Does Product Market Competition Increase Wage Inequality?

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Abstract

This paper shows that increasing product market competition can have a direct impact on the employment relationship and on wage inequality. I develop a simple model in which an increase in product market competition induces higher returns to skill: as competition rises, profits are more sensitive to cost reductions so that the relative marginal product of a high to a low skill worker is higher. This implies that relative wages increase with competition.

I then estimate empirically whether skills are more highly rewarded (in relative terms) in highly competitive industries using a large panel of UK workers (1982-1999) with complete work histories. I use three different measures of product market competition and identify the impact of competition on returns to observed skill out of its "within" variation, controlling for individual fixed effects. I show results for concentration ratios and for two exogenous measures of competition provided by two quasi-natural experiments. I finally estimate quantile regressions that indicate that increased competition also raised returns to unobserved skills.

Keywords: Wage Structure; Returns to Skill; Product Market Competition.

JEL Classification: J31, J33, L22, D21

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1 Introduction

In recent times we have witnessed a number of economic and institutional changes leading to increased competition in goods and services markets. Numerous sectors have been deregulated, there has been an increase in economic integration of different geographic blocks (NAFTA, EU) and transportation and information transmission costs have been falling steadily. These are all trends leading to more competition in product markets. During the same period wage inequality increased sharply, especially in the US and the UK. This rise in inequality has generated a vast literature trying to explain its causes that has established two important facts, namely that returns to skill have increased markedly and that a large fraction of the increase in inequality has occurred within sector and even within skill groups. Closer inspection provides reasons to suspect that these trends are correlated. For instance most of the increase in inequality in the US and the UK occurred in the 1980s, which is precisely the period of large deregulations. And a cross country comparison suggests that the US and the UK are those countries with both higher inequality and a higher degree of product market competition relative to France or Germany for instance.

However, and in spite of their strength and economic relevance there has been little attempt to link these very strong trends in the economy. The question addressed in this paper is precisely to what extent changes in product market competition alter the behavior of labor market actors and the wage structure. And whether we can we identify a causal mechanism from product market competition to increasing returns to skill and wage inequality that is consistent with recent trends.

The relationship between product market competition and labor market outcomes has long been recognized, with imperfectly competitive industries generating higher monopoly rents and thus the ability of firms to pay higher wages (Krueger and Summers, 1988[1]). This mechanism generates between-sector wage differentials for workers with the same skills. While the focus of existing studies has been on the impact of product market competition on mean wages in different sectors, and on between-sector inequality, in this paper I will argue that the variance of wages within sectors and, more generally, the whole within-sector wage distribution will also be affected as product market competition increases. In particular, returns to skill will change within sectors in response to competition. Product market competition will therefore have an impact on the within-sector wage distribution over and above the strict rent sharing argument.

[1] Evidence of this rent-sharing mechanism is provided in Card (1996) for airline industry deregulation in the US, Revenga (1992) for international competition from import prices and Borjas and Ramey (1995) for international competition in durable goods markets. Abowd and Lemieux (1993) instrument quasi-rents with import prices in Canadian data and Van Reenen (1996) uses innovations as an instrument.

This paper establishes the causality between product market competition and returns to skill and provides a theoretical illustration of why such a link might exist.

The theoretical mechanism proposed relies on the theoretical result that states that as markets become more competitive the sensitivity of profits to costs is higher. This feature of product market competition is common to most parametrizations of competition as will be shown (Boone, 2002). If high-skill workers are capable of producing at lower costs, as product market competition increases there will be stronger competition among firms to attract skilled workers, thus raising their wages. It follows that returns to skill will be higher in sectors with more product market competition; that is the relative wage of a high to a low skill worker is higher in more competitive sectors[2].

The mechanism put forward also provides an explanation for within industry and within skill wage inequality. What is rewarded are both the skills and the ability of workers and these may be observed by the worker and the employer but not by the econometrician. Under my hypothesis there will be higher returns to both observed and unobserved skills within industries.

The paper then explores empirically how product market competition actually relates to the wage structure. It seeks to establish whether there is a causal effect from increased product market competition to increased returns to skill, its magnitude and economic relevance. To do this in a convincing manner two difficulties must be overcome. The first is to find convincing and exogenous sources of variation in the degree of product market competition. The second is to be able to provide estimates that account for individual fixed effects and that allow me to provide estimates based on the "within" variation in returns to skill following exogenous changes in competition. I am able to address these difficulties by exploiting the New Earning Survey (1982-1999) which is a one percent random sample of the UK workforce (with full employment histories where workers are followed as they change employers and sectors) together with three different measures of product market competition including two quasi-natural experiments that the UK economy underwent in the past twenty years.

The hypothesis that product market competition leads to changes in wage dispersion, is first tested using a standard measure of product market competition, namely concentration ratios. However, these ratios can be criticized from a conceptual point of view on the grounds that they may not be perfect measures of competition and from an econometric point of view because they may be correlated with an omitted variable and hence the estimates do not capture the causal effect of competition on changes in the returns to skills.

[2] Other potential explanations for the existence of a link between competition and returns to skill (such as the role of trade unions and other explanations for the increase in inequality) are discussed and addressed in the empirical section.

I therefore turn to two alternative identification strategies that are better from the identification viewpoint to the extent that they represent arguably exogenous and uncontroversial measures of increasing competition within sectors. These are based on two different quasi-natural experiments that affected different sectors in different periods. The first corresponds to the sharp appreciation of the British pound in 1996 that implied that sectors more open to international trade experienced a larger increase in competition relative to fairly closed sectors. The second quasi-natural experiment used is the implementation of the European Single Market program in 1992 that I argue implied a bigger increase in competition for sectors with high non-tariff barriers prior to 1992. I provide difference in differences estimates of changes in returns to skill following the changes in product market competition. Results in all the specifications point to the fact that returns to skill increased after the increase in competition from each of these sources and that actually wages for high skilled workers were higher as a result of increased competition in some cases. The fact that the results are similar in all cases, for different sources of competition in different time periods, indicates that the suggested causal effect of competition is empirically relevant.

The effects of changes in competition on labor markets are likely to be numerous and sizeable[3]. A nascent theoretical literature links product markets to labor markets in terms of employment, wage levels and the joint regulation of the two (Blanchard and Giavazzi, 2003; Amable and Gatti, 1997) however none outline the type of effect of the level of competition on the variance of wages within sectors outlined here[4]. A parallel effect of product market competition that is not dealt with here is its impact on the use of performance related pay. Cuñat and Guadalupe (2003) shows that increased product market competition increases the sensitivity of pay to performance. This increase may also lead to increased dispersion in wages and possibly in returns to skills (if skilled workers are those that perform systematically better).

This paper should also be thought of taking into account existing explanations that have been put forward for the increase in wage inequality[5], in particular skill-biased technical change, international trade, organizational change (Caroli and Van Reenen, 2001; Black and Lynch,

[3] Other consequences of competition that are beyond the domain of this paper are its impact on employment (Bertrand and Kramarz, 2001), on market value and innovation (Blundell et al., 1999; Aghion et al., 2002; Nickell 1996 and Griffith, 2001) find empirical evidence of increased product market competition leading to increased effort exertion/efficiency. Bertrand (1999) argues that increased competition also alters the employment relationship in that it brings it to a setting where contracts are increasingly dominated by the market at the expense of implicit agreements where worker insurance against shocks was more relevant.

[4] OECD (2002) Employment Outlook actually note the lack of evidence on this subject and document a negative cross country relationship between the index of product market liberalization and wage inequality, but this can only be considered as exploratory evidence of the relationship.

[5] The papers in this area are too numerous to refer to. Katz and Autor 1999 provide a survey and lay out the main issues.

2003; Garicano and Rossi-Hansberg, 2003) and changes in unionization (Machin, 1997; Card, 2001). The effect of competition probably coexists with these other explanations and it is possible that changing product market competition also has an effect on some of these changes, however this paper is only concerned with the direct effect of competition on wage dispersion and explicitly attempts to partial out other direct and indirect effects, leaving for future research additional implications of such a link.

In the light of the existing literature, the contribution of the paper is twofold. Firstly I bring product market structure to bear on the compensation structure and the wage distribution and provide a theoretical reason for why competition may raise returns to skill and ability. Secondly, I establish empirically that increased product market competition does indeed raise returns to observed and unobserved skills within sectors and therefore within sector wage inequality. The proposed mechanism therefore constitutes a reason for why inequality has increased in the past decades in a way that is consistent with the established facts: that much of the explained increase in inequality has taken the form of increased returns to skill and that inequality has increased within sector and skill group.

The next section lays out the proposed theoretical mechanism for a link between competition and returns to skill. Section 3 describes the econometric specification and the identification strategies used in the empirical analysis and section 4 discusses the results. Section 5 concludes.

2 The economic link between product market competition and wages

The purpose of this section is to lay out the reasons why changes in product market competition may affect wage setting behavior and the wage distribution. I present a simple model that illustrates why such a link may exist and underlines some properties of product markets when firms are heterogeneous. The argument will be that as product market competition increases, and even in the presence of competitive labor markets, firms will be willing to pay (relatively) more to attract good workers and hence returns to skill will be higher and wage dispersion will increase. As will be shown below the crucial assumption for this to be true is that profits[6] are more sensitive to the ability of the worker hired, the higher is product market competition. In that situation firms will be willing to pay more for high skilled workers and increase the fraction of profits they share with them. This simple economic mechanism follows from the two assumptions made throughout this paper: imperfect competition in product markets and heterogeneity and imperfect substitutability of workers. The result is very general in that it

[6] In the model below the condition will be on what I will call gross profits (gross of bargained wages $w(d_i)$).

does not depend on the particularities of functional forms for competition assumed.

The story proposed relies on the enhanced cost cutting abilities of a high relative to a low skilled worker and how much firms are willing to pay for this. However there are at least two other stories for why competition may change returns to skill. If trade unions compress wages whenever there are rents to share, the increase in competition may imply a fall in rents and hence a reduction in the ability to compress wages. One might also think that the increase in competition actually changes the form of production and raises the demand for managerial positions relative to non-managerial ones. I will address these issues in the data and see to what extent they are also part of the causal relationship between competition and wages. We will see that although both play a role, the effect of competition on wages is also present when we control for union presence and when we restrict the analysis to sectors with low levels of unionization and that the effect is also at work within large occupational groups.

I now first turn to a simple illustration that captures the thrust of the theoretical result used in this paper, that states that the sensitivity of profits to costs increases in the degree of competition. Then I set up a more general case with more economic structure that lays out the assumptions necessary and determines a sufficient condition under which an increase in product market competition leads to an increase in returns to skill. Finally I show that this sufficient condition is a general result that is satisfied in a number of theoretical models of product market competition.

