity of substitution increases, if productivity is correlated with factor intensity in production which is a feature of the data.

The model also shows how the aggregate output elasticity of skilled workers increases when concentration rises, even though firm-specific output elasticities remain constant. This happens because market concentration reallocates workers away from smaller firms where skilled workers have lower output elasticities towards larger firms which use skilled workers more productively. This means that a rise in mean productivity of skilled workers can occur even in the absence of for example firm-level skill-biased technological shocks, and that relative labor market outcomes of skilled workers can improve even though one does not observe any within-firm changes in skill-specific productivity levels. The model therefore adds to the canonical models of skill-biased technological change by for example Acemoglu and Autor (2011), and points out an alternative mechanism through which new technology affects the relative output elasticity of skilled workers. And instead of within-firm changes in technology, it is the effect of technology on competition that causes a reallocation of workers across firms with heterogeneous production technologies that affects the change in the aggregate relative output elasticity of skilled workers.

The empirical analysis also looks at the relative employment of skilled workers, in addition to the relative wage. Although relative endowments of labor are fixed in the model, the idea is that in reality aggregate relative employment responds to changes in the relative wage such that the relative endowment of skilled workers increases when the relative wage of skilled workers increases. Such an adjustment in relative endowments can be caused both by workers moving into a sector from elsewhere and that they face certain costs of doing so, as well as by existing workers obtaining a university education and thus changing skill status.

3 Data

3.1 Sources and summary statistics

The paper is based on registry data, collected by the Swedish Tax Authority, on the balance sheets of the universe of private firms in Sweden. I use data for the period 1997–2016 which covers the universe of firms and individuals in the private sector of Sweden. Its reliability and quality are regarded as very high since misreporting is punishable by law.

To calculate the share of a firm's workers that are skilled, I link the firm level data to individual level data which contains information on both the education as well as annual wage income for all workers employed by private firms during the sample period. In line with much of the literature on the evolution of the skill premium, I count workers as skilled if they have completed college education. I include only firms which employ at least five workers, since I am interested in variation in the share of skilled workers in the number of employees and wages of firms. In the smallest firms there will naturally be less variation. I only use one match per worker and year, and this match is based on employment in the month of November.

Regarding my measure of relative wages, I do not have data on hours worked and instead use the annual wage income as a measure of wages. Changes in this measure thus capture both changes in hours worked and in the hourly wage. I view, however, the annual wage as more suitable in this context than the hourly wage. The reason is that annual wages are likely to more closely reflect market outcomes. While hourly wages are negotiated between trade unions and employers and therefore more rigid, annual wages reflect also changes in working time and overtime which are more flexible from an institutional perspective. In most theoretical settings, it is indeed reasonable to expect a rise in the relative demand for skilled workers to increase both relative hours worked and the relative hourly wage.

Table 1 provides descriptive data and shows in Panel A that the manufacturing sample consists of 237 four-digit industries and on average 10,974 firms per year (there are in total 219,475 firm-year observations). The wages to sales ratio (labor share) is remarkably similar to that reported by Autor et al. (2020), 15.23 in my sample and 15.24 in their sample for US manufacturing firms. Regarding the importance of college educated workers in employment, I see that about a quarter of wages of a representative firm are paid to skilled workers, and that almost a fifth of the workers are skilled. The difference reflects the skill premium: skilled workers are paid more than less skilled workers. In fact, the weighted average skill premium is 0.27 log points. Swedish manufacturing seems somewhat more concentrated than its US equivalent. For example, the mean market share of the top 4 firms is 58 percent in Sweden and 41 percent in the US. Table 1 Panel B displays the same numbers for the economy as a whole. One can note that the manufacturing sector is largely similar to the rest of the economy in terms of the reported moments. It is slightly more concentrated than the rest of the economy and the skill premium is somewhat larger.

In addition, for the robustness analysis with respect to import competition I use data from UN Comtrade on merchandise imports to Sweden. I use cross-walks from Autor et al. (2013) that link six-digit Harmonized System product codes (HS) to four-digit 1987 Standard Industrial Classification System sector codes (SIC87). I also use cross-walks from Eurostat's Ramon server which link SIC87 to the European NACE rev 1 system (with four digits), which corresponds to the sectoral codes for Swedish firms. I therefore observe sector-level imports in all sectors in Sweden, from all foreign countries, during these years.

Table 1. Descriptive statistics.

	Mean	Std. dev.	Min	Max
A. Manufacturing				
237 industries (4,532 industry-year observations)				
Number of firms per year in total	10,974	649	9,787	11,732
Wages to Sales Ratio	15.23	5.61	0.95	97.85
Skilled Worker Share of Wage Bill	24.15	16.77	0.00	80.55
Skilled Worker Share of Employment	19.49	15.05	0.00	72.20
Skill Log Wage Premium	0.27	0.12	-3.37	1.82
CN4	57.94	28.25	5.09	10.00
CN20	84.32	19.84	19.09	10.00
Herfindahl Index	25.14	25.41	0.39	10.00
B. All industries				
507 industries (9,333 industry-year observations)				
Number of firms per year in total	64,913	7,406	53,494	77,858
Wages to Sales Ratio	19.46	9.86	0.95	97.85
Skilled Worker Share of Wage Bill	25.27	19.33	0.00	100.00
Skilled Worker Share of Employment	20.93	17.80	0.00	100.00
Skill Log Wage Premium	0.24	0.16	-3.37	1.82
CN4	45.92	29.67	3.49	100.00
CN20	69.98	27.09	14.69	100.00
Herfindahl Index	18.65	24.79	0.21	100.00

Note: Detailed descriptions of the variables are given in Appendix Table A.1. The number of firms indicates the total annual number of firms. All other numbers show weighted averages over four-digit sectors for the years 1997–2016, where the weights are 1997 levels of value added at the four-digit sector level.

3.2 Evolution of relative wages, skill composition and market concentration over time

The evolution of market concentration is displayed in Figure 1. The measures of market concentration shown are all weighted averages across four-digit sectors where the weights are levels of value added in the first year of the sample. I plot the share of sales and employment, respectively, that is accounted for by the four largest firms (CN4) and also the Herfindahl index based on sales and employment, respectively. When I use sales as a measure of concentration, I observe a steady increase throughout the sample. This is regardless of which concentration measure I use. I find an increasing slope for the Herfindahl index also when I look at concentration of employment, but not for the importance of the four largest firms. This difference between patterns for concentration measures based on sales and employment is in line with what Autor et al. (2020) find for the United States. Appendix Figure B.1 conducts the same exercise at a more disaggregated

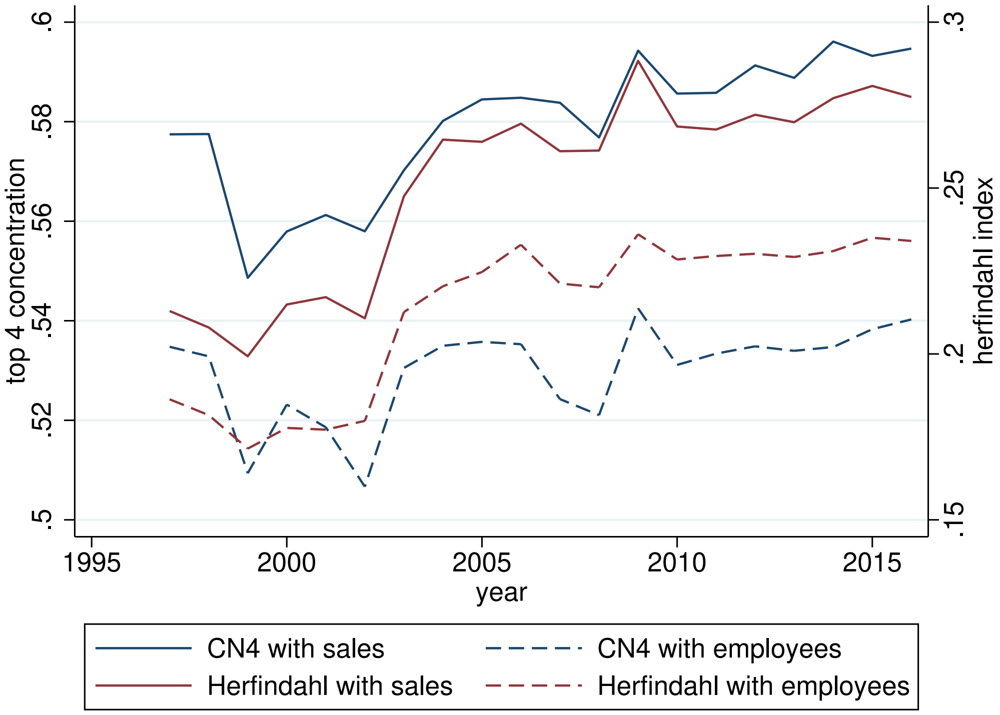


Figure 1. Evolution of market concentration.

Note: The sample consists of firms in the manufacturing sector during 1997–2016. For each year, I calculate for each four-digit sector the share of the four largest firms as well as the Herfindahl index and then calculate the overall weighted mean where the weights are the 1997 levels of value added for each four-digit sector. I calculate values based on both sales (solid lines) and employment (dashed lines).

level and plots the sales-based concentration measures for each two-digit sector. I find that 11 out of 14 two-digit manufacturing sectors experienced increasing concentration regardless of measure used.

Figure 2 shows how the skill composition of workers evolves during the sample period. The increase is dramatic: as shown by the solid blue line the share of workers that have a college degree has more than doubled from 9% in 1997 to 23% in 2016. The share of wages paid to skilled workers has also roughly doubled (solid purple line). Appendix Figure B.2 shows the increase in two-digit sectors and that the share has increased in all sectors. Figure 2 also plots the unweighted mean skill composition across firms in the dashed lines. The aggregate numbers (equivalent to weighted means if the weights are the number of workers per firm) are much higher than the unweighted means. This means that there must be substantial variation in skill composition across firms and that larger firms on average employ relatively more skilled workers. Moreover, the aggregate numbers increase faster over time which suggests that the most skill-intensive firms increase faster in relative size over time.