2.1 Simple illustration of a general result

To illustrate the fact that profits are more sensitive to costs the higher the degree of product market competition, consider the following simple calculation. Let profits of firm i be

$$\pi_i = (p_i - c_i)Y_i$$

where in standard notation p_i is the price set by firm i, Y_i is the firm's output given some exogenous production function and c_i are (exogenous) unit production costs that are assumed to be decreasing in the ability of the worker hired. Using the envelope theorem one can show that

$$d\pi_i/dc_i = -Y_i$$

and the elasticity of profits with respect to c_i is

$$\varepsilon = (c_i/\pi_i)(d\pi_i/dc_i) = -c_i/(p_i - c_i)$$

Note that $(p-c)/c$ is the markup (Lerner index) that in turn reflects the level of competition. Hence the sensitivity of profits to costs is higher the higher the competition level. If high skill

workers are those who are able to produce at lower costs, then the sensitivity of profits to skill increases in competition. This is the basic economic mechanism (coupled with imperfect substitutability between workers) that supports the link between competition and wage dispersion. In this situation high ability workers will extract more surplus in form of wages when product market competition increases.

2.2 Formal setting

The purpose now is to identify a sufficient condition in a fairly general setting for increased product market competition triggering increasing returns to skill, therefore what follows is a simple and stylized model that is kept at a high level of generality. I then turn to specific Industrial Organization models of product market competition (Cournot and Dixit Stiglitz monopolistic competition) and show that this sufficient condition is present in them.

Consider N firms selling goods in a non-competitive product market. Each firm hires one worker such that the number of workers employed in the monopolistic sector is given by the number of firms in that sector, N (that is determined by product market structure). Workers that are not hired in the sector will be self employed and get some exogenous reservation wage b. Product markets are not competitive but labor markets are perfectly competitive in the sense that there are no restrictions on hiring, firing or mobility costs.

Workers are of different skill levels. This skill is innate or acquired but given at some point in time when the hiring decision emerges. A high skill level means that the worker is able to produce at lower costs, i.e. that he is more productive. And workers of different skills are not substitutable. A way of reflecting this is that the worker's job is to set up a machine. A worker of ability d_i (where d_i is an inverse index of the skill level) sets the machine so that when the machine produces Y_i units of output, the unit costs are affected by d_i. A high d means that the worker produces at high costs and hence is of low skill. d is distributed between d_1 (for the highest skill worker that produces at lowest cost) and d_L, and no assumption is made on whether there are more or fewer workers than firms in the monopolistic sector.

The firms' profit function gross of wages is increasing in ability. This gross profit function can be written as a function of ability and the level of product market competition $\theta : \widetilde{\pi}(d_i, \theta)$[7]. I thus assume that $\widetilde{\pi}$ is such that $\frac{d\widetilde{\pi}}{dd_i} < 0$.

The stages of the game are as follows. In the first stage N identical firms compete for workers of different abilities. They post a complete wage profile, that is a wage associated to each skill level. Both firms and workers know perfectly the ability level of all workers and the degree of competition. When they meet, firms offer workers a given wage level and each worker

[7] $\widetilde{\pi}(d_i, \theta)$ is "profit" prior to paying the worker's wages.

can accept or reject those offers[8].

Once workers are allocated to firms, production occurs and in the second stage firms compete in the product market where they sell their products. The level of competition in the product market is also known throughout.

In equilibrium no firm will have an incentive to post a different wage profile (Nash equilibrium). The game is solved backwards. In the second stage firms chose prices and/or quantities (depending on the type of competition game played) that maximize gross profits $\widetilde{\pi}(d_i;\theta)$ given the level of competition θ. The resulting optimized $\widetilde{\pi}(d_i;\theta)$ is a function of the ability of the worker hired.

In the first stage firms take into account this gross profit function and compete for workers through the wage offers. Firms maximize net profits $\pi(d_i;\theta)$[9] (net of wages) subject to the participation constraint of workers according to which they will only accept a wage offer if it is above their reservation utility b and the wage that any other firm may offer them.

$$\begin{aligned} \max \pi(d_i;\theta) &= \widetilde{\pi}(d_i;\theta) - w_F(d_i) \\ s.t. w_F(d_i) &\geqslant \min\{w_J(d_i), b\} \text{ for all } J \in [1, N] \end{aligned} \tag{1}$$

Where b is the exogenous reservation wage and w_J is the wage offered by any other firms.

For a given N, in equilibrium the N^{th} firm that hires the N^{th} ability worker (if we ranked workers by ability level, the one at the N^{th} position) pays him the reservation wage. This yields profits for the N^{th} firm given by: $\pi(d_N,\theta) = \widetilde{\pi}_N(d_N) - b$.

The optimal strategy for firm F is to offer $w_F(d_i)$ to worker i such that in equilibrium it could not make higher profits by paying w_F and hiring a worker of different ability d_j, nor by paying that i^{th} worker a different wage.

$$\begin{aligned} \widetilde{\pi}(d_i) - w_F(d_i) &\geq \widetilde{\pi}(d_j) - w_F(d_j), \text{ for all } i, j \\ \widetilde{\pi}(d_i) - w_F(d_i) &\geq \widetilde{\pi}(d_i) - w_J(d_i), \text{ for all } i, j \end{aligned} \tag{2}$$

Since firms are identical we have a symmetric equilibrium $w_F(d_i) = w_J(d_i) = w(d_i)$, the above conditions collapse to:

$$\widetilde{\pi}(d_i) - w(d_i) \geq \widetilde{\pi}(d_j) - w(d_j), \text{ for all } i, j$$

[8] We could extend the model to allow for workers to be compensated per unit produced and the effort exerted. This is straightforward when we assume constant disutility of effort where the disutility of effort is precisely d_i.

[9] Profits appear as a function of ability d_i and the competition level θ. Implicitly they are also a function of quantity produced $q(d_i,\theta)$ which is already optimised as $q^*(d_i,\theta)$ when we write the profit function: $\pi(d_i;\theta) = \pi(d_i, q^*(d_i,\theta);\theta)$

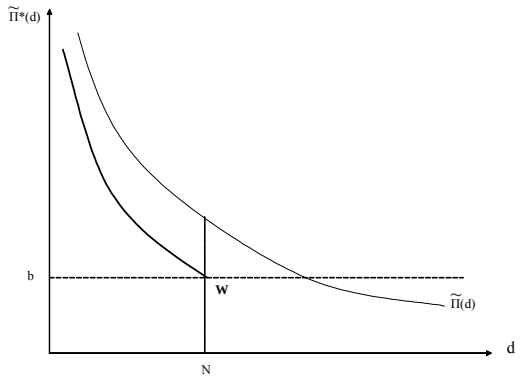


Figure 1: Equilibrium revenue and wage schedules

In equilibrium all firms make equal profits:

$$\widetilde{\pi}(d_i,\theta) - w(d_i,\theta) = \widetilde{\pi}(d_j,\theta) - w(d_j,\theta) = \widetilde{\pi}_N(d_N,\theta) - b \tag{3}$$

$$w(d_i,\theta) = \widetilde{\pi}(d_i,\theta) - \widetilde{\pi}_N(d_N,\theta) + b \tag{4}$$

In equilibrium no firm will have an incentive to alter the wage profile offered because they cannot increase profits by doing so. If they lowered the wage of the worker hired, the worker would leave and if they raised it they would be strictly worse off. In equilibrium all firms are making equal profits and are indifferent as to which worker they hire.

One can define two relevant schedules that are related as in equation (3). The gross profit schedule $\widetilde{\pi}(d_i,\theta)$ and the optimal wage schedule $w(d_i,\theta)$. These are pictured in Figure (1) for a given N. Note that $\frac{dw(d_i,\theta)}{dd_i} = \frac{d\widetilde{\pi}(d_i,\theta)}{dd_i}$. This was assumed to be negative, i.e. revenue is decreasing in costs - increasing in ability. I will show below that different models of product market competition do deliver the assumed negative slope in $\widetilde{\pi}$. So the wage schedule is decreasing in d and has the same slope as the revenue schedule but it is shifted down by $\widetilde{\pi}_N(d_N,\theta) + b$. It has a lower bound given by b.

With firms entering until the last firm makes zero profits: $\widetilde{\pi}_N(d_N,\theta) - b = 0$. Then in equilibrium all other firms also make zero profits and wages are such that $w(d_i,\theta) = \widetilde{\pi}(d_i,\theta)$.

So far I have not assumed any functional form for product market competition, just that θ was the competition parameter[10]. All the assumptions required were that gross profits $\widetilde{\pi}$ are increasing in the ability of the worker hired and that each firm hires one worker and the bargaining process is as described above.

[10] Note that it is possible that other features of product markets or technologies have similar effects on profits, and hence they will also imply increasing returns to skill. This is not studied here.

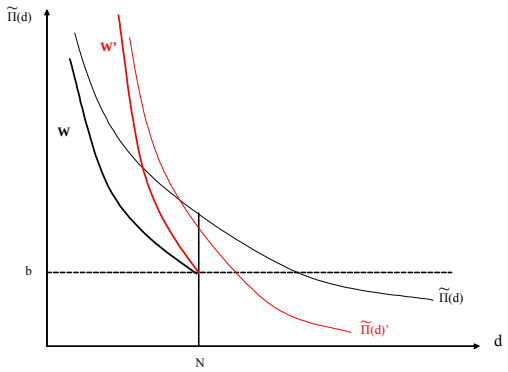


Figure 2: Comparative statics of a change in product market competition

The next step is to see what is the sufficient condition in this setting for an increase in competition triggering and increase in wage dispersion. This is:

$$\frac{d^2 w(d_i, \theta)}{dd_i d\theta} = \frac{d^2 \widetilde{\pi}(d_i, \theta)}{dd_i d\theta} < 0 \tag{5}$$

Which is a single crossing condition.

Figure (2) illustrates what happens when product market competition increases and the condition above is satisfied for a given number of firms N. As θ changes, the gross profit function becomes steeper. The wage schedule also shifts so that the vertical distance between the two curves is constant, and the wage schedule is anchored at b for the N^{th} worker hired (assuming no free entry). The wage function becomes steeper and the ratio of high to low skill wages is higher. In the picture we hold N fixed. If we assumed free entry and the number of firms increased until all of them were making zero profits, then the $\widetilde{\pi}$ function and the wage schedule would overlap and the same comparative statics would result.

So far all I have stated is that if the type of product market competition generates a profit function with the properties outlined above, an increase in competition will trigger an increase in returns to ability and wage dispersion. Since it can be argued that product market competition can take different forms in different markets it is important to check whether the classical forms of competition traditionally modelled satisfy the above property.

Boone (2000, 2002) is an illuminating reference in relation to this analysis. It has been noted before (especially in relation to the empirical analysis of competition) that the competition measures traditionally used are non monotone in competition, and that their validity as measures of competition depends highly on the competitive framework assumed, in particular

when firms are not symmetric. For example, it is different whether the number of competitors increases because entry costs fall (an increase in competition) or if it is because firms interact less aggressively (a fall in competition). Boone (2002) finds that the common feature to a number of models of competition with heterogenous costs is that the mapping of relative marginal costs to relative profits increases with competition. This can therefore be thought of as the key defining property (the "definition") of competition. And it is precisely the sufficient condition required in this paper. If we add to this feature bargaining over the surplus in the way I have outlined we obtain the main prediction in this paper: that higher product market competition increases returns to skill and wage dispersion.

In the remainder of this section I will show that this is the case under Cournot and Dixit-Stiglitz competition. The general problem encountered when analyzing the different models is that in my setting even though firms are homogeneous ex ante, once they have hired a worker they are heterogeneous. The models no longer have symmetric firms and this causes difficulties in obtaining closed forms for the comparative statics. It will therefore be more convenient to work in terms of relative profits and instead of proving single crossing in levels (as in equation 5) show that:

$$\frac{d^2(\widetilde{\pi}(d_i,\theta)/\widetilde{\pi}(d_j,\theta))}{d\theta d(d_i)} < 0 \tag{6}$$

Where d_j can be any arbitrary chosen worker hired with $d_j < d_i$. This different version of the same condition will be useful when a functional form is attached to the profit function. In what follows I investigate two standard models of product market competition (Dixit-Stiglitz and Cournot) and show they satisfy the properties required for an increase in product market competition leading to increased wage dispersion[11].

2.2.1 Competition à la Dixit-Stiglitz (1977)

In the previous section I showed that firms will decide how much to offer different workers according to their expectations of what will occur in the product market stage but no functional form was attached to the final revenue function. Let's assume now an explicit form of product

[11] A related idea to the one in this paper is the winner-take-all concept or the idea of "superstars". Rosen (1981) develops a theory of why small differences in skill can lead to large difference in wages as is seen with the development of the idea of superstars. The argument is that the production of some workers has the characteristics of a public good. This type of technology will imply that as the size of the market increases (following reductions in transportation costs say) the superstar gets a large part of the market and his earnings will increase relative to the person that is just below him in ability terms. Wage dispersion will be larger.

In my framework wage inequality increases without the need of the public good technology. What the public good technology delivers is the extreme polarisation of earnings.

market competition, namely horizontal product differentiation in the market, of the Dixit-Stiglitz type. Denote by Y_i the quantity that firms produce in the final stage and that they will sell at a price p_i. To produce they use the worker employed in the first stage that can produce at costs d_i (that indicates the level of (dis)ability). Monopolistic competition[12] (Dixit Stiglitz 1977) implies that

$$Y_i = (\frac{p_i}{p})^{-\theta} * \overline{Y}$$

where $\overline{Y}$ and p are index functions and $\theta > 1$ ($-\theta$ is the elasticity of substitution between products)

Firms maximize gross profits (gross of wages) that are a function of d_i

$\underset{p_i}{Max}\ \pi(d_i) = (p_i - d_i) * Y_i$

$\pi(d_i) = \overline{Y} p^{\theta}(p_i^{1-\theta} - d_i p_i^{-\theta})$

First order condition yields $p_i = \frac{\theta d_i}{\theta - 1}$

Hence

$$\widetilde{\pi}(d_i) = \overline{Y}(p/\theta)^{\theta}(d_i/(\theta-1))^{1-\theta}$$

Which is decreasing in d_i. The next step is to show how revenues change with θ. The problem is that as θ changes the index functions $\overline{Y}$ and p also change and it is not simple to solve analytically for the comparative statics. Thus I focus on how the ratio of profits between firms hiring high and low skilled workers changes as competition changes. Take two workers i and j such that $d_i > d_j$ (take j to be the more able worker).

$$\frac{\widetilde{\pi}(d_i)}{\widetilde{\pi}(d_j)} = \frac{\overline{Y}(p/\theta)^{\theta}(d_i/(\theta-1))^{1-\theta}}{\overline{Y}(p/\theta)^{\theta}(d_j/(\theta-1))^{1-\theta}} = (\frac{d_i}{d_j})^{1-\theta}$$

$$\frac{d(\widetilde{\pi}(d_i,\theta)/\widetilde{\pi}(d_j,\theta))}{d(d_i)} = (1-\theta) d_i^{-\theta} d_j^{\theta-1}$$

Now it is easy to see that the condition on the slope of the wage function for changes in θ is satisfied:

$$\frac{d^2(\widetilde{\pi}(d_i,\theta)/\widetilde{\pi}(d_j,\theta))}{d\theta d(d_i)} = d_j^{-1}[-(\frac{d_j}{d_i})^{\theta} + (\frac{d_j}{d_i})^{\theta}(\ln\frac{d_j}{d_i} - \theta \ln\frac{d_j}{d_i})] < 0$$

This is negative, which proves condition (6).

The result above applies for any given number of firms (one may not want to assume free entry).

[12] Where consumers have CES demand functions and there are N differentiated goods in the economy.

2.2.2 Competition à la Cournot

Now imagine that firms compete à la Cournot in a market with N firms. Firms take product price as given and price is a function of total production in the sector $P(\sum_{j=1}^{N} Y_j)$. Firms are profit maximizers such that in the first stage they solve:

$$\underset{Y_i}{Max}\pi(d_i) = (P(\sum_{j=1}^{N} Y_j) - d_i) * Y_i$$

The first order condition yields:

$$Y_i = (1 - \frac{d_i}{P})\eta \sum_{j=1}^{N} Y_j$$

Where η is the elasticity of demand. Using the above one can rewrite revenues as:

$$\widetilde{\pi}(d_i) = (P(\sum_{j=1}^{N} Y_j) - d_i) * (1 - \frac{d_i}{P})\eta \sum_{j=1}^{N} Y_j$$

Take again two workers i and j such that $d_i > d_j$.

$$\frac{\widetilde{\pi}(d_i)}{\widetilde{\pi}(d_j)} = \frac{(P - d_i)^2}{(P - d_j)^2}$$

Note this is positive and increasing in the difference in ability between the two workers.

$$d(\frac{\widetilde{\pi}(d_i)}{\widetilde{\pi}(d_j)})/d(d_i) = \frac{-2(P - d_i)}{(P - d_j)^2}$$

Which is negative since $d_s < P$, for any worker s employed in the sector, which is the condition for firms making non-negative profits.

An increase in competition in this market is equivalent to an increase in N. One can prove that:

$$\frac{d^2(\widetilde{\pi}(d_i)/\widetilde{\pi}(d_i))}{dNd(d_i)} = \frac{d^2(\widetilde{\pi}(d_i)/\widetilde{\pi}(d_j))}{dPd(d_i)}\frac{dP}{dN} < 0 \tag{7}$$

The first term of the equation is positive and the second is negative (both proofs may be found in the appendix). So as N increases in the Cournot setting (price falls) the sensitivity of gross profits to ability will increase which proves condition (6).

I now turn to the empirical analysis of this economic relationship to assess its significance and quantitative importance. Next section describes the econometric specification and identification strategy adopted.

3 Specification and identification strategy

The identification of the main effect in this paper exploits the effect of changes in product market competition in different sectors on the relative returns to skill over time based on individual wage equations with UK data. Most of the analysis concerns returns to observed skill level as proxied by the occupational distribution. However I will also say something on the relationship between unobserved ability, competition and wage dispersion. The model in the previous section predicts that the difference in wages between high and low skill workers will be higher in more competitive sectors. Recall that this is independent of whether mean wages are higher or lower in more competitive sectors as it is just a statement about relative wages. So the parameter of interest is the difference in the returns to skill between the different skill groups as product market competition changes. As I will explain below the data used are particularly well-suited for this analysis since it is a long individual panel of complete work histories and employer-reported wage data.

One of the difficulties will be to find appropriate and convincing measures of product market competition. The strategy followed will be to look at a number of different measures. I will start with standard concentration ratios and then exploit two natural experiments that implied an increase in competition. This is explained below.

As has been widely documented elsewhere inequality has been increasing markedly in the UK over the past 20 to 30 years (Gosling et al., 2000). Figure 3 shows the evolution of the difference in mean log wages between the highest and the lowest skill group in my data (males in the manufacturing sector), with my skill group definitions. Inequality between skill groups increased by 0.28 log points.

Figure 4 draws the evolution of top 5 concentration ratios measured by output and employment for the period 1982-1999 in the manufacturing sector in the UK. For some sectors the measures of concentration have increased while for other sectors they fell which is good for the identification since this is precisely the source of variation I will be exploiting to identify skill differentials.

Figures 5 and 6 bring these two trends together and show the cross sectional and time series relationship between competition (measured by concentration) and inequality. Figure 5 plots wage dispersion (measured by the 90/10 differential in wages) by sector between 1982 and 1999 against average concentration by sector for those years. More concentrated sectors have lower dispersion than more competitive sectors. Figure 6 plots dispersion by year against average concentration by year, which again yields a negative relationship, i.e. over time concentration fell and inequality increased.

Interestingly, a number of papers in the literature report either descriptive or related (because their focus is on a different mechanism) evidence consistent with the results in this paper. Card (1986, 1996a) and Hirsch and Macpherson (2000) report some evidence of increased wage dispersion after the US airline deregulation. Black and Strahan (2001) look at the impact of banking deregulation on wages and while they find that average wages fell after the deregulation, their results also point to the fact that they fell more for low than high skill workers. Hirsch (1993) and Rose (1987) look at the impact of trucking deregulation and find it increased inequality although they argue that this was due to a fall in union strength. Finally, Fortin and Lemieux (1997) assess the impact of a number of institutional changes in the US on the wage distribution. Deregulation of major industries explains some of the effect.

So there is some preliminary evidence in the literature and at the aggregate level of the existence of a cross sectional and time series relationship between wage dispersion and product market competition. The purpose of the remainder of the paper is to establish whether there is evidence for a causal link between the two.

3.1 Basic model

Let's suppose that the equation determining the log wage of individual i working in sector j with skill level k at time t can be written as:

$$\ln(w_{ijkt}) = \alpha + \theta_k C_{jt} + X'_{ijkt}\gamma + d_t + d_k + d_j + v_{ijkt} \quad (8)$$

$$v_{ijkt} = d_{kt} + d_{kj} + \eta_i + \varepsilon_{ijkt} \quad (9)$$

Where C_{jt} is competition in sector j at time t (in the empirical analysis I present evidence on three different measures of C_{jt}), X_{ijkt} is a vector of individual characteristics (including age, age squared, tenure, tenure squared), η_i is an unobserved permanent individual component, time, sector and skill dummies are given by d_t, d_j and d_k. d_{kt} represents fully interacted skill and time dummies and d_{kj} are fully interacted skill and sector dummies. ε_{ijkt} is a white noise.

The estimate of returns to skill θ_k will reflect how returns to different skill levels (k) vary with product market concentration (in the actual estimation I will include C_{jt} in levels and drop the low skill level and competition interaction to avoid collinearity). We are interested in the differential returns to skill in different competitive environments. In fact it is easier to see this as an interest in $(\theta_{k1} - \theta_{k2})$ where $k1$ and $k2$ are two different skill levels.

The basic model estimated in equation (8) controls for heterogeneity at sector level and for between sector differences in wages. It identifies θ_k out of the within sector variation in

competition over time and will be unbiased provided sector specific trends in returns to skills are uncorrelated with competition.

However, the estimate of our parameter of interest will be biased if $Cov(C_{jt}, v_{ijkt}) \neq 0$. Equation (9) identifies the potential sources of bias.