Finally, Figure 3 displays the annual growth in real wage income for unskilled and skilled workers, respectively. One notes that skilled workers have experienced a con-

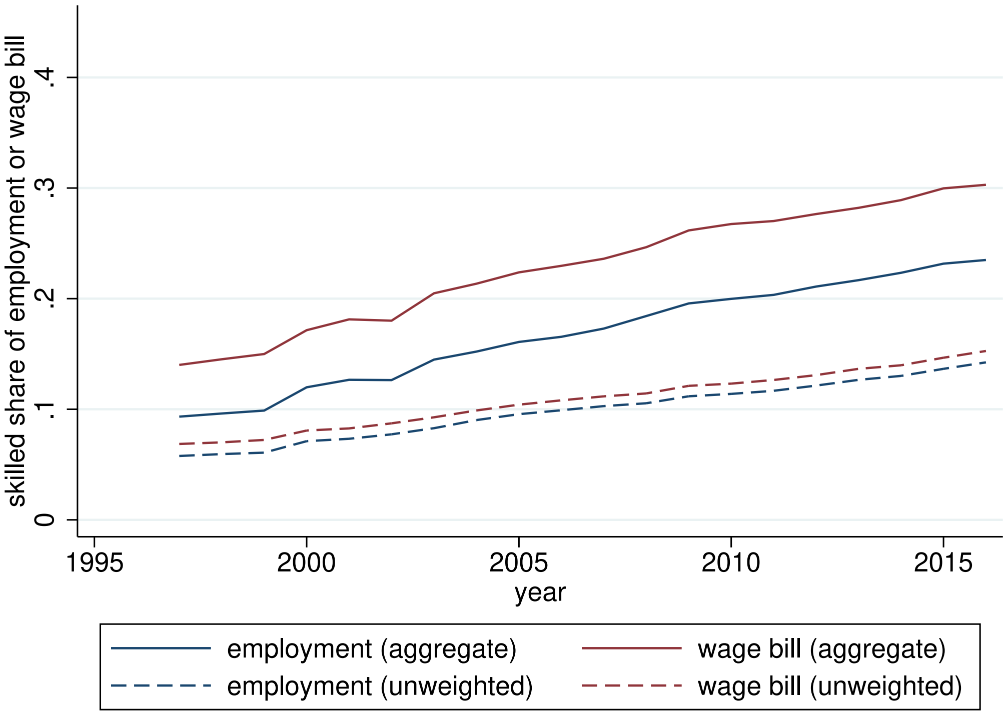


Figure 2. Evolution of worker skill composition.

Note: The sample consists of workers for firms in the manufacturing sector during 1997–2016. For each year, I calculate the aggregate share of workers that have a college degree and the share of total wages that is paid to these workers and plot these in the solid lines. The dashed lines show the unweighted means of the same variables across firms for each year.

sistently higher rate of income growth than unskilled workers have. Interestingly, the difference is the most pronounced in the first half of the sample, which is also the part of the sample during which the rise in market concentration is the most rapid. The equivalent figure for all sectors is found in Appendix Figure B.3.

4 Do larger firms employ more skilled workers?

The hypothesis of the paper is that market concentration is linked to the aggregate relative demand for skill through the reallocation of production from firms using fewer skilled workers to firms using more. A requirement for this hypothesis is that larger firms systematically differ from smaller firms in the skill composition of their workers. It is not certain whether so-called superstar firms hire relatively more or fewer skilled workers than other firms. We may for example expect Spotify, Ericsson or Volvo to be very skill-intensive, while IKEA and H&M are famous large-scale employers of unskilled workers.

I therefore proceed to analyze the relationship between size and skill intensity in Sweden. I illustrate the relationship between size and skill intensity in worker composition

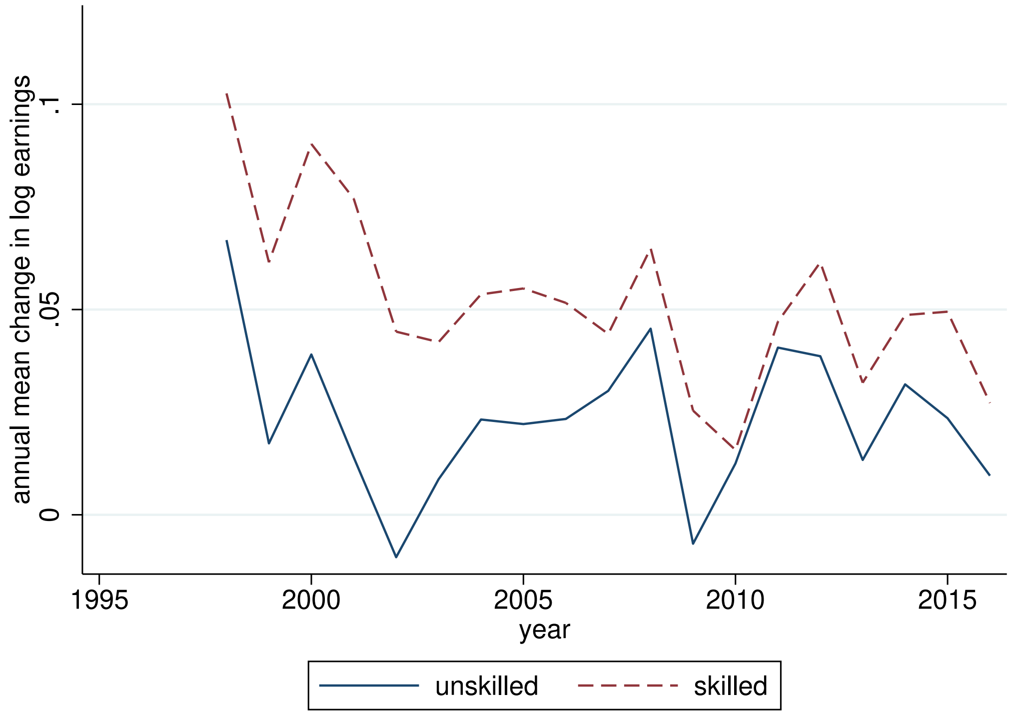
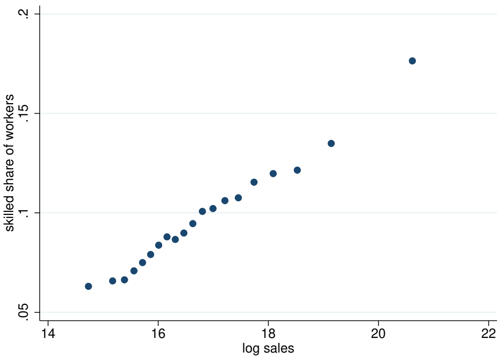


Figure 3. Evolution of real earnings growth.

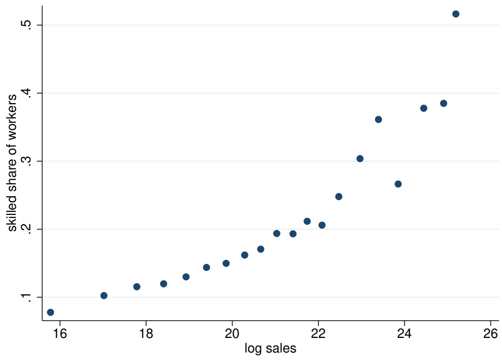
Note: The sample consists of workers for firms in the manufacturing sector during 1997–2016. For each year, I calculate the mean real change in log wage income over all workers. The equivalent figure for all sectors is found in Appendix Figure B.3. Swedish CPI (KPI) has been used to transform nominal growth to real growth.

in Figure 4. I divide all 219,475 firm-year observations in the manufacturing sector into twenty quantiles based on sales, and plot the mean share of skilled workers in employment for each quantile in panel a). I observe a remarkably strong correlation between size and the skill intensity in employment. Only about 6 percent of the workforce of the smallest firms have a college degree versus 17 percent for workers in the firms in the highest size quantile. In panel b) I weight each observation by its value added and the pattern is the same. In panel c) I plot the weighted residuals after taking out sector and year fixed effects and, if anything, the slope of the line seems to become steeper. This is true especially for the largest firms. In panel d) I plot weighted residuals after controlling for non-parametric sector-specific time trends (more exactly sector specific year fixed effects), but this does not change the result. Appendix Figure B.5 shows that these patterns hold also for the entire private economy.

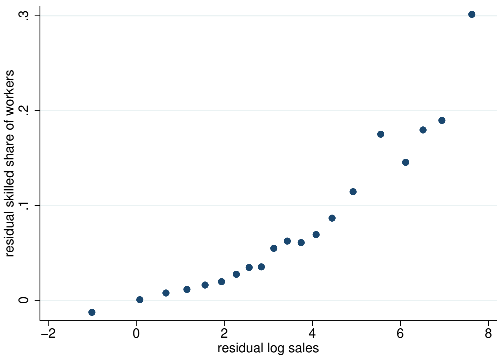
An important aspect of my hypothesis is that aggregate changes are driven by reallocation across firms, and not within-firm changes when the relative size of firms changes. A way to see if the differences across firms discussed in the previous paragraph are stable across time, or if firms instead adjust the skill composition among their workers when they grow or shrink, is to look at residuals after controlling for firm fixed effects. One then



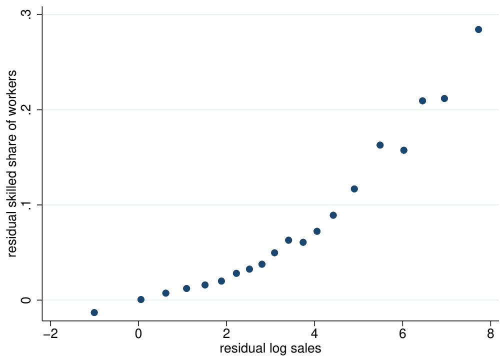
(a) Unweighted.



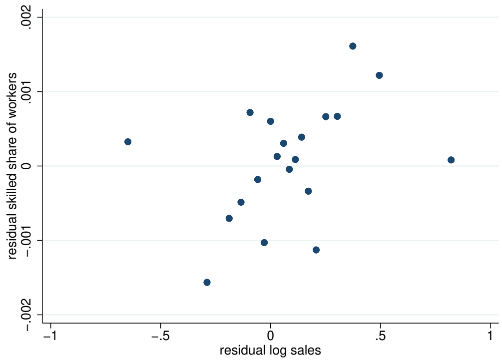
(b) Weighted by value added.



(c) Four-digit sector and year fixed effects.



(d) Four-digit sector-specific year fixed effects.



(e) Firm fixed effects.

Figure 4. Firm size and the share of skilled workers in employment.