The first major source of bias is individual unobserved heterogeneity. For this purpose I exploit the longitudinal character of my data and estimate an individual fixed effects model. This takes care of omitted variable bias that would result from $Cov(C_{jt}, \eta_i) \neq 0$, i.e. from the individual permanent unobserved component being correlated with competition levels. This could occur if there was sorting of workers with different skill levels into sectors with different levels of competition. In practice, if the composition of workers within a sector changes with the degree of product market competition it becomes important to control for individual fixed effects. Table 4 shows regressions of the logarithm of sectoral employment on the three competition variables used in this paper, plus sector and year dummies. The results indicate that the increase in competition led to larger employment falls in sectors more affected by the exchange rate appreciation and the SMP (with no significant effects of competition measured by concentration). This indicates that the composition of sectors may be changing and hence it is important to control for individual fixed effects. Note that the NES, is ideal for this exercise because it is a longer panel than most usually available providing considerable "within" variation to identify the main effects out of individual behavior. Furthermore I am able to distinguish between the identification coming from stayers and that arising from individuals changing sectors by allowing for sector specific individual fixed effects (where the identification is strictly from within sector changes in competition) and comparing the estimates to the standard individual effects results.

The second source of bias would arise from a correlation between C_{jt} and d_{kj}, that is between sector specific returns to skill and competition. I include skill and sector specific dummies in the regression to capture this. If we omitted this set of interactions, the results would be biased only if the wage differential between two skill groups varies by sector and this variation is correlated with competition. This could arise for instance through a trade union effect if trade unions are stronger in sectors with less competition implying that wages are more compressed in those sectors.

I also introduce fully interacted skill and year dummies that capture any trend or time variation in returns to the different skills. The most immediate example of this would be skill biased technical change. There is a large literature on this issue and skill biased technical change is thought to be one of the main culprits of the increase in wage inequality in the UK

and the US[13]. If returns to skill are increasing over time (due to skill biased technical change or any other reason) in a way that is correlated with competition, we may capture a spurious relationship in our coefficient of interest. This is taken account of in the skill and year dummies interaction.

Note that accounting for the terms in the error term equation in a fully unrestricted way leads to a highly saturated model of wages. The drawback is a loss in efficiency from the large number of dummy variables included in the regression and that the "within" variation will be lower.

Although the variation exploited to assess the effect of product market competition on wage dispersion is at the level of sector and time, I exploit the individual panel for two main reasons. One is that in this way I can control for compositional changes in the sectors over time. If the tenure, skill, age or ability structure of a particular sector varies over time this will be accounted for by using individual records. Second, some individuals will be changing jobs and sectors and this constitutes highly informative variation since the fact that we have movers allows us to compare the different returns to skills of the same individual in sectors with different levels of competition[14]. The standard errors will be adjusted where necessary to account for the fact that the correlation between the measures of competition of two different individuals in the same sector is non-zero (Moulton, 1986).

However, even in the most saturated specification there are a number of objections to the results that one could come up with. The first and simplest is whether one believes the measure of product market competition used. There are numerous discussions in the Industrial Organization literature on the nature of product market competition, how it should be measured and what different commonly used measures capture. In the first part of the empirical analysis I use the top 5 concentration ratio. This is a standard and commonly used measure of competition and a good starting point for the analysis, however a number of criticisms can be raised against this measure. Still, since it may only be an imperfect measure of the true level of competition the next step in the analysis is to find other uncontroversial and exogenous measures of changing competition. These will be the natural experiments developed in what follows. The natural experiments used are clear measures of increasing competition that furthermore cover different periods and affect different sectors and where the source of competition is different (an increase in import competition in on case and a fall in entry barriers

[13] Although see Card and DiNardo (2002).

[14] Some individuals will experience skill upgrading because as we will see the measure of skill used is based on hte occupational classification.To confirm that we can interpret the results as returns to skill I will also run quantile regressions within skill groups and show that the distribution of wages changes and that returns to skill increase with competition also within occupational groups.

in another).

The second objection is that the concentration measure used may still be correlated with some variable W_{jt} that also determines returns to skills. These could be the standard explanations for increasing inequality in the literature such as skill biased technological change, international trade, falling unionization and changes in institutions. In these circumstances, a natural way out is again provided by the use of natural experiments since these are exogenous changes in product market competition and the causal mechanism is clearly identified. This exogeneity is what allows us to get at an estimate of the causal effect of competition.

3.2 First quasi-natural experiment: trade openness and the 1996 appreciation

The first source of exogenous variation in competition I exploit is based on the UK being an open economy, small enough not to be able to influence international markets and the fact that fluctuations in the exchange rate are largely exogenous to the wage setting conditions within the country. Hence, sharp and sudden changes in the pound sterling can be considered as a quasi-natural experiment.

The sharp appreciation of the pound sterling in 1996 (see Figure 7) can be used as an exogenous shock that affected sectors differently depending on their openness to trade. I use import penetration as my measure of openness (imports divided by the sum of imports and total sector product). The identification assumes that the appreciation was strictly exogenous and could not be forecasted by firms in the UK.

The idea is that a change in the exchange rate will affect more deeply sectors that were relatively open before 1996. They will face a larger increase in competition after the appreciation of the pound and hence the wage differential of high to low skill workers should increase more in those sectors after 1996 than in the least open and low trading sectors[15].

I first assess whether the appreciation implied a larger increase in returns to skill in highly open sectors. For this purpose I estimate:

$$\ln w_{ijkt} = \alpha + \gamma X_{ijkt} + \delta_k(post_t * impenetr_j) + d_t + d_j + d_k + \eta_i + \varepsilon_{ijkt}$$

where $post_t$ is a dummy variable that takes value one in the second period (post 96), $impenetr_j$ is import penetration for sector j. Note that since openness may change endogenously with the exchange rate change, import penetration is computed as the average import penetration measure over the years 1993 to 1995. It therefore only varies by j. The rest are defined as before.

[15] Articles that use similar effects of exchange rate fluctuations on imports as measures of competition include Revenga (1992) and Bertrand (1999).

However, to exploit the fact that we can exploit the differential effect that the experiment had on different sectors, I also estimate the differential change in returns to skill pre and post appreciation for sectors with different degrees of openness. This is like a difference in differences estimate of returns to skill. The estimated difference in differences specification is:

$$\begin{aligned} \ln w_{ijkt} &= \gamma X_{ijkt} + \delta_k(post_t * impenetr_j) + d_t + d_j \\ &\quad + \lambda_k^0 * post_t + \lambda_k^1 * impenetr_j + \eta_i + \varepsilon_{ijkt} \end{aligned}$$

In this specification λ_k^0 captures the differential returns to skill before and after the change in the exchange rate and λ_k^1 captures the differences in returns to skill between sectors with different degrees of import penetration. These are necessary to obtain a difference in differences estimate of the returns to skill δ_k.

I also address explicitly the role of changing unionization in the whole process. This is done by controlling for union density in the sector and by restricting the sample to sectors with low unionization. Finally, standard errors are clustered at sector level which accounts for potential autocorrelation within the treatment groups.

3.3 Second quasi-natural experiment: the 1992 European Single Market Program (SMP)

The European Single Market Program was designed to allow for the free movement of goods, services, capital and labor in the European Union. In a 1985 White Paper, the Commission devised a number of measures (300) aimed at achieving this. The actual implementation of the measures was staged between 1988 and 1992.

The White paper designed measures to eliminate barriers to the development of a unique internal market arising from: physical controls at the frontiers, technical rules, regulations and standards, public procurement policies, differences in fiscal structures and restraints on the movement of labor and capital. The channels through which the SMP was expected to operate were the following: reducing transaction costs, lowering barriers which enabled firms to segment markets, removing the means through which national governments can discriminate in favor of its firms, reducing costs of capital and labor (increasing mobility), assisting the process of structural change by investing in infrastructure, technology and skills.

To exploit the exogenous variation in competition generated by the introduction of the SMP I use the fact that different industries had different levels of non-tariff barriers in place before the SMP implementation. I use the same classification and time periods as Griffith (2001)[16]. This is derived from Mayes and Hart (1994). They divide industries depending on

[16] This experiment is also used in Aghion et al. (2003).

whether they had low, medium or high non-tariff barriers prior to the SMP. It was expected that the introduction of the SMP would affect more those with medium or high barriers that would see these considerably reduced. The classification is at 3 digit SIC and as Griffith (2001) I will consider those with medium or high barriers previous to the development of the single market as the sectors for which competition increased more sharply; and given the measures were designed to be implemented between 1988 and 1992 I will consider two time periods - before and after 1992; and two groups of sectors - those most and least affected by the SMP.

Below, I provide evidence for the validity of the SMP as an indicator of product market competition by looking at whether it affected differently what we call high and low sensitivity sectors before and after 1992.

Identification comes from the differential effect that the SMP had on sensitive (affected) and non-sensitive (non-affected) industries depending on their level of non-tariff barriers and hence is a difference in differences estimator of returns to skill.

The specification I estimate is

$$\begin{aligned} \ln w_{ijkt} &= \alpha + \gamma X_{ijkt} + \delta_k(post92_t * sensitive_{jt}) + d_t + d_j \\ &\quad + \lambda_k^0 * post92_t + \lambda_k^1 * sensitive_{jt} + \eta_i + \varepsilon_{ijkt} \end{aligned}$$

where now the interaction $(post92_t * sensitive_{jt})$ is a dummy that takes value one for sensitive/affected sectors after 1992, $t = pre92, post92$ and $j = sensitive, nonsensitive$. The rest are defined as before.

In this specification λ_k^0 captures the differential returns to skill before and after the SMP implementation in 1992 and λ_k^1 captures the differences in returns to skill between affected and non affected sectors. As before, these are necessary to obtain a difference in differences estimate of the returns to skill δ_k. I also provide the difference results and results restricted to the low unionization sample. Standard errors are clustered by sector.

3.4 Returns to unobserved ability

In the basic specification that uses concentration ratios I estimate the returns to observed skill interacted with competition. However it is also interesting to find out whether returns to unobserved ability are higher in more competitive sectors. The story would then also provide an explanation of within skill and sector changes in wage inequality. The existing literature points out that a large fraction of the increase in overall inequality cannot be explained by sector and skill differences. Product market competition may be a potential explanatory variable for that aspect of wage inequality.

One can argue that the best measure of the ability of a worker is the wage he receives (as in Card, 1996b). We can then potentially rank workers according to their predicted wages. Taking different percentiles as the skill groups, quantile regressions at different quantiles yield a measure of returns to skill as a function of the measure of competition. I run the following quantile regressions for a number of quantiles q :

$$\ln(w_{ijkt}) = \delta^q C_{jt} + \gamma^q X_{ijkt} + d_k^q + d_j^q + d_t^q + v_{ijkt}$$

Where the variables are defined as before. If the dispersion of wages is increasing in competition conditional on all the covariates included we should obtain that $\widehat{\delta^q} > \widehat{\delta^{q'}}$ for $q > q'$[17]. This would indicate that as competition increases high skilled workers are relatively more highly rewarded. To assess whether these are returns to unobserved ability I also run the regressions within the observed skill groups.

4 Estimates of the impact of competition on the wage structure

4.1 The Data

To assess the link between product market competition and relative wages I use the New Earnings Survey (NES) and a number of different sources for the competition measures and the natural experiments.

The NES is a very large sample survey of 1% of all individuals employed in the U.K. Employers are bound by law to provide directly information on all individuals whose national insurance number ends in two given digits. These individuals constitute the NES sample that has a number of characteristics that make it ideal for this study. Since NI numbers are issued randomly to individuals and are retained for life we have a very long panel with complete employment histories. It contains very detailed (employer reported) data on earnings and hours worked. The records correspond to a specific week in April for each year and are available from 1975 to 1999. The data contain information on weekly and hourly wages, on hours and overtime hours worked and also on age, occupation, region, industry and whether or not the individual was in the same job on the previous year. The sample is restricted to males working full time and whose pay has not been affected by absence in the reference week. The observable skill variable is derived from the occupational data. I obtain three skill groups (high medium and low skill) along the lines suggested by Elias (1995) and shown in Table 1.

[17] In the case C_{jt} measures concentration as in the data this would be $|\widehat{\delta^q}| > |\widehat{\delta^{q'}}|$ for $q > q'$.

The advantage of using the NES over other datasets for this purpose is that it is a very long panel that follows individuals throughout their working lives so it provides enough individual variation for longitudinal, within individual analysis. Furthermore it provides very accurate hourly measures of wages such that one can isolate hourly wages excluding overtime, and abstract from the changes in hours worked. Finally it is a very large random sample that contains observations from all economic sectors which allows us to control for a large number of effects.

The measure of wages used is real weekly pay of workers whose pay was not affected by absence excluding over-time pay divided by weekly hours excluding over-time hours.

To estimate the role played by standard competition measures in the wage equations I originally obtained competition measures from the UK Office of National Statistics (ONS) based on the ARD dataset[18]. The results presented here correspond to the top 5 concentration ratio measured by employment. This is a measure of concentration that reflects the percentage of total employment in the sector accounted for by its five largest firms. The sample used to compute this concentration ratio (CR5) was the actual population of UK manufacturing firms[19]. This dataset has the advantage that it goes back to 1982 but restricts the analysis to the manufacturing sector (SIC 1992 codes from 151 to 372).

Trade data are used in the second part of the empirical section. These were obtained from the 'Imports and Exports data: MQ10 dataset', elaborated by the ONS[20] that provides imports and exports at current prices by three digit SIC92 (in million pounds) and seasonally adjusted derived from the balance of payments. The data are available yearly from 1990. To construct import penetration (imports divided by imports plus sector output), I use total production from the ARD/ONS dataset previously mentioned.

To assess the effect of the single market program (SMP) I define two groups of industries in the NES depending on their degree of sensitivity to the program and following the classification in Griffith (2001). Industries are defined by their SIC80 3-digit code.

Finally, I obtain measures of union density by sector from the Labor Force Survey. Unfortunately one can only construct a consistent measure of unionization since 1994, and I am only able to control for unions from that date. I also generate a low unionization sample given by sectors that in 1994 were below 10% unionization.

[18] The ARD is the establishment level data that is collected under the Annual Census of Production in the UK.

[19] This measure is better computed than concentration measured by output and therefore less subject to measurement error, that is why I decided to use it throughout the paper. The results for top 5 output concentration were qualitatively similar to the ones using employment concentration. Table 3 shows the correlation between the two measures (0.92) and indicates that their distribution is very similar.

[20] Available online on the ONS website.

The analysis is done on three slightly different subsections of the data because of limitations in the process of merging the datasets that cover different time periods. I deliberately chose to keep the three subgroups different instead of restricting the analysis to one homogeneous subgroup by dropping observations. The sample size for the basic specification contains 449562 observations representing 83002 individuals. It contains male workers in manufacturing industries (SIC 151 to SIC 372) for the years 1982 to 1999. In the exchange rate experiment, the analysis is done on the manufacturing sector for the years 1992 to 1999. Finally the SMP analysis is for the whole period 1982-1999 but is limited by the definition of the affected sectors and the fact that they are defined with the SIC80 classification. The three samples do not differ substantially in terms of descriptive statistics and the descriptive statistics for the basic specification can be found in Table 2.

4.2 Results

This section seeks to provide a picture of how competition in the product market relates to the wage structure, and how returns to skill change with changes in competition. The central hypothesis to be tested is whether as product market competition goes up the wage gap between high and low skilled workers increases. This was the main prediction of the model in Section 2. For this purpose I will use three different measures of competition to try and confirm the robustness and generality of the mechanism identified. However when we go from the theory to the empirical testing a number of comments are in order and a series of other mechanisms must be accounted for.

First, one must account for the possible presence of interindustry wage differentials. This should mean that sectors with more competition will pay lower wages on average. This is a different problem from whether the returns to skills are higher or lower in more competitive sectors. But the two effects interact. Even if returns to skill are higher in more competitive sectors, it may well be that even for that high skilled worker wages are lower than in non-competitive sectors (from the fall in rents). This is important when we think about possible selection issues since it is not clear that even though able workers will reap higher relative rewards in more competitive sectors (a change in the slope), since their wages may be lower there (a change in the level of wages for all skill levels from the fall in rents), it does not necessarily follow that good workers will end up in more competitive sectors. The only unambiguous statement one can make is on relative wages within sectors.

Second, note that provided skills are not fully transferable between sectors (if there is a cost of changing sector or if the worker is less productive in another sector than in the sector of origin), it will be sectoral variation in competition what matters for individual wages.

Workers consider their sector as the relevant labor market and only very large swings in product market competition will make it worthwhile to change sectors. That is why sectoral variation in competition is exploited here.

Finally, as was stated before there are a number of reasons why product market competition may have a direct effect on relative wages. One story is the one developed in section 2 that says that firms will be more willing to pay for the cost-cutting ability of high skilled workers. Other stories include the role of trade unions in compressing wages and rent sharing. I will address the empirical relevance of alternative stories in the data.

I will address both issues by comparing the specification with individual fixed effects (where the effect is identified out of the within sector variation in competition) and the specification with sector specific individual fixed effects (that exploits only within sector and individual variation in competition). In this way I will get at the effect of the pure within sector change in competition on relative wages.

4.2.1 Effect of competition measured by concentration ratios

Table 5 presents the results for concentration ratios as the measure of competition. The dependent variable is log real hourly wages. The coefficients of interest are those on the interaction between the medium and high skill variables with sectoral concentration. The results show that as concentration falls (competition increases) the relative wages of the high skilled go up, ceteris paribus. So there will be more wage compression in sectors with low competition.

Column 1 shows the results for the pooled specification with sector fixed effects (without individual effects). A change from the 75th (0.3) to the 25th (0.085) percentile in CR5 raises the difference between high and low skill wages by 0.03 log points (the observed increase in wage differentials between high and low skilled workers in the sample is 0.28 log points).

However, the identification in column 1 does not take into account the fact that the permanent unobserved component of wages may be related to changes in competition, in particular as workers are sorted between sectors and does not exploit the individual variation in wages for that matter. This is addressed in the following columns.

Columns (2) to (7) are all individual fixed effects specifications and progressively include sector dummies, fully interacted time and skill dummies and fully interacted sector (at 2 digit SIC) and skill dummies. Standard errors are adjusted for clustering on sector and year. Hausman tests of random versus fixed effects rejected the null of absence of correlation between the error term and the regressors.

The coefficients of interest on the interaction of the skill variables with sectoral concen-

tration show again that when competition increases the gap between high and low skill wages is higher, ceteris paribus. As for the magnitude of the effect, estimated coefficients are (in absolute value) lower than in the pooled observations specification.

Columns (3), (4) and (5) have respectively individual effects, sector specific individual effects and firm specific individual effects. By comparing the results in these specifications we can assess how much of the estimated coefficient results from workers changing sectors or firms within a sector. The results indicate that seventy percent of the effect is due to within sector changes in competition, and thirty percent is actually due to wages changing within firms as competition changes. As for the between sector changes (from sector movers), it seems that high skilled workers do move to sectors with more competition.

Column (6), takes into account the fact that returns to skills have been increasing economy-wide over time for other reasons such as skill biased technical change by controlling in a non-restricted way for changes in returns to skills over time. The coefficient on returns to being high skilled falls to -0.05. Finally, column (7) accounts for the fact that some sectors may have systematically higher returns to skill (for instance because of different union presence), by introducing fully interacted sector and skill dummies. Note though, that if CR5 is persistent within sectors this will absorb much of the variation in returns to skills, and this is will be one reason for the coefficient falling. In fact the coefficient on CR5*medium skill is -0.36 and the one on CR5*high skill is now -0.022 (both are significant although not statistically significantly different from each other). So even in this fully saturated specification, it appears that returns to skills are increasing within sector with product market competition.

Notice that in the individual fixed effects regression without sector dummies (column 2), I find that more concentrated sectors pay higher wages as would be predicted by the inter-industry wage differentials story. However, as soon as one includes sector dummies and the individual fixed effects, the effect is negative and significant. This result has been found elsewhere in the literature[21], however mine was only a statement about relative wages, and the result is confirmed.

Finally, a different way of assessing the greater dispersion in wages resulting from increased product market competition and differential returns to skills is using quantile regressions. If wages are the best indicator of both observed and unobserved skill then we can assess the effect of competition on wage/skills at different percentiles conditional on the covariates. Furthermore, since my skill variable is based on the occupational classification, one could argue

[21] The most frequent explanation for this result has been that concentration is a poor measure of competition. However in a model with heterogeneous costs of production it is possible for instance that as product market competition increases, inefficient firms drop out of the market, low skilled workers are laid off and average profits (and wages) of the remaining actors are higher (Aghion and Shankerman, 1999).

that different occupations do different things and it is not clear whether comparing their relative wages is the appropriate thing to do. To address this issue I present quantile regressions for each skill group. The coefficients will reflect the returns to overall skills within the observed skill groups and conditional on age, tenure, their squares, year and sector dummies. Table 6 presents the results for the 10th, 25th, 50th, 75th and 90th quantiles. The coefficient on the concentration variable has a decreasing pattern within the three skill groups that seems to accelerate at the 75th and 90th quantiles. The fact that it is larger in absolute value for the high percentiles indicates again that the returns to being in a competitive sector are higher for high wage/skill workers, and that returns to skill are increasing in product market competition once we have conditioned on individual characteristics, sector and year (note I have also conditioned on skill, so this is within observable skill differential returns). The last panel of Table 6 presents similar results for the three pooled groups.

The previous results indicate that falling concentration is associated with increasing returns to skills under a number of different specifications. At this point and as was mentioned above, there are a number of reasons why we might want to have a strictly exogenous measure of changes in competition to test the basic relationship. First, concentration may be criticized as a highly imperfect measure of product market competition. Second, it is still possible that concentration is correlated with another variable that also varies by sector and time and that determines wage dispersion, so it is harder to establish the causal effect. To account for this I explore two different exogenous sources of variation. The 1996 appreciation of the British pound and the introduction of the European Single Market Program.

4.2.2 Exchange rate changes: the 1996 appreciation

The 1996 appreciation of the pound implied an exogenous increase in competition that should affect more sectors that are more open to foreign trade, that is sectors where imports represent a large fraction of total sales. In practice, the appreciation meant that foreign firms could sell at lower prices in the British market and hence competition for national firms was higher. I use this exogenous increase and compare the behavior of the different sectors in their wage setting behavior before and after 1996 as a function of their openness. Figure 7 shows the evolution of the British pound effective exchange rate. Two different regimes of low and high exchange rate before and after 1996 are apparent.