Note: I divide the manufacturing sample consisting of 219,475 firm-year observations into 20 quantiles based on annual sales and plot the mean share of skilled workers in employment for each quantile. In panels b), c), d) and e) I weight each firm by its value added. In panel c) I do not use raw numbers but instead residuals after taking out four-digit sector and year fixed effects. In panel d) I use residuals after taking out four-digit sector times year fixed effects (i.e. year fixed effects that are specific to each four-digit sector). In panel e) I use residuals after taking out firm and year fixed effects. Appendix Figure B.4 shows the same figures but uses the wage share of skilled workers rather than the employment share. Appendix Figure B.5 shows that these patterns for the entire private economy.

removes all permanent differences across firms and only uses within-firm variation. The results from doing this are shown in panel e). The differences across bins are now very small.[14]

Differences across rather than within firms therefore seem to be the main cause for the patterns in the previous figures. Importantly, these results are in line with a key assumption of the model in Section 2, permanent differences in skill intensities between firms appear quantitatively much more important than within-firm upgrading of skill intensities when for example firms increase in size. In fact, 84 percent of the variation in the skill composition across observations is between-firm variation and only 16 percent is within-firm variation.[15]

To see if there is a significant change over time in the relationship between size and the skill intensity of the workforce, I plot how this relationship evolves in Figure 5. All three series use residuals after taking out fixed effects for four-digit sector and year. The slopes do not differ dramatically, except towards the right tail where the slope is steeper in more recent years. The change is again most dramatic in the top quantile. The residual share of skilled workers among superstar firms has actually almost doubled, further increasing the potential effect that a reallocation of production towards the largest firms has on the aggregate employment of skilled workers. In any case, since a correlation between size and skill intensity has prevailed throughout the sample, and has in fact even increased, a reallocation of production from smaller to larger firms must also mean that the aggregate utilization of skilled workers increases.

5 Market Concentration, Skill Composition and the Skill Wage Premium

5.1 Skill Composition

I now investigate whether an increase in market concentration is linked to an increase in the usage of skill in production. I first plot a scatter diagram where overall changes during the sample period in the share of workers that have a college degree are linked to changes in market concentration. These graphs are shown for two-digit and four-digit sectors, respectively, and use the change in the concentration among the four largest firms and the change in the Herfindahl index. Figure 6 shows that there appears to be a positive correlation, regardless of whether one looks at two-digit industries in panel a) or four-digit industries in panel b) or whether one looks at the share of the four largest firms or the Herfindahl index. The industries which experienced an increase in concentration relative

[14] The slope is positive but close to zero as can be seen from the very small range on the vertical axis.

[15] Appendix Figure B.4 shows that these patterns hold also when one uses the wage share rather than the employment share of skilled workers.

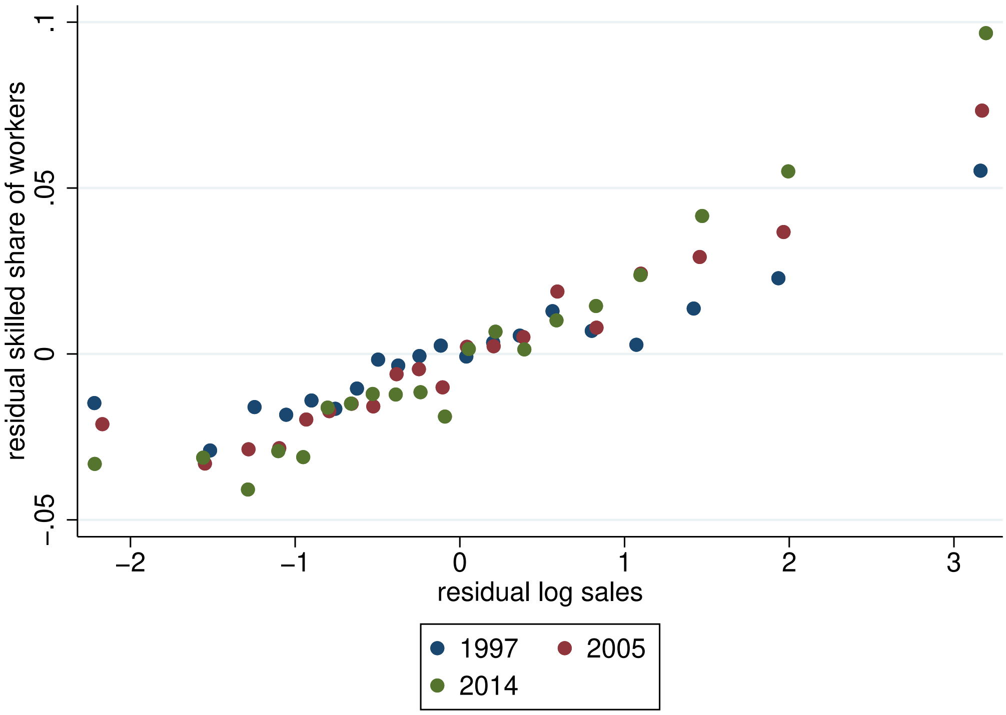


Figure 5. Firm size and the skill share over time.

Note: For the first, middle and last year of the manufacturing firm sample (1997, 2005 and 2014) I divide the observations into 20 quantiles based on annual sales and plot the mean share of skilled workers in employment for each quantile, separately by year. All observations are weighted by value added and are the residuals after taking out fixed effects for four-digit sectors.

to other industries therefore also increased their employment of college-educated workers relatively more.[16]

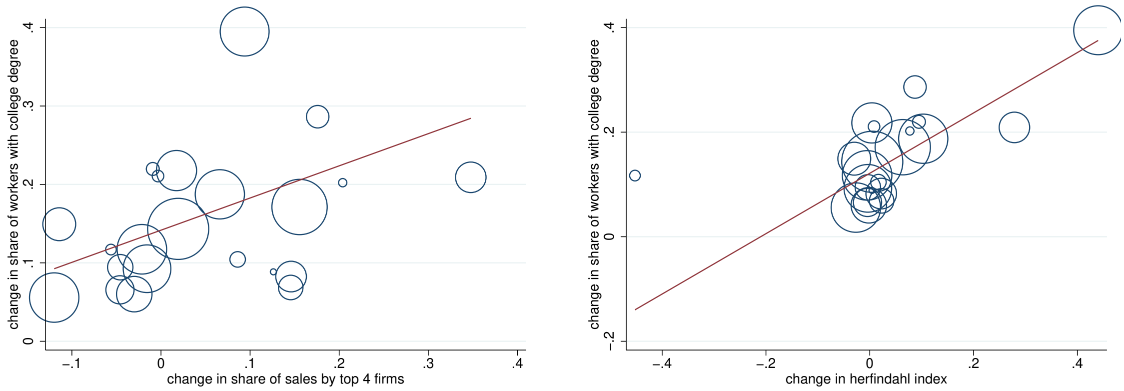
The following is the main specification for my regressions:

$$\Delta Y_{it} = \beta \Delta C_{it} + d_t + \varepsilon_{it} \tag{7}$$

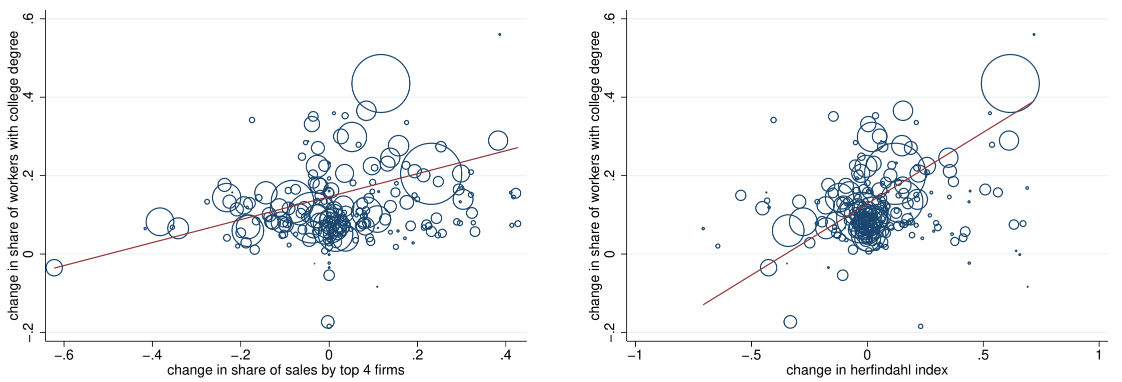
where Y_{it} is a measure of the share of skilled workers in production in industry i and year t, C_{it} is the market concentration and d_t are year fixed effects. I use 2-year and 4-year non-overlapping changes in the baseline specification, and cluster the standard errors by industry to allow for correlation over time.

Row 1 in Table 2 reports the results for the baseline specification. The results are reported for using the share of the top four firms, the top twenty firms, and the Herfindahl index as concentration measures. The estimated coefficients are positive and statistically significant for all cases. Industries that experience a relatively larger rise in market concentration than other industries also experience a relatively stronger rise in the share of workers that have a college degree. In row 2 I add industry fixed effects, which means that

[16]Appendix Figure B.6 shows that an almost identical pattern applies when one looks at changes in the share of the wage bill that is paid to college-educated workers instead.



(a) Two-digit industries.



(b) Four-digit industries.

Figure 6. Change in the share of workers with a college degree and change in market concentration.

Note: I calculate for each manufacturing industry the share of workers that have a college degree and the market concentration for the first and last year of the sample: 1997 and 2016. I then plot the changes in the figures where the size of the circles is determined by the baseline value added of each industry. In panel (a) I use two-digit industries and in (b) I use four-digit industries. The straight line shows a linear relationship between the two variables. This line is weighted by the baseline value added in each industry.

the estimation is based only on accelerations and decelerations in the rate of change relative to industry-specific trends. The coefficients are of very similar magnitudes, although the standard errors are slightly larger. In rows 3 and 4 I split the sample into two time periods to examine whether the patterns hold throughout the sample. The coefficients are largely similar. The results are slightly more pronounced in the early period but they are significant and reasonably large also in the second period. In row 5 I use concentration measures based on employment instead of sales and find somewhat larger coefficients. Finally, I account also for imports since the Swedish market is served not only by domestic firms but also by firms from abroad. Ignoring foreign supply may therefore lead to an exaggeration of the true levels of concentration. I include imports from twelve blocks of countries and treat these blocks as individual firms when I compute the concentration measure.[17] Note

[17] The blocks of countries are the following: Denmark; Norway; Finland; Germany; the United Kingdom; the rest of Western Europe; Eastern Europe including Russia; China; NAFTA; East and South-East Asia;

that imports therefore enter also the denominator in the construction of the concentration measures since the total market is larger when I include also the sales of foreign firms in Sweden. Row 6 reports these estimates and I note that the estimates do not change substantially.

5.2 Skill Wage Premium

It is important to understand changes in the relative demand for skilled workers since they affect differences in welfare-relevant outcomes for skilled and unskilled workers, and perhaps most importantly differences in wages between the two groups. For relative demand to affect relative wages in a sector, however, there have to be at least some frictions, such as in a specific-factor model, in the mobility of workers across sectors. Without such frictions wages would equalize across sectors and the relative wage be the same. This is important to keep in mind when interpreting the results in the paper, even though it is highly plausible that such frictions exist (see for example Rogerson, 2008).

I will thus analyze whether changes in market concentration are linked to changes in relative wages. For this purpose I use data on the annual wage income of all workers in the sample and calculate a so-called skill premium for each four-digit industry, i.e. the difference between the mean log wage income for skilled workers and the mean log wage income for unskilled workers. In Figure 7I plot the long-term 1997–2016 changes in the skill premium and market concentration for four-digit industries where I weight each industry with its baseline share of aggregate value added. I find a positive and statistically significant relationship between the change in the skill premium and market concentration.

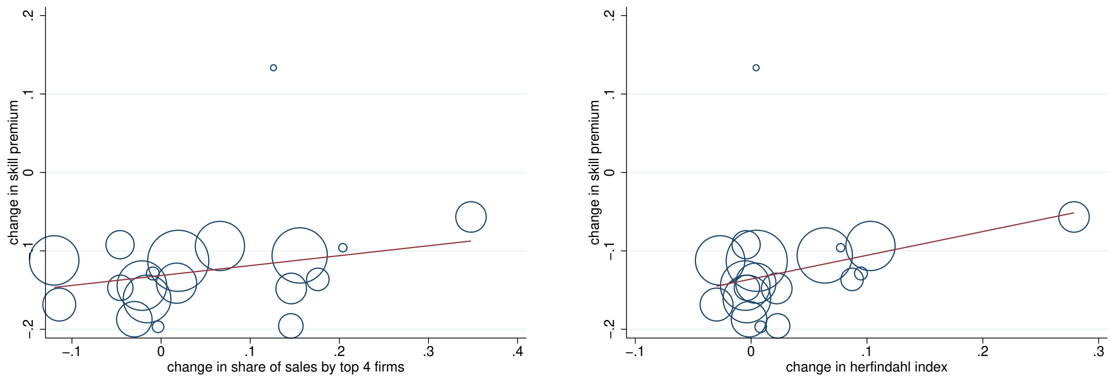
I proceed to putting the same hypothesis to test in a regression analysis. I estimate the regression in equation (7) where 2-year and 4-year changes in the skilled wage premium are the dependent variables and changes in concentration represent is the explanatory variable. Table 3 reports the results. In the baseline specification in row 1 I note a positive effect for all measures of concentration and for both 2-year and 4-year changes. This means that an increase in market concentration is correlated with an increase in wage inequality. I proceed to including industry fixed effects in row 2. Since I use changes and not levels in the skill premium and concentration, adding industry fixed effects, again, means that I only use variation in accelerations and decelerations in the rate of change in the variables. Nevertheless, the coefficients change only in a minor way. In rows 3 and 4 I divide the sample into two and in row 5 I use the employment-based concentration measure instead of the sales-based measure as in the other rows. In row 6 I also include the potential effects of foreign competition as in Table 2. These specifications yield more

South and Central America; and the rest of the world.

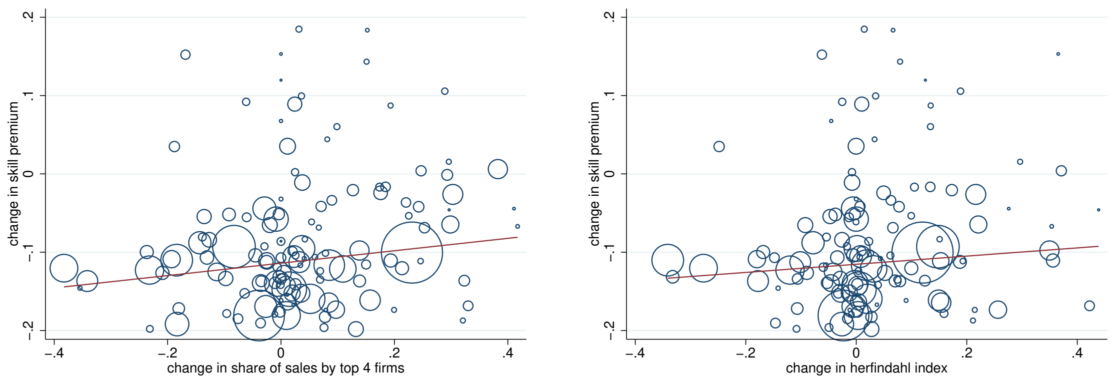
Table 2. Regression results for the relative employment of skilled workers.

	2-year			4-year		
	CN4	CN20	HHI	CN4	CN20	HHI
	(1)	(2)	(3)	(4)	(5)	(6)
Dep. var.: Change in relative employment of skilled workers						
1. Baseline	0.10***	0.14***	0.10***	0.13***	0.15***	0.15***
	(0.02)	(0.04)	(0.03)	(0.04)	(0.04)	(0.06)
2. Industry fixed effects	0.09***	0.13***	0.08***	0.10***	0.15***	0.11**
	(0.02)	(0.05)	(0.02)	(0.03)	(0.04)	(0.04)
3. First half of sample: year $\leq$ 2008	0.10***	0.15***	0.11**	0.13***	0.17***	0.17**
	(0.02)	(0.05)	(0.04)	(0.04)	(0.05)	(0.07)
4. Second half of sample: year $\geq$ 2008	0.10***	0.08**	0.09***	0.11***	0.16***	0.10***
	(0.04)	(0.03)	(0.04)	(0.02)	(0.04)	(0.03)
5. Employment-based concentration measure	0.11***	0.13***	0.13***	0.14***	0.15***	0.17***
	(0.03)	(0.03)	(0.04)	(0.05)	(0.03)	(0.06)
6. Including imports	0.08***	0.12***	0.10***	0.11***	0.13***	0.16***
	(0.02)	(0.03)	(0.03)	(0.03)	(0.04)	(0.06)

Note: The sample consists of all four-digit manufacturing industries during 1997–2016. Columns (1) to (3) use 2-year changes and columns (4) to (6) use 4-year changes. The number of observations is 1,992 for columns (1) to (3) and 1,100 for columns (4) to (6), except for row 3 where the numbers of observations are 1,112 and 443, respectively, and for row 4 where the numbers are 880 and 657, respectively. Each cell reports estimates for coefficient β in equation (7). The coefficient therefore represents the average correlation between the change in the sales-based concentration measure and the change in the share of workers that have college degrees. The unit of observation is a four-digit industry and each industry is weighted by its baseline level of value added. Each regression includes year fixed effects and the errors are clustered at the four-digit industry. CN4 (CN20) refers to the share of sales that is attributed to the largest four (twenty) firms in a four-digit industry. HHI refers to the Herfindahl index for a four-digit industry. Row 2 includes also four-digit industry specific fixed effects. Rows 3 and 4 split the sample in two, such that row 3 uses the first half and row 4 the second half. Row 5 uses employment-based concentration measures instead of sales-based measures as in the other rows. Row 6 includes also imports in the construction of the concentration measures. I include imports from twelve blocks of countries and treat these blocks as individual firms when I compute the concentration measure. The blocks of countries are the following: Denmark; Norway; Finland; Germany; the United Kingdom; the rest of Western Europe; Eastern Europe including Russia; China; NAFTA; East and South-East Asia; South and Central America; and the rest of the world. Note that imports therefore enter also the denominator in the construction of the concentration measures since the total market is larger when I include also the sales of foreign firms in Sweden. * indicates a p-value of less than 10%, ** less than 5%, and *** less than 1%.



(a) Two-digit industries.



(b) Four-digit industries.

Figure 7. Change in the skill premium and change in market concentration.

Note: I calculate for each manufacturing industry the difference in the mean log wage of skilled and unskilled workers as well as the market concentration for the first and last year of the sample: 1997 and 2016. I then plot the changes in the figures where the size of the circles is determined by the baseline value added of each industry. In panel (a) I use two-digit industries and in (b) I use four-digit industries. The straight line shows a linear relationship between the two variables. This line is weighted by the baseline value added in each industry.

or less the same coefficients as above.

These findings are in line with the hypothesis of the paper: that a rise in market concentration which reallocates workers from less to more skill intensive firms is linked to a rise in relative wage income. They are thus also consistent with the notion that changes in this measure of wage inequality may at least partly be due to the rise in market concentration.

5.3 Results for non-manufacturing sectors

I now turn to analyze these relationships also in non-manufacturing sectors. One can see the links between market concentration and the relative employment and wage of skilled workers in Table 4. Most importantly, Row 1 reports the results for the economy as a whole and it appears that the effects are positive and highly significant. There are fewer observations in more detailed sectors outside manufacturing which cause standard errors

Table 3. Regression results for wage inequality.

	2-year			4-year		
	CN4	CN20	HHI	CN4	CN20	HHI
	(1)	(2)	(3)	(4)	(5)	(6)
Dep. var.: Change in skilled wage premium						
1. Baseline	0.11***	0.20***	0.11*	0.09*	0.22**	0.06
	(0.04)	(0.05)	(0.06)	(0.05)	(0.10)	(0.06)
2. Industry fixed effects	0.11***	0.21***	0.13*	0.10	0.26*	0.09
	(0.04)	(0.05)	(0.07)	(0.06)	(0.13)	(0.06)
3. First half of sample: year $\leq$ 2008	0.08**	0.20***	0.08	0.09*	0.27**	0.04
	(0.04)	(0.05)	(0.06)	(0.05)	(0.11)	(0.07)
4. Second half of sample: year $\geq$ 2008	0.18**	0.19**	0.16*	0.15**	0.25**	0.14**
	(0.08)	(0.09)	(0.10)	(0.06)	(0.11)	(0.07)
5. Employment-based concentration measure	0.09	0.21***	0.04	0.05	0.17**	-0.00
	(0.06)	(0.04)	(0.10)	(0.06)	(0.07)	(0.09)
6. Including imports	0.09**	0.19***	0.10	0.07	0.20**	0.02
	(0.04)	(0.06)	(0.07)	(0.04)	(0.10)	(0.06)

Note: The sample consists of all four-digit manufacturing industries during 1997–2016. Columns (1) to (3) use 2-year changes and columns (4) to (6) use 4-year changes. The number of observations is 1,939 for columns (1) to (3) and 1,073 for columns (4) to (6), except for row 3 where the numbers of observations are 1,086 and 647, respectively, and for row 4 where the numbers are 853 and 639, respectively. Each cell reports estimates for coefficient β in equation (7). The coefficient therefore represents the average correlation between the change in the sales-based concentration measure and the change in the difference in mean log wage income between skilled and unskilled workers. The unit of observation is a four-digit industry and each industry is weighted by its baseline level of value added. Each regression includes year fixed effects and the errors are clustered at the four-digit industry. CN4 (CN20) refers to the share of sales that is attributed to the largest four (twenty) firms in a four-digit industry. HHI refers to the Herfindahl index for a four-digit industry. Row 2 includes also four-digit industry specific fixed effects. Rows 3 and 4 split the sample in two, such that row 3 uses the first half and row 4 the second half. Row 5 uses employment-based concentration measures instead of sales-based measures as in the other rows. Row 6 includes also imports in the construction of the concentration measures. * indicates a p-value of less than 10%, ** less than 5%, and *** less than 1%.

to be somewhat larger. But the overall message is that the coefficients for the link between relative employment of skilled workers and market concentration are positive for all sectors. The link for relative wages is also positive in all cases except in retail trade, a sector that employs relatively few skilled workers, where the coefficients are instead located around zero.