The appreciation generated a significant shock on UK exports and imports. Table 7 shows the aggregate effect on the balance of trade of goods. In 1997 there is a small positive effect on the balance of trade. This is a natural effect if there is some inertia on the quantities exported and imported; the appreciation meant higher export prices and lower import prices, so the

balance of payments can initially improve. However from 1998 onwards the quantity effect dominates and the balance of trade nearly doubled its previous deficit. It is striking that in spite of the appreciation of the pound by almost 20% the value of imports still went slightly up after the appreciation (which indicates that the quantity effect was extremely large). The effect on imports is also noticeable. Gagnon (2003) estimates that UK firms absorbed about 40% of the impact by reducing their prices. The rest of the impact was absorbed by quantities. This is indirect evidence that the appreciation did have an effect on competition. I also tested for the presence of pre-existing differential trends in returns to skills prior to 1992. No significant pattern was found which confirms the validity of the experiment as an exogenous shock to competition and that the results found are not spuriously just the result of pre-existing trends in returns to skill.

The estimates in Table 8 use the appreciation as the exogenous change in competition. Columns 1 and 2 present the difference results. High skilled workers experienced larger wage increases after the appreciation the more open their sector was. The effect at average openness was 4%. Column 2 controls for sector specific individual fixed effects and confirms that the effect arises from within sector changes in competition. Notice that now the within sector effect is negative, so that high skilled workers that move to a more competitive sector experience a reduction in relative wages.

However columns 1 and 2 do not take account of the fact that highly exposed sectors may have had higher returns to skills to start with or that after 1996 returns to skill were increasing throughout the economy. Columns 3 to 5 deal with this as they are difference in differences specifications for the returns to skill (with openness a continuous variable). Column 3 does not control for individual fixed effects and this has a very large effect on the estimates since in that case the effect of competition is not significant. This indicates that there is sorting along the competition dimension in this setting. This is less strong for the other measures of competition where not accounting for individual effects alters the coefficients, but their sign and statistical significance is maintained.

Columns 4 and 5 show that controlling for individual (and sector specific individual) fixed effects in a difference in differences specification there is a direct impact of this exogenous measure of competition on returns to skill. At average openness the effect was to increase returns to skill by 0.02 log points.

However, one could argue that something else is driving the results, and that actually the increase in competition is reflecting an indirect effect through some other variable, the natural candidate being unionization. If as product market competition increases unions are less able to compress wages all I may be capturing is a union effect. To address this issue I include in

table 9 a variable for the degree of union density in the sector (available from 1994) and allow it to interact with the skill dummies to capture that changing unionization may alter the degree of wage compression. Controlling for unionization, and for the degree of wage compression implied by union presence the result on the impact of competition still holds and is of the same magnitude as before. The coefficient on the density variable and its interactions indicate that sectors with more union density have lower returns to skill, and therefore that unions tend to compress wages (Card, 1996).

A further way to address the same issue is to restrict the sample to sectors with low unionization (below 10% density in 1994). In this sample, wage compression through unions will not be at work. This is done in columns 3 and 4. Again in column 3 the difference estimator indicates that even in low unionized sectors the effect of competition on returns to skill was at work. Also in the difference in differences specification in column 4 the effect has the expected sign and it is large and significant which indicates that returns to skill increased more after the appreciation in sectors that were more exposed to it, even when we restrict the sample to sectors where changes in union wage compression cannot be driving the results. Therefore even though changes in the degree of wage compression by unions may be part of the explanation for a causal effect of competition on returns to skill, it cannot be the only one[22].

4.2.3 The 1992 European Single Market Program

The introduction of the SMP implied a larger increase in product market competition for sectors with high non-tariff barriers prior to 1992. To test the impact and validity of the program as an indicator of product market competition one can look at whether it affected differently what we call high and low sensitivity sectors before and after 1992. For this purpose I regress concentration ratios by sector (3-digit SIC80) on a set of time and industry dummies and the interaction of the SMP group (a dummy variable that equals one if the sector is classified as having moderate or high barriers previous to SMP) and the post-92 period (the period covered is 1982-1999).This is shown on Table 12. Employment top 5 concentration ratios fell by 3.3% more in sensitive sectors post-SMP than in the sectors that were expected to be least affected.

[22] In addition to the 1996 appreciation, a sizeable devaluation took place in 1992 that actually forced the Pound out of the European Monetary System. The size of the devaluation is considerably lower than the appreciation as can be seen from Figure 7. I estimated the effect of that devaluationon returns to skill by running identical regressions to the previous ones but where import penetration was computed as the average in 1990-1992 and the treatment period was 1993 to 1996. The devaluation implied a larger fall in competition for sectors with high levels of import penetration. The results on returns to skill were negative (returns to skill fell by more in sectors with high import penetration), however the estimated coefficients were not significant. This may be due to the fact that the 1992 depreciation was smaller than the 1996 appreciation in size but in any case it is relatively positive evidence on the main causal effect found in this papaer.

Griffith (2001) who also uses this experiment, is able to test directly (using the ARD database) the effect of the SMP program on firm level rents, measured by the Lerner index. She finds that the Lerner index fell 1% more in sensitive sectors. This combined evidence indicates that the experiment is a good measure for differential changes in competitive pressure[23].

Table 11 presents individual fixed effects regressions of log wages on the same individual characteristics as before and an interaction of the experiment variable (that takes value one for sensitive sectors post-92 and zero elsewhere) and the skill levels.

The coefficient on returns to high skill in the first column is 0.097 implying that after the SMP introduction, returns to skill increased by 10% in sensitive sectors, i.e. those who experienced a larger increase in competition. Column 2 includes sector specific individual effects and indicates that most (80%) of the estimated change occurs within sectors. Column 3 shows the difference in differences estimate of returns to skill. Again, the coefficient (0.018) is reduced with respect to the one in the first column but is still statistically significant, and the results confirm that in sectors more affected by the SMP, i.e. where competition increased most, the relative wage of high to low skilled workers increased by more. Note also that the coefficient on the interaction between skill and the sensitive sector dummy is negative. If sensitive sectors are precisely those where product market competition was lower, this supports the idea that returns to skill are higher in more competitive sectors. The difference of high skill to low skill log wages after 1992 increased by almost 2% more in the more affected than in the less affected industries.

I address the issue of unionization in Table 12 by restricting the sample to sectors with union density lower than 10% in 1994[24]. For this group, column 1 shows that after the SMP returns to high skill were 5% higher in the sensitive sectors. When one controls for pre-existing differential returns between the two groups and for the change in returns to skill throughout all sectors after 1992, the difference in differences coefficient on returns to skill is still positive but becomes non-significant for high skill; it is still positive and significant for medium skills. So the evidence is again suggestive of the same effect on returns to skill, even at low levels of unionization, and the role played by unions is much larger here.

Finally, I use quantile regressions to assess whether the greater dispersion in wages resulting from increased product market competition due to the SMP reflects in increasing returns to unobserved skills even within skill groups. Table 13 presents the results for each skill group for the 10th, 25th, 50th, 75th and 90th quantiles. The coefficient on the experiment variable

[23] As with the 1996 experiment, I also tested for the presence of pre-existing differential trends in returns to skills prior to 1996. Again no significant pattern was found which confirms the validity of the experiment.

[24] Yearly data on union density are only available from 1994 and hence I cannot control directly for the degree of unionisation here. That is why I only present evidence on the restricted sample of low unionisation sectors.

(SENSAFT) has an increasing pattern in all skill groups which indicates that the returns to being in a competitive sector are higher for high wage/skill workers, and that returns to skill (both observable and unobservable) are increasing in product market competition once we have conditioned on individual characteristics, sector and year. The magnitude of the effect is actually greatest at the higher quantiles of the distribution. If we restrict to the low unionization sample, the same type of effect goes trough with returns to skill increasing in the degree of competition. Finally, given the skill measure was based on the occupational classification, this also addresses the issue of whether what I am capturing is increasing returns to being in a managerial position or increasing returns to skill. The fact that quantile regressions show an effect in the overall distribution and also when looking at the effect of competition within skill groups indicates that skills are indeed more highly rewarded in relative terms as competition increases.

4.2.4 Contribution to changes in wage inequality

The analysis above indicates that product market competition increases returns to skill. One would now want to have a sense of the size of the effect. One difficulty with this is that competition will be changing through different channels and each of the measures used here only identifies one channel at a time. Therefore I can evaluate the effect of each of these measures of competition on returns to skill but not the contribution of all changes in competition to increased wage inequality.

In my sample, the ratio of wages of high to low skilled workers increased by 0.28 log points. At the same time concentration fell 5.5 percentage points. This implies an increase in inequality (depending on the specification) between 0.001 and 0.0055 log points. That is changes in concentration represent between 0.4% (in the fully saturated specification) and 2% of the total increase in the gap between skills.

Concerning the effects of the natural experiments, the results indicate that the direct effect of the SMP on relative wages was to raise by 0.018 the gap between high and low skilled workers. Taking into account the fact that 41% of the labor force was affected by the program, this implies a change in returns to skill of 0.074 log points, i.e. 2.6% of the measured increase in the skill gap. And the effect of the 1996 appreciation yields a difference of 0.02 log points at average import penetration which is 7% of the total increase in the skill gap. These are all non-negligible effects that represent 10% of the observed increase in the differential between high and low skill workers. Competition has increased through many other sources and therefore this estimate is a lower bound of the contribution of competition to returns to skill. The size of the overall effect may be larger.

5 Conclusion

This paper identified product market competition as a source of increased returns to skill. The proposed mechanism that feeds back from changes in competition in goods and services markets to changes in the wage structure is the following. As competition increases, profits are more sensitive to cost reductions and since high skilled workers are better at producing at low costs firms will be willing to pay them higher wages relative to low skilled workers. This will generate increased wage differentials. I developed a stylized model of that mechanism that relied on two basic assumptions: that (at least some) product markets are imperfectly competitive and that workers are heterogeneous. Other mechanisms that may relate product market competition to returns to skill were discussed and assessed empirically.

I tested the hypothesis that skills are more highly rewarded (in relative terms) in highly competitive industries. Using an individual panel of UK male workers in the manufacturing sector for the period 1982-1999 the hypothesis was confirmed using concentration ratios as a measure of competition. The data used are particularly well-suited for this analysis. Results indicated that competition raised returns to observed skill (in panel regressions) and also to unobserved skills and ability (in quantile regressions). Then, in order to address criticisms to using concentration measures as a measure of competition, I used two different quasi-natural experiments that improved on the identification of the true causal effect of competition. The first quasi-natural experiment exploited the large appreciation of the British pound in 1996 that implied a higher increase in competition for sectors with a high openness to trade. The second was the introduction of the European Single Market program in 1992 that developed the European internal market by reducing a number of entry barriers. I exploited the differential effect this had on sectors with different degrees of non-tariff barriers prior to 1992. The effect of these experiments on returns to skill was identified in a difference in differences specification. Quantile regressions also indicated that returns to unobserved skills and ability went up.

Overall, the results indicated quite clearly that higher competition leads to higher returns to both observed and unobserved skills. The effect was present in sectors with high levels of unionization and also in sectors with limited union presence indicating that although the causal mechanism may be through changes in the degree of wage compression following the fall in rents, the effect was also present independently of that mechanism. Another important result is that it is crucial to be able to account for individual effects and the sorting of individuals between sectors when computing returns to skill in this setting.