6 Decomposing aggregate changes into within and between firm changes

I now turn to examining if the relationship between market concentration and the relative employment and income of skilled workers is due to a reallocation of production across firms, i.e. from smaller firms with less educated workers towards larger firms with more educated workers, or to a general skill upgrading among all firms. To do so, I decompose industry-level changes in skill composition into within and between firm changes as well as changes due to the entry and exit of firms. Between-firm changes must be linked to changes in market concentration in a quantitatively important way if the hypothesis of this paper is true and if reallocation across firms is an important mechanism.

More specifically, I use the model in Olley and Pakes (1996) to divide the change in an industry's aggregate skill composition into, on the one hand, changes in the unweighted mean across firms and, on the other hand, changes in the allocation of production across firms. In line with Olley and Pakes (1996) I decompose Y, the industry share of skilled workers in total employment, in the following way:

$$Y = \sum_i s_i Y_i = \bar{Y} + \sum_i (s_i - \bar{s})(Y_i - \bar{Y}) \tag{8}$$

where s_i denotes the share of firm i in an industry's value added; Y_i denotes the firm-level share of skilled workers in total employment; and $\bar{s}$ and $\bar{Y}$ denote unweighted means of the share of value added and the share of skilled workers in total employment, respectively. The first term, $\bar{Y}$, captures the mean share of skilled workers across firms, which is independent of allocation of production. The second term, $\sum_i (s_i - \bar{s})(Y_i - \bar{Y})$, captures how the allocation of production between firms with varying skill intensity affects the aggregate share of skilled workers in total employment.

When one analyzes changes over time in the industry-level share of skilled workers in total employment, $\Delta Y \equiv Y_2 - Y_1$ where the subscripts indicate time, and attribute this change to changes in its various components, it is useful to account also for the effect of entry and exit. Melitz and Polanec (2015) expand the model in equation (8) in the

Table 4. Regression results for all sectors.

	2-year					
Dep. var.:	*Change in relative employment of skilled workers*			*Change in skilled wage premium*		
	CN4	CN20	HHI	CN4	CN20	HHI
	(1)	(2)	(3)	(4)	(5)	(6)
1. All industries	0.08***	0.08***	0.12**	0.09***	0.14***	0.09*
	(0.02)	(0.02)	(0.06)	(0.03)	(0.04)	(0.04)
2. Manufacturing	0.10***	0.14***	0.10***	0.11***	0.20***	0.11*
	(0.02)	(0.04)	(0.03)	(0.04)	(0.05)	(0.06)
3. Services	0.04*	0.02*	0.07*	0.07	0.14***	0.07
	(0.02)	(0.01)	(0.04)	(0.06)	(0.05)	(0.07)
4. Utilities and Transportation	0.18	0.12	0.36	0.21	0.17	0.16
	(0.18)	(0.15)	(0.36)	(0.16)	(0.20)	(0.13)
5. Retail Trade	0.04**	0.07***	0.01	0.01	-0.08	0.02
	(0.02)	(0.02)	(0.02)	(0.06)	(0.13)	(0.06)
6. Wholesale Trade	0.05***	0.05***	0.08***	0.10	0.22	0.45
	(0.01)	(0.01)	(0.01)	(0.20)	(0.18)	(0.64)

Note: The sample consists of all four-digit industries during 1998–2016. Columns (1) to (3) use 2-year changes in the relative employment of skilled workers and columns (4) to (6) 2-year changes in the skilled wage premium. The number of observations in the six rows are the following. Row 1: 3,194; row 2: 1,992; row 3: 360; row 4: 213; row5: 584; row6: 45. Each cell reports estimates for coefficient β in equation (7). The coefficient therefore represents the average correlation between the change in the sales-based concentration measure and the change in the difference in mean log wage income between skilled and unskilled workers. The unit of observation is a four-digit industry and each industry is weighted by its baseline level of value added. Each regression includes year fixed effects and the errors are clustered at the four-digit industry. CN4 (CN20) refers to the share of sales that is attributed to the largest four (twenty) firms in a four-digit industry. HHI refers to the Herfindahl index for a four-digit industry. * indicates a p-value of less than 10%, ** less than 5%, and *** less than 1%.

following way:

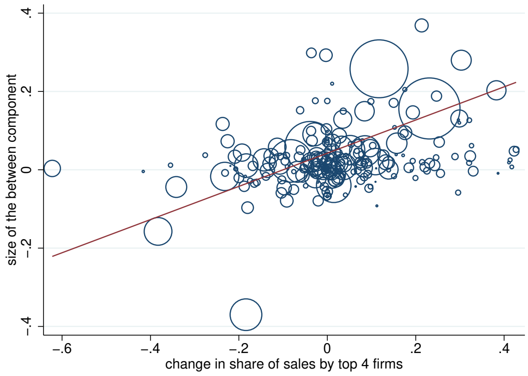
$$\Delta Y = \Delta \bar{Y}_S + \Delta \left(\sum_i (s_i - \bar{s})(Y_i - \bar{Y}) \right)_S + s_{E2}(Y_{E2} - Y_{S2}) + s_{X1}(Y_{S1} - Y_{X1}) \quad (9)$$

where subscript S, E and X indicate firms that survive, enter and exit, respectively. s_{E2} denotes the share of value added in period 2 of firms that enter, while s_{X1} denotes the share of value added in period 1 of firms that exit. The first component in equation (9) is therefore the within-firm change, i.e. the change in the unweighted mean skill share. The second component contains the between-firm effects: the change in the covariance between size and the share of skilled workers in total employment. The third component shows the effect from entry: the share of value added of these firms in the second period multiplied with how their skill composition of workers differ from that of existing firms. Similarly, the fourth component captures the effect from exit by multiplying the share of value added of exiting firms with how their skill composition differs from surviving firms.

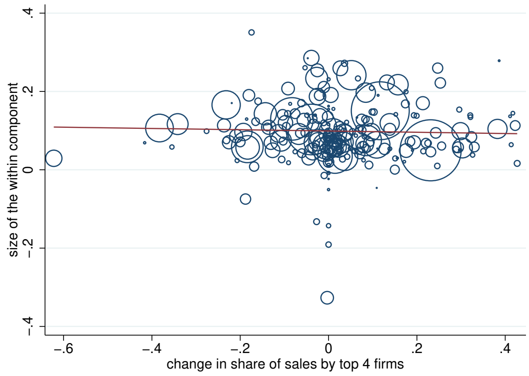
If the hypothesis of this paper is true, there should be a link between the rise in concentration and the reallocation of production from firms with a less skilled workforce to those with a more skilled workforce. A way to analyze this is to examine whether the between-firm component is correlated with changes in market concentration, and if it is more strongly correlated than for example the within-firm component. Figure 8 plots the cumulative effects from the between- and within-firm components for each four-digit industry versus the change in market concentration based on the share in industry sales by the largest four firms. One can detect a strong correlation between the changes in market concentration and the between-firm component, but not with the within-firm component. This result is in line with the hypothesis. Figure 8 also shows that this conclusion holds both for the manufacturing sector specifically and for the economy as a whole. Appendix Figures B.7 and B.8 show that this pattern holds also when I use the share in industry sales by the top twenty firms and the Herfindahl index of sales, respectively, as measures of market concentration instead.[18]

Table 5 provides results from regressing annual levels in the four different components that Melitz and Polanec (2015) emphasize on the change in market concentration at the four-digit industry level. The regressions contain year fixed effects and industries are weighted by baseline levels of value added. The first four columns report results for manufacturing sectors and show that market concentration is most strongly correlated with the between-firm component and hardly correlated at all with the within-firm component. The last four columns confirm that this holds also for the economy as a whole and not only

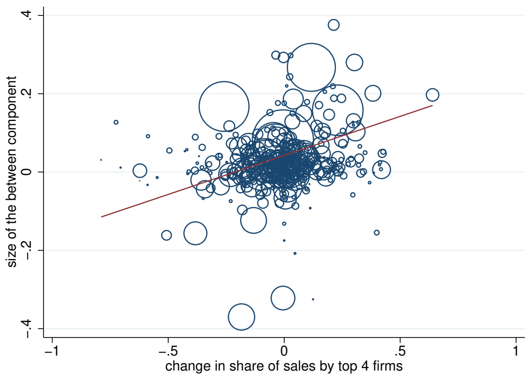
[18]The patterns are virtually the same when I use the share of the wage bill instead. These graphs are available upon request.



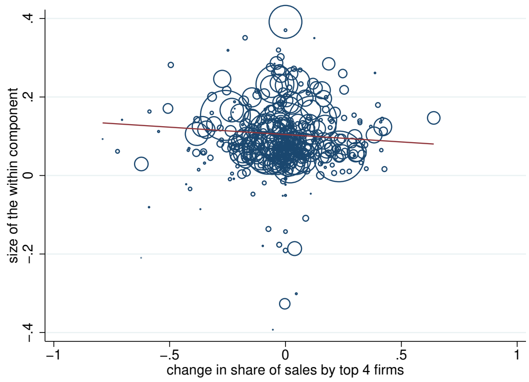
(b) Between firm component (manufacturing).



(c) Within firm component (manufacturing).



(e) Between firm component (all sectors).



(f) Within firm component (all sectors).

Figure 8. Between- and within-firm components in the aggregate share of skilled workers in employment and the change in market concentration (share in sales to top four firms) across four-digit industries.

Note: The sample consists of four-digit industries during 1997–2016. For each year I have decomposed the change in the aggregate share of college-educated workers in employment into between firm change, within firm change as well as entry and exit according to Melitz and Polanec (2015) as outlined in equation (9). The vertical axis in the scatter diagram contains the cumulative effect of a specific component and the horizontal axis contains the change in market concentration as measured by the share of the top four firms in total industry sales. The straight line shows a linear relationship between the two variables. This line is weighted by the baseline value added in each industry. Subfigures a and b show manufacturing sectors only, while c and d show all sectors. Appendix Figures B.7 and B.8 show the same graphs using the share of the top twenty firms in sales and the Herfindahl index of sales, respectively, instead.

for manufacturing.

I conclude that the between-firm component is quantitatively a very important source of change in the aggregate share of college-educated workers in employment. Moreover, the between-firm component is the component that is most strongly affected by changes in market concentration. This means that the main mechanism by which a rise in market concentration raises the skill utilization in an industry is by reallocating production across firms in a way that is systematically linked to how firms differ in their use of skilled workers. Importantly, these results also indicate that shocks to market concentration do not appear to be linked to within-firm changes in which workers firms employ. When

Table 5. The components of changes in aggregate skill shares in employment and their relation to changes in market concentration.

	Manufacturing				All sectors			
	Between	Within	Entry	Exit	Between	Within	Entry	Exit
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
CN4	0.20***	0.00	0.07**	0.02	0.12***	0.01*	0.07*	0.04
	(0.07)	(0.01)	(0.03)	(0.01)	(0.04)	(0.01)	(0.04)	(0.03)
CN20	0.39***	0.01	0.07***	0.03	0.17**	0.00	0.03***	0.03
	(0.14)	(0.01)	(0.02)	(0.02)	(0.08)	(0.02)	(0.01)	(0.02)
HHI	0.21***	0.00	0.11*	0.01	0.12**	0.03***	0.12**	0.06
	(0.07)	(0.01)	(0.06)	(0.02)	(0.06)	(0.01)	(0.06)	(0.05)

Note: The sample consists of all four-digit industries during 1997–2016. For each year I have decomposed the change in the aggregate share of college-educated workers in employment into within firm change, between firm change as well as entry and exit according to Melitz and Polanec (2015) as outlined in equation (9). I then perform regressions of the four different components on changes in market concentration with year fixed effects. Each four-digit industry is weighted based on its baseline level of value added. All columns use the decomposition components of the share of workers that have a college degree while columns (1) to (4) focus on the manufacturing sector only and (5) to (8) on all sectors. The unit of observation is a four-digit industry and each industry is weighted by its baseline level of value added. Each regression includes year fixed effects and the errors are clustered at the four-digit industry. CN4 (CN20) refers to the share of sales that is attributed to the largest 4 (20) firms in a four-digit industry. HHI refers to the Herfindahl index for a four-digit industry. * indicates a p-value of less than 10%, ** less than 5%, and *** less than 1%.

concentration increases, it is thus the case that output is reallocated across firms rather than firms changing their skill composition within.

7 Conclusion

The rise in market concentration can potentially explain some of the rise in the skill wage premium and the rise in the employment of skilled workers if large firms systematically use skilled workers relatively more than other firms. I find that they do: there is a strong correlation between firm size and the share of employees that have a college degree as well as the share of the wage bill that is paid to college-educated workers. The gradient is the steepest among the very largest firms.

In addition, the analysis in this paper shows that changes in the share of skilled workers in employment and also the relative wage of skilled workers are systematically linked to changes in market concentration. Regardless of which concentration measure I use, be it the share of the top four or twenty firms in sales or the Herfindahl index, sectors where superstar firms become more important also increase their usage of skilled workers and increase the wage premium to skill. I find that this link is robust to several specification checks and also holds for different sample periods as well as across sectors.

I subsequently decompose the change in the aggregate relative employment of skilled workers into between- and within-firm components, as well as contributions from entry and exit. The between-firm component is the component that is by far most strongly correlated with changes in market concentration, and the within-firm component is not correlated at all. This shows that sectors with rising concentration have had a higher reallocation of production from less skill-intensive to more skill-intensive firms than other sectors. Moreover, the results contradict alternative explanations that build on skill upgrading that occurs across all firms when market concentration increases.

This paper therefore points to a potential new reason for the rise in the demand for skill and income inequality, namely that the structure of markets has changed in a way that has benefited firms using skilled workers more intensively. If superstar firms are more skill-intensive than other firms, any policy or technology that causes these firms to expand more than other firms will raise the aggregate relative demand for skilled workers. Much of the literature has so far focused on market concentration lowering the share of labor in income. I show that market concentration may not only lead to inequality between workers and owners of other factors of production, but also to inequality between different types of workers.

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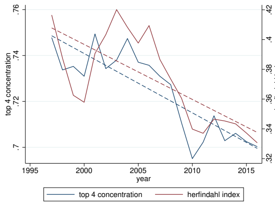
Appendix A: Data and expansion

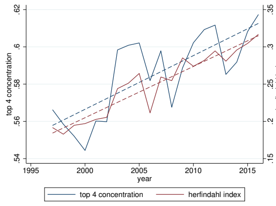
Table A.1. Variable definitions

Variable	Description
Firm accounts	Source: The Account Statistics.
Revenues	Total sales by a firm in year t.
Value added	Total value added by a firm in year t.
Industry	4-digit code classifying a firm's main activity in year t according to the Nomenclature of Economic Activities (SNI2002/NACE Rev. 1) system.
Individual characteristics	Source: National Education Database and Central Population Register.
Education level	Years of schooling.
Annual income	Labor income of an individual in year t in Swedish kronor.
International Trade	Source: UN Comtrade.
Imports	Imports in a year t by country grouping at the four-digit sectoral level. I include imports from twelve blocks of countries and treat these blocks as individual firms when I compute the concentration measure. The blocks of countries are the following: Denmark; Norway; Finland; Germany; the United Kingdom; the rest of Western Europe; Eastern Europe including Russia; China; NAFTA; East and South-East Asia; South and Central America; and the rest of the world.

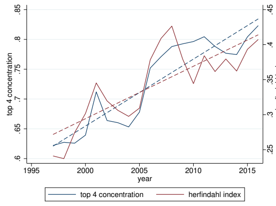
Appendix B: Figures



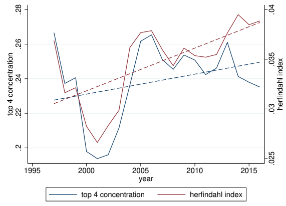
(a) Food products, beverages and tobacco.



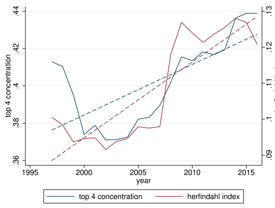
(b) Textiles and textile products.



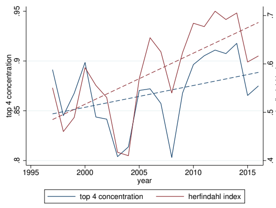
(c) Leather and leather products.



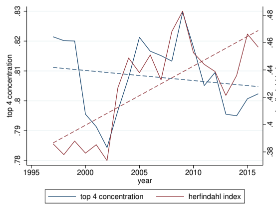
(d) Wood and wood products.



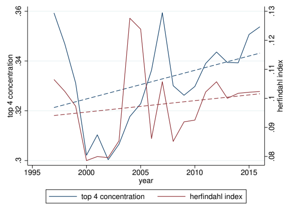
(e) Pulp and paper.



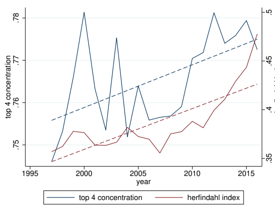
(f) Coke and refined petroleum products.



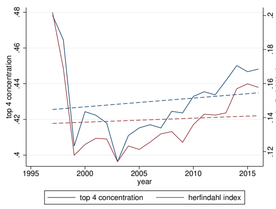
(g) Chemicals and man-made fibres.



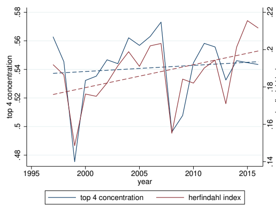
(h) Rubber and plastic.



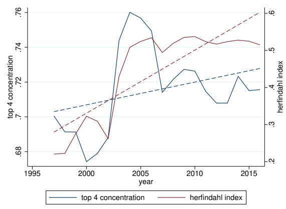
(i) Other non-metallic products.



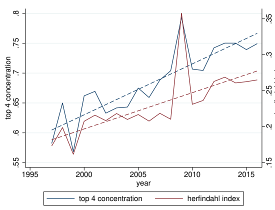
(j) Basic metals and fabricated metal products.



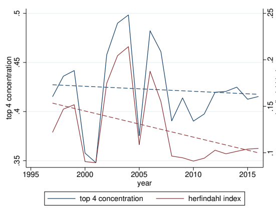
(k) Machinery and equipment nec.



(l) Electrical and optical equipment.



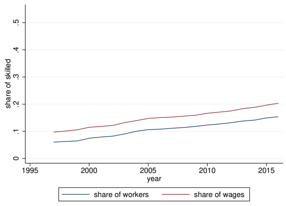
(m) Transport equipment.



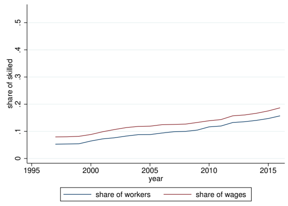
(n) Manufacturing nec.

Figure B.1. Evolution of market concentration in two-digit manufacturing sectors.

Note: The sample consists of firms in the manufacturing sector during 1997–2016. For each year and two-digit sector, I calculate for each four-digit sector the share of sales of the four largest firms as well as the Herfindahl index for sales and then calculate the overall weighted mean where the weights are the 1997 levels of value added for each four-digit sector. The dashed lines show linear trends for the two variables of interest.

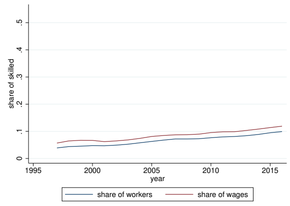


(a) Food products, beverages and tobacco.

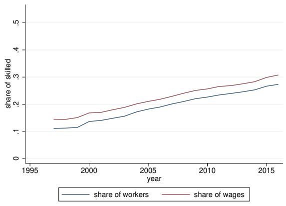


(b) Textiles and textile products.

(c) Leather and leather products.



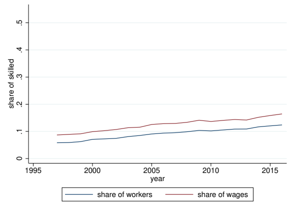
(d) Wood and wood products.



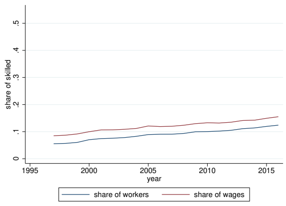
(e) Pulp and paper.

(f) Coke and refined petroleum products.