Therefore there is evidence for an explanation based on increasing product market competition for the observed trends in inequality over the past twenty years. This explanation coexists

with the traditionally studied skill biased technical change, institutional change etc. What this study contributes is an explanation for a major component of the increase in inequality, namely the large and largely unexplained increase in "within" sector and observed skill wage differentials, as well as a theoretical justification that is consistent with the data.

This paper only constitutes a first attempt to establish the relationship between product market competition and the wage structure. In the light of the evidence provided here there seems to be a robust relationship between the two and further investigation to assess other implications of those links is required. This avenue can yield interesting insights to understand other aspects of wage differentials and it also calls for a study of the interaction between product market competition on the one hand and de-unionization, technical change and organizational change on the other as explanations of changes in the wage structure. These questions are left for future research.

References

[1] Abowd, John and Lemieux, Thomas (1993), "The effects of product market competition on collective bargaining agreements: The case of foreign competition in Canada", *Quarterly Journal of Economics*, Volume 108, Issue 4 November, 983-1014

[2] Aghion, Philippe; Bloom, Nicholas; Blundell, Richard; Griffith, Rachel and Howitt, Peter (2002), "Competition and Innovation: An Inverted U Relationship"

[3] Aghion, Philippe and Shankerman, Mark (1999), "Competition, entry and the social returns to infrastructure in transition economies" (1999), *Economics of transition*, Volume 7 (1), pp 79-101

[4] Amable, Bruno and Gatti, Donatella (1997), "Macroeconomic Effects of Product Market Competition in a Dynamic Efficiency Wage Model", *Economics Letters*; 75(1), March 2002, pages 39 46.

[5] Autor, David; Katz, Lawrence, Krueger, Alan B. (1998), "Computing Inequality: Have Computers Changed the Labor Market", *Quarterly Journal of Ecnomics*, November 1169-1213

[6] Berman, Eli; Bound, John and Griliches, Zvi (1994), "Changes in the Demand for Skilled Labor within U.S. Manufacturing Industries: Evidence from the Annual Survey of Manufactures", *Quarterly Journal ofEconomics*, May

[7] Bertrand, Marianne (1999), "From the invisible handshake to the invisible hand: how product market competition chnages the employment relationship" NBER Working Paper 6900

[8] Bertrand, Marianne and Kramarz, Francis (2001), "Does Entry Regulation Hinder Job Creation? Evidence from the French Retail Industry", NBER working paper w8211, April

[9] Bertrand, Marianne; Duflo, Esther and Mullainathan, Sendhil (2002), "How Much Should We Trust Difference-in-Difference Estimates?' *NBER working paper,* March

[10] Black, Sandra and Lynch, Lisa (2003), "How workers fare when employers innovate", NBER working paper, w9569 March

[11] Black, Sandra and Strahan, Philip (2001), "The Division of Spoils: Rent-Sharing and Discrimination in a Regulated Industry", *American Economic Review* , 91(4), 814-31

[12] Blanchard, Olivier; Giavazzi, Francesco (2003), "Macroeconomic Effects of Regulation and Deregulation in Goods and Labor Markets", *Quarterly Journal of Economics,* vol.118 Issue 3

[13] Blundell, Richard; Griffith, Rachel and Van Reenen, John (1999), "Market Share, Market Value and Innovation in a Panel of British Manufacturing Firms", *Review of Economic Studies*, 66, July, 529-554

[14] Boone, Jan (2000), "Competition", CEPR DP 2636, December

[15] Boone, Jan (2002), "Competition: the case of asymmetric firms", mimeo

[16] Borjas, George J.and Ramey, Valerie A., (1995), "Foreign Competition, Market Power, and Wage Inequality", Quarterly Journal of Economics; 110(4), November 1995, pages 1075 1110.

[17] Card, David (1986), "The impact of deregulation on the employment and wages of airline mechanics", *Industrial and Labor Relations Review*, July Volume 39 Issue 4 pp.527-538

[18] Card, David (1996 a), "Deregulation and labor earnings in the airline industry", NBER WP 5687

[19] Card, David (1996 b), "The Effect of Unions on the Structure of Wages: A Longitudinal Analysis" (1996) *Econometrica* 64 July

[20] Card, David (2001), "The Effect of unions on wage inequality in the U.S. labor market" *Industrial and Labour Relations Review,* Vol. 54, No. 2, p. 296.

[21] Card, David; DiNardo, John (2002), "Skill-biased technological change and rising wage inequality: some problems and puzzles", *Journal of Labour Economics*, Volume 20, number 4, October, pp 710-733

[22] Caroli, Eve and Van Reenen, John (2001), "Skilled-biased organizational change? Evidence from a panel of British and French establishments", *Quarterly Journal of Economics*, November, pp.1449 1492

[23] Cuñat, Vicente and Guadalupe, Maria (2003), "Executive compensation and product market competition", mimeo

[24] Dixit, Avinash K. and Stiglitz, Joseph E. (1977), "Monopolistic Competition and Optimum Product Diversity", *American Economic Review*; 67(3), June 1977, pages 297 308.

[25] Elias, P.(1995), "Social class and the standard occupational classifications", in D. Rose ed., A report on phase 1 of the ESRC review of the OPCS Social Classification. Swindon: Economic and Social Research Council.

[26] Fortin, Nicole M. and Lemieux, Thomas (1997), "Institutional Changes and Rising Wage Inequality: Is There a Linkage?", *Journal of Economic Perspectives*; 11(2), Spring 1997, pages 75 96.

[27] Freeman, Richard and Schettkat, Ronald (2001), "Skill Compression, Wage Differentials, and Employment: Germany vs the US", *Oxford Economic Papers*; 53(3), July 2001, pages 582 603.

[28] Gagnon, Joseph E. (2003), "The Effect of Exchange Rates on Prices, Wages, and Profits: A Case Study of the United Kingdom in the 1990s", FRB International Finance Discussion Paper No. 772, August

[29] Garicano, Luis and Rossi-Hansberg, Esteban (2003), "Inequality and Organization in a Knowledge Economy" Mimeo, University of Chicago

[30] Gosling, Amanda; Machin, Stephen and Meghir, Costas (2000), "The Changing Distribution of Male Wages in the U.K.", *Review of Economic Studies*; 67(4), October 2000, pages 635 66.

[31] Griffith, Rachel (2001), "Product market competition, efficiency and agency costs: an empirical analysis", IFS working paper

[32] Hirsch, Barry T. (1993), "Trucking Deregulation, Unionization, and Earnings: Is the Union Premium a Compensating Differential?" *Journal of Labor Economics*, Vol. 11, No. 2, April 1993, pp. 279-301.

[33] Hirsch, Barry T. and Macpherson, David A. (2000), "Earnings, Rents, and Competition in the Airline Labor Market", *Journal of Labor Economics*, Vol. 18, No. 1, January 2000, pp. 125-55

[34] Juhn, Chinhui; Murphy, Kevin and Pierce, Brooks (1993), "Wage Inequality and the Rise in Returns to Skill" *The Journal of Political Economy*, Vol.101, No.3 June

[35] Katz, Lawrence and Autor, David (1999), "Changes in the Wage Structure and Earnings Inequality" in Orley Ashenfelter and David Card *Handbook of Labor Economics*, Vol: 3A

[36] Krueger, Alan and Summers, Lawrence (1988), "Efficiency wages and interindustry wage structure, *Econometrica* 56, pp. 259-293.

[37] Machin, Stephen (1997), "The decline of labour market institutions and the rise in wage inequality", *European Economic Review* 41, 647-657

[38] Mayes, Peter and Hart, David (1994), "The single market programme as a stimulus to change: Comparisons between Britain and Germany" , National Institute of Economic and Social Research Occasional Papers, vol. 47. Cambridge University Press

[39] Moulton, Brent (1986), "Random Group Effects and the Precision of Regression Estimates", *Journal of Econometrics* 32 , pp. 385-97.

[40] Nickell, Stephen J. (1996), "Competition and Corporate Performance", *Journal of Political Economy*; 104(4), August 1996, pages 724 46.

[41] Revenga, Ana (1992), "Exporting jobs? The impact of import competition on employment and wages in U.S. manufacturing, *Quarterly Journal of Economics*, 107, 255-284

[42] Rose, Nancy (1987), "Labor Rent-Sharing and Regulation: Evidence from the Trucking Industry", *Journal of Political Economy*, December 1987, 95:1146-1178.

[43] Rosen, Sherwin (1981), "The Economics of Superstars", *American Economic Review,* Vol. 71 (5) pp. 845-58.

[44] Van Reenen, John (1996), "The Creation and Capture of Rents: Wages and Innovation in a Panel of U.K. Companies", *Quarterly Journal of Economics* February; 111(1): 195-226

6 Appendices

6.1 Cournot model

Part 1:

I prove that

$$\frac{d(\pi^*(d_j)/\pi^*(d_i))}{dP\ dd_i} > 0 \tag{10}$$

$$\frac{d^2(\pi^*(d_j)/\pi^*(d_i))}{dP\ dd_i} = \frac{2}{(P-d_i)^2}$$

Which is always positive.

Part 2 (price is decreasing in the number of competitors)

$$\begin{aligned} PY_i &= (P-d_i)\eta Y \\ \sum_{i=1}^{N} PY_i &= PY = NP\eta Y - \eta Y \sum_{i=1}^{N} d_i \\ P &= \frac{\eta N \overline{d}_N}{(\eta N - 1)} \end{aligned}$$

Where $\overline{d}_N = \frac{1}{N}\sum_{i=1}^{N} d_i$.

Denote the price in an industry of size N as $P_N = \frac{\eta N \overline{d}_N}{(\eta N-1)}$

In order for the model to make sense, Y_N must be positive, so $P_N > d_N$ since $Y_N = \frac{\eta Y(P-d_N)}{P}$ for an industry of size N. Now $P_N > d_N$ implies that $\frac{\eta N \overline{d}_N}{(\eta N-1)} > d_N$, hence

$$\begin{aligned} \eta N \overline{d}_N - (\eta N - 1) &> 0 \\ N &< \frac{\overline{d}_N}{\eta(d_N - \overline{d}_N)} \end{aligned} \tag{11}$$

The right hand side depends on the pattern of d.

For prices to be decreasing in N, we need to show that $\frac{P_{N-1}}{P_N} > 1$

$$\begin{aligned} \frac{P_{N-1}}{P_N} &= \frac{\eta(N-1)\overline{d}_{N-1}}{\eta(N-1)-1} * \frac{\eta(N-1)}{\eta N \overline{d}_N} \\ &= \frac{\eta(N-1)(N\overline{d}_N - \overline{d}_N)}{(N-1)(\eta(N-1)-1)} * \frac{\eta(N-1)}{\eta N \overline{d}_N} \end{aligned} \tag{12}$$

Since $\overline{d}_{N-1} = \frac{1}{N-1}\sum_{i=1}^{N} d_i = \frac{1}{N-1}(\sum_{i=1}^{N} d_i - d_N) = \frac{1}{N-1}(N\overline{d}_N - d_N)$

Manipulation of 12 yields:

$$\eta N\overline{d}_N - d_N(\eta N - 1) > 0$$

which is true if and only if $P_N > d_N$ from 11 above. So all that is required is that output is positive for all N firms, in that case prices fall as firms enter. Note that I also assumed constant elasticity η.