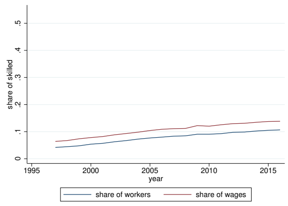
(g) Chemicals and man-made fibres.



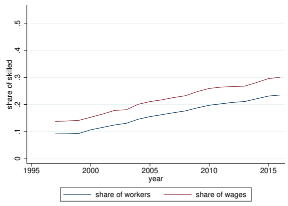
(h) Rubber and plastic.



(i) Other non-metallic products.

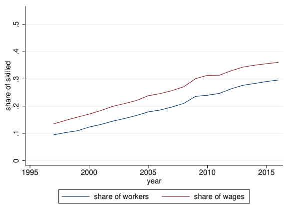


(j) Basic metals and fabricated metal products.

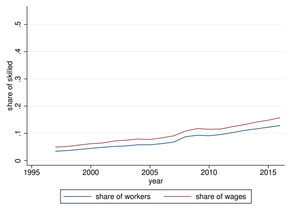


(k) Machinery and equipment nec.

(l) Electrical and optical equipment.



(m) Transport equipment.



(n) Manufacturing nec.

Figure B.2. Evolution of worker skill composition in two-digit manufacturing sectors.

Note: The sample consists of workers for firms in the manufacturing sector during 1997–2016. For each year, I calculate for each two-digit manufacturing sector the share of workers that have a college degree and the share of total wages that is paid to these workers.

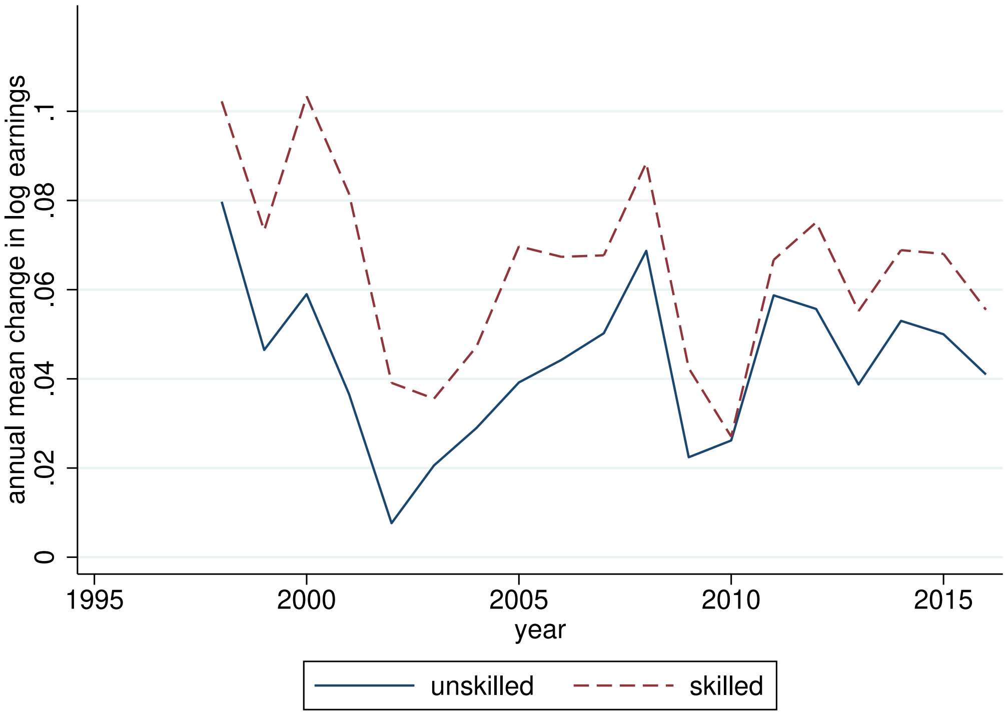
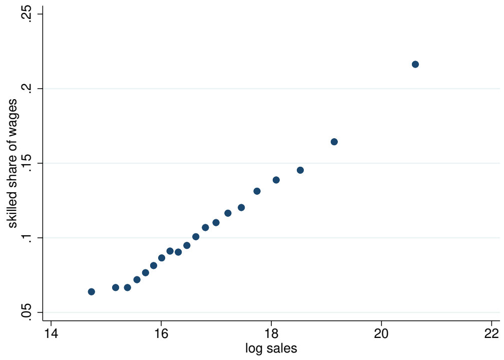
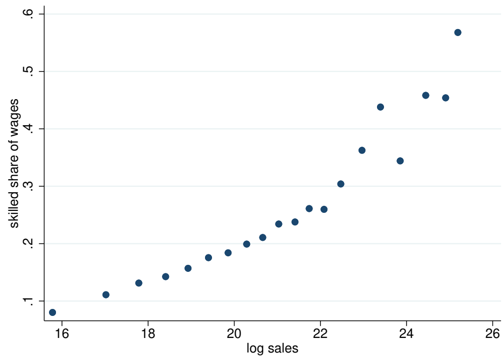


Figure B.3. Evolution of real earnings.

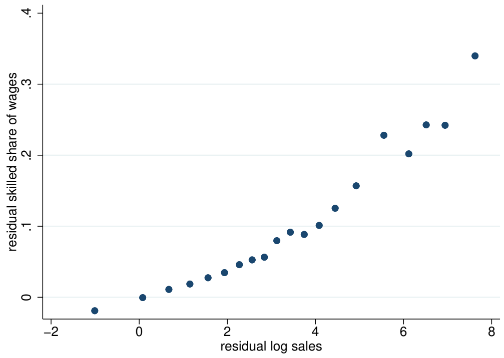
Note: The sample consists of workers for firms in the private sector during 1997–2016. For each year, I calculate the mean real change in log wage income over all workers.



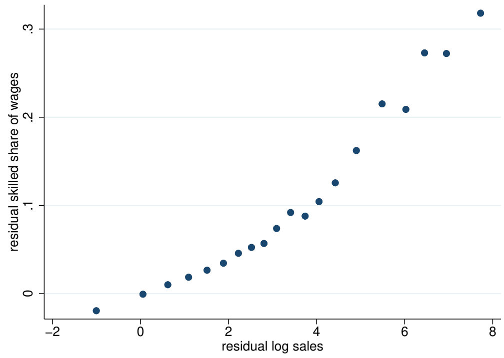
(a) Unweighted.



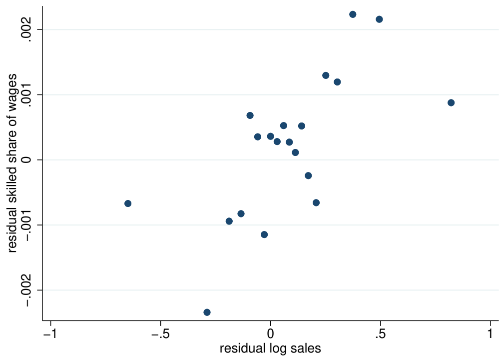
(b) Weighted by value added.



(c) Four-digit sector and year fixed effects.



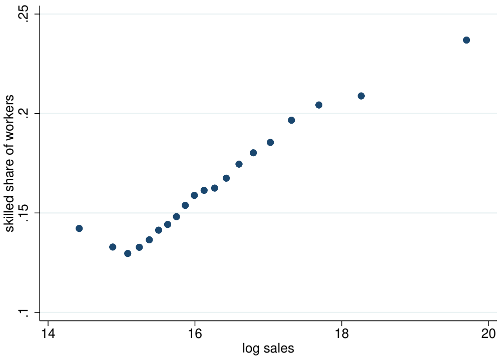
(d) Four-digit sector-specific year fixed effects.



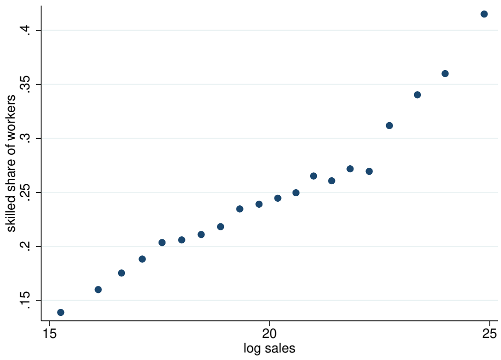
(e) Firm fixed effects.

Figure B.4. Firm size and the share of skilled workers in the wage bill.

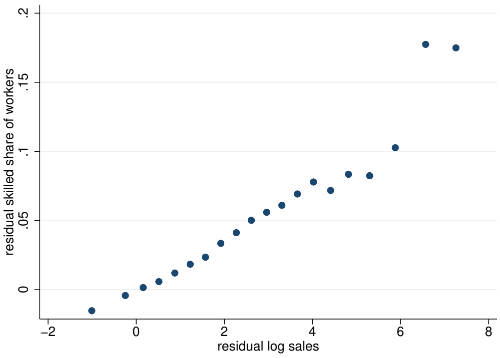
Note: I divide the manufacturing sample consisting of 219,475 firm-year observations into 20 quantiles based on annual sales and plot the mean share of skilled workers in the wages paid by firms for each quantile. In panels b), c), d) and e) I weight each firm by its value added. In panel c) I do not use raw numbers but instead residuals after taking out four-digit sector and year fixed effects. In panel d) I use residuals after taking out four-digit sector times year fixed effects (i.e. year fixed effects that are specific to each four-digit sector). In panel e) I use residuals after taking out firm and year fixed effects.



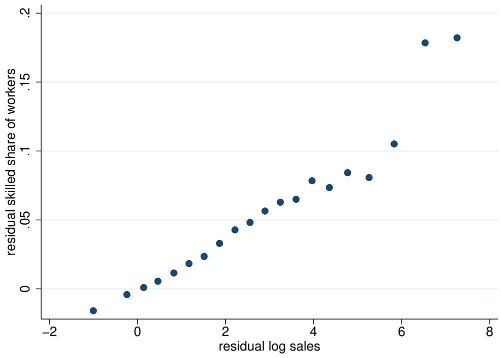
(a) Unweighted.



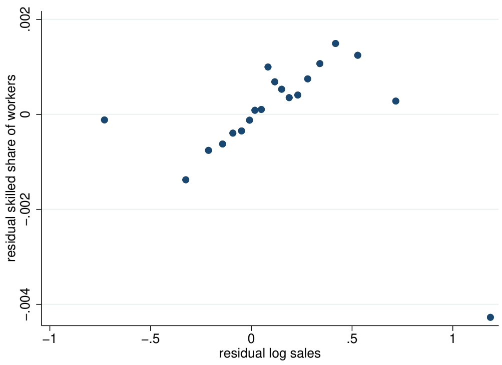
(b) Weighted by value added.