7 Figures and tables

7.1 Figures

Figure 3: High to low skill wage differential in the manufacturing sector 1982-1999

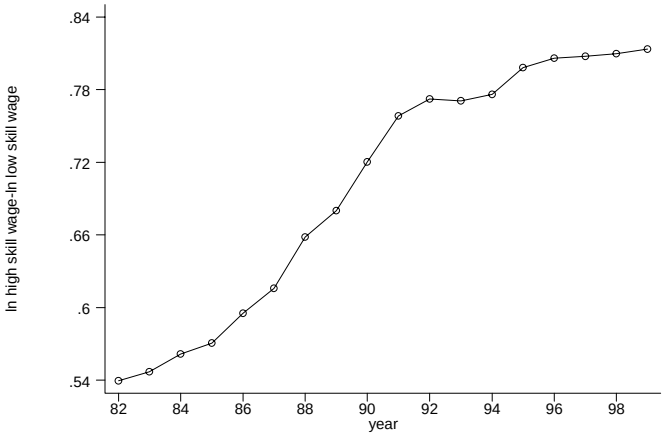
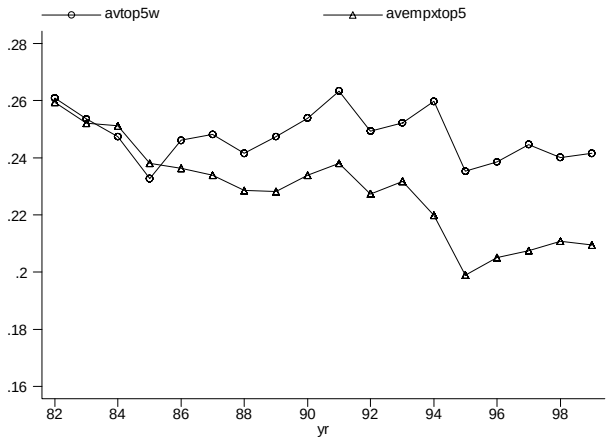


Figure 4: Employment and output concentration ratios for the UK manufacturing sector



o output conc. Δ employment conc.

Figure 5: Between sector correlation CR5 employment and wage dispersion

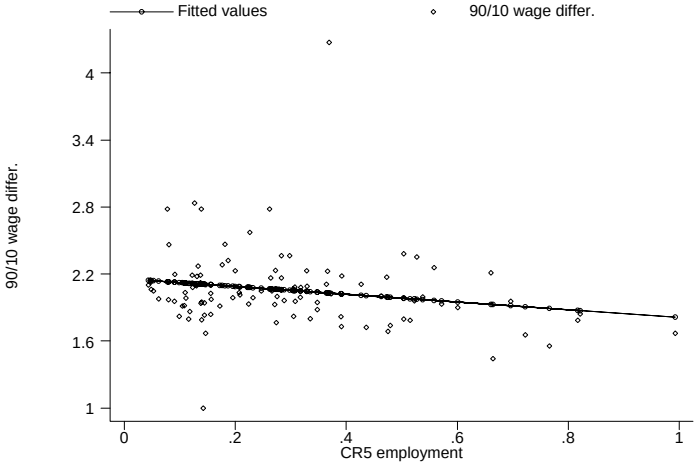


Figure 6: Time series correlation between CR5 employment and wage dispersion

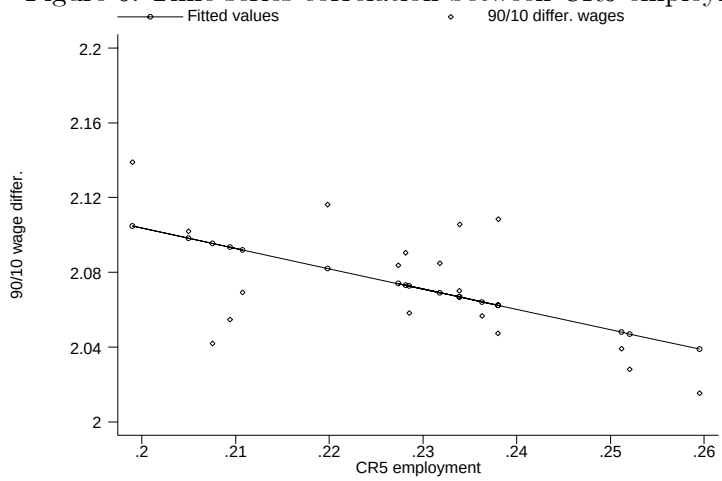
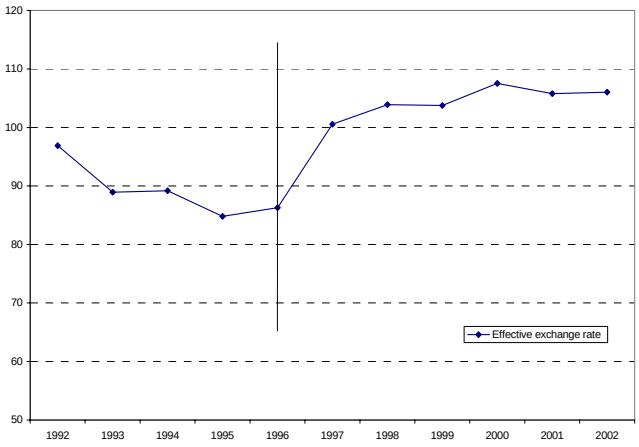


Figure 7: Effective exchange rate, Pound Sterling (1990=100)



Source: Bank of England

7.2 Tables

7.2.1 Skill classification

Table 1: Skill groups in the NES

Skill level	Major groups	SOC code (minor gr.)
High	Managers and administrators	10,11,12,15,19
	(excl. office manag. and manag./prop. in agric.&services)	
	Professional occupations	20-27,29
Medium	Office managers and manag./propietors in agric. and services	13,14,16,17
	Associate professional and technician occupations	30-39
	Craft and relations occupations	50-59
	Buyers, brokers, sales representatives	
Low	Clerical, secretarial occupations	40-46,49
	Personal and protective services occupations	60-67,69
	Sales occupations (except buyers, browkers, sales reps)	72,73,79
	Plant and machine operatives	80-89
	Other occupations in agriculture, forestry, fishing	90
	Other elementary occupations	91-95,99

Source: Based on Elias (1995)

7.2.2 Descriptive statistics

Table 2: Descriptive statistics

	All skill groups	Low skill	Med skill	High skill
log real hourly wages	1.480 (0.446)	1.310 (0.344)	1.466 (0.397)	1.921 (0.478)
real hourly wages	4.910 (3.04)	3.936 (1.437)	4.709 (2.428)	7.729 (4.887)
age	39.30 (12.41)	39.213 (12.86)	38.46 (12.44)	41.42 (10.92)
age squared	1698.6 (1004.5)	1703.1 (1039.9)	1633.(7 995.9)	1834.9 (919.2)
tenure	4.874 (4.165)	4.866 (4.172)	4.964 (995.9)	4.69 (3.98)
tenure squared	41.10 (69.7)	41.08 (69.92)	42.54 (71.57)	37.9 (64.8)
low skilled	0.426	1	0	0
medium skilled	0.398	0	1	0
high skilled	0.176	0	0	1
CR5 output	0.248 (0.194)	0.242 (0.188)	0.244 (0.196)	0.271 (0.200)
CR5 employment	0.230 (0.187)	0.229 (0.186)	0.225 (0.188)	0.244 (0.185)
Import penetration	0.238 (0.141)			
Observations	449551	191597	178822	79111

Notes: Mean of variables for the whole sample and by skill group, standard deviation in parenthesis

Table 3: Coeff. of correl. between different concentration measures and distributions

Correlations	CR5 output	CR5 employment	
CR5 output	1		
CR5 employment	0.928	1	
Distributions	25th perc.	Median	75th perc.
CR5 output	0.136	0.240	0.408
CR5 employment	0.133	0.244	0.405

Table 4: Effect Competition on employment

	lnEmployment	lnEmployment	lnEmployment
	(1)	(2)	(3)
Concentration	-0.388		
	(0.347)		
Impenetr.*1996		-0.416	
		(0.128)***	
SENSAFT			-0.202
			(0.044)***
Year dummies	yes	yes	yes
Sector dummies	yes (SIC 92)	yes (SIC 92)	yes (SIC 80)
Observations	1687	789	1806

Notes: Std. errors in parentheses; *** significant at 1%

Based on NES employment, males in the manufacturing sector.

Dependent variable is ln(employment) by sector and year

Sample periods: (1) and (3) 1982-1999 (2) 1992-1999

7.2.3 Results

Table 5: Effect of concentration on returns to skill

	Sector eff..	Indiv. eff.	Sector and individual effects			With year return	With sect. ret.
			All	Sector stayers	Firm stay.		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Age	0.0632	0.0627	0.0619	0.0541	0.0393	0.0636	0.0635
	(0.0005)***	(0.0019)***	(0.0019)***	(0.0026)***	(0.0024)***	(0.0019)***	(0.001)***
Tenure	0.0112	0.0095	0.0093	0.0059	0.0082	0.0089	0.0089
	(0.0005)***	(0.0003)***	(0.0003)***	(0.0004)***	(0.0006)***	(0.0003)***	(3.35)***
Med. skill	0.1675	0.0453	0.0461	0.0323	0.0268	0.0192	0.0499
	(0.0035)***	(0.0027)***	(0.0027)***	(0.0037)***	(0.0043)***	(0.0045)***	(0.007)***
High skill	0.5617	0.1491	0.149	0.1168	0.1046	-0.0066	0.0392
	(0.0068)***	(0.0047)***	(0.0046)***	(0.0057)***	(0.0061)***	-0.0059	(0.011)***
CR top5	-0.0231	0.1016	-0.0987	-0.0951	0.0234	-0.077	-0.0817
	-0.0277	(0.0086)***	(0.0212)***	(0.0239)***	(0.0082)***	(0.0209)***	(0.021)***
CR top5*Med. skill	-0.0534	-0.0378	-0.0387	-0.0259	-0.0108	-0.0299	-0.0367
	(0.0124)***	(0.0075)***	(0.0074)***	(0.0101)***	-0.0088	(0.0078)***	(0.009)***
CR top5*High skill	-0.1421	-0.0995	-0.1004	-0.0696	-0.0375	-0.0513	-0.0218
	(0.0198)***	(0.0144)***	(0.0143)***	(0.0181)***	(0.0139)***	(0.0112)***	(0.012)*
Year effects	yes	yes	yes	yes	yes	yes	yes
Sector dummies	yes	-	yes			yes	yes
Indiv. Fixed eff.	-	yes	yes			yes	yes
Ind*sector effects	-	-	-	yes		-	-
Ind*firm effects	-	-	-	-	yes	-	-
Year*skill	-	-	-	-	-	yes	yes
Sector*skill	-	-	-	-	-	-	yes
Observations	449562	449562	449562	449562	449562	449562	449562

Notes: Robust std errors