(c) Four-digit sector and year fixed effects.



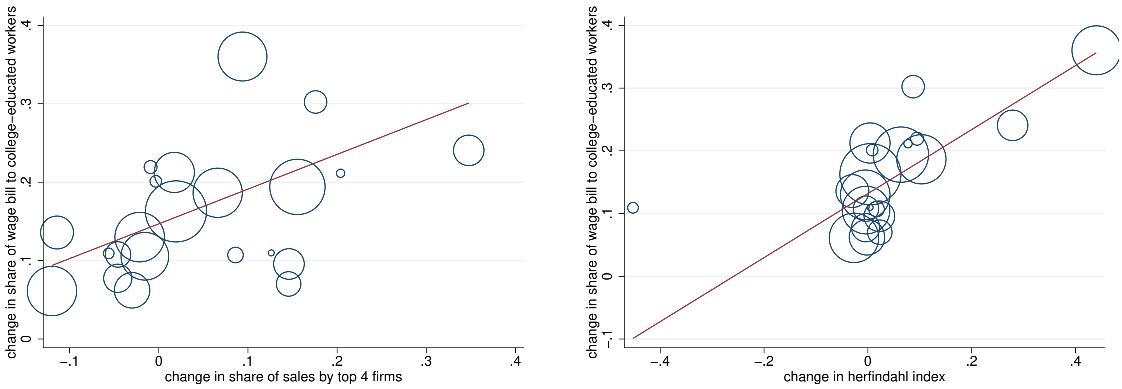
(d) Four-digit sector-specific year fixed effects.



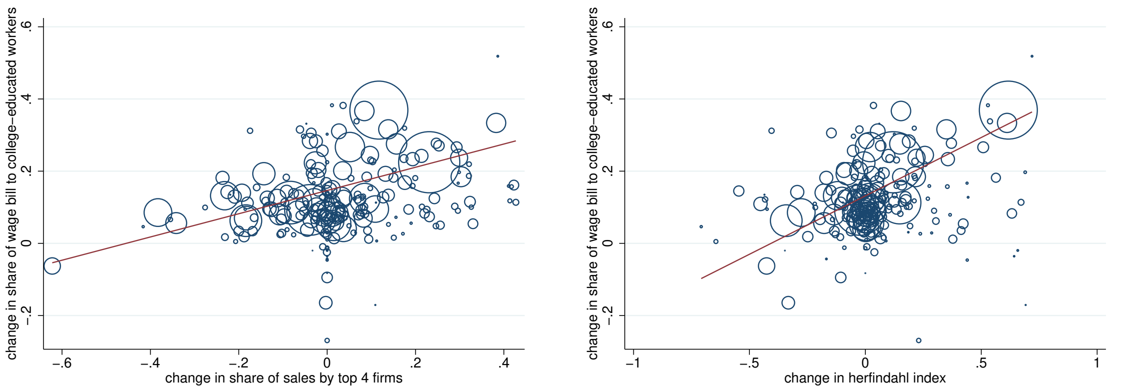
(e) Firm fixed effects.

Figure B.5. Firm size and the share of skilled workers in employment. Entire private sector.

Note: I divide the sample consisting of 1,145,210 firm-year observations into 20 quantiles based on annual sales and plot the mean share of skilled workers in employment for each quantile. In panels b), c), d) and e) I weight each firm by its value added. In panel c) I do not use raw numbers but instead residuals after taking out four-digit sector and year fixed effects. In panel d) I use residuals after taking out four-digit sector times year fixed effects (i.e. year fixed effects that are specific to each four-digit sector). In panel e) I use residuals after taking out firm and year fixed effects.



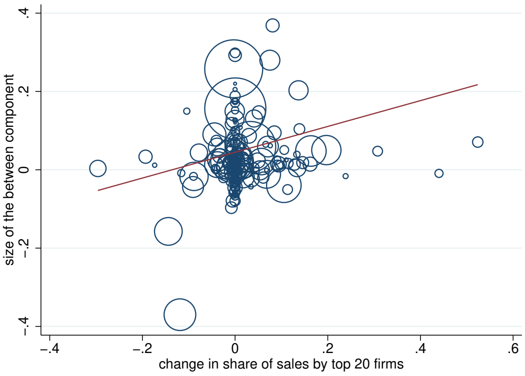
(a) Two-digit industries.



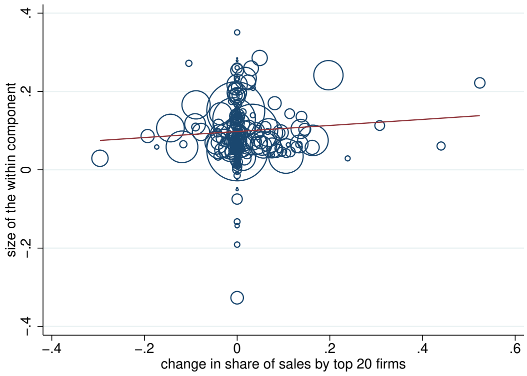
(b) Four-digit industries.

Figure B.6. Change in the share of the wage bill that is paid to workers with a college degree and change in market concentration.

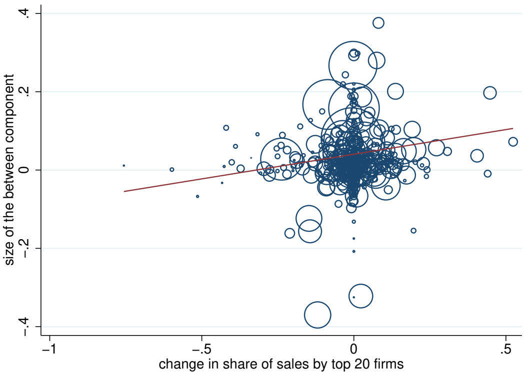
Note: I calculate for each manufacturing industry the share of the wage bill that is paid to workers that have a college degree and the market concentration for the first and last year of the sample: 1997 and 2016. I then plot the changes in the figures where the size of the circles is determined by the baseline value added of each industry. In panel (a) I use two-digit industries and in (b) I use four-digit industries. The straight line shows a linear relationship between the two variables. This line is weighted by the baseline value added in each industry.



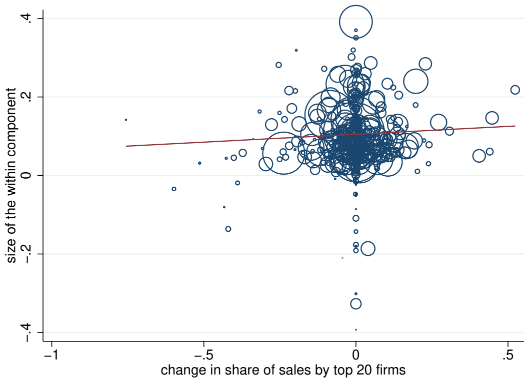
(b) Between firm component (manufacturing).



(c) Within firm component (manufacturing).



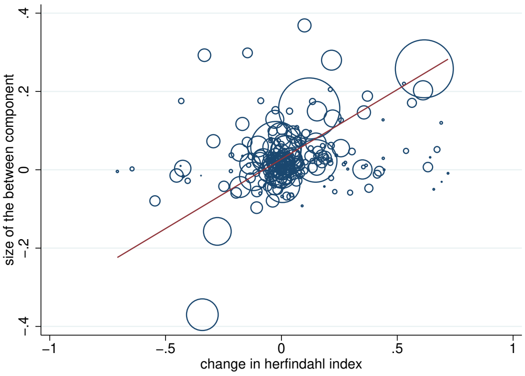
(e) Between firm component (all sectors).



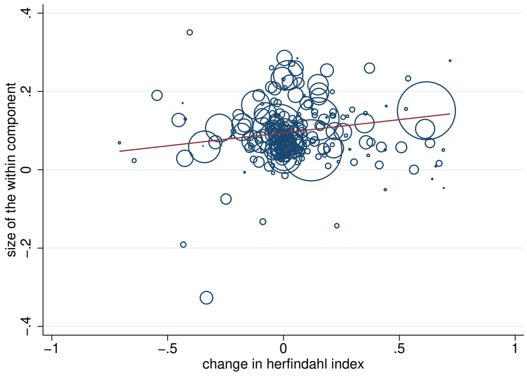
(f) Within firm component (all sectors).

Figure B.7. Between- and within-firm components in the aggregate share of skilled workers in employment and the change in market concentration (share in sales to top twenty firms) across four-digit industries.

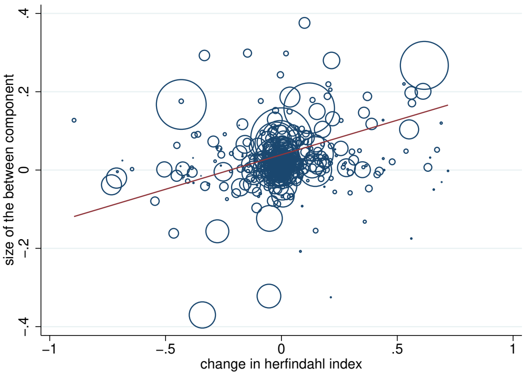
Note: The sample consists of all four-digit industries in the manufacturing sector during 1997–2016. For each year I have decomposed the change in the aggregate share of college-educated workers in employment, as defined in equation (8), into between firm change, within firm change as well as entry and exit according to Melitz and Polanec (2015) as outlined in equation (9). The vertical axis in the scatter diagram contains the cumulative effect of a specific component and the horizontal axis contains the change in market concentration as measured by the share of the top twenty firms in total industry sales. The straight line shows a linear relationship between the two variables. This line is weighted by the baseline value added in each industry. Subfigures a and b show manufacturing sectors only, while c and d show all sectors.



(b) Between firm component (manufacturing).



(c) Within firm component (manufacturing).



(e) Between firm component (all sectors).

(f) Within firm component (all sectors).

Figure B.8. Between- and within-firm components in the aggregate share of skilled workers in employment and the change in market concentration (Herfindahl index) across four-digit industries.

Note: The sample consists of all four-digit industries in the manufacturing sector during 1997–2016. For each year I have decomposed the change in the aggregate share of college-educated workers in employment, as defined in equation (8), into between firm change, within firm change as well as entry and exit according to Melitz and Polanec (2015) as outlined in equation (9). The vertical axis in the scatter diagram contains the cumulative effect of a specific component and the horizontal axis contains the change in market concentration as measured by the Herfindahl index of industry sales. The straight line shows a linear relationship between the two variables. This line is weighted by the baseline value added in each industry. Subfigures a and b show manufacturing sectors only, while c and d show all sectors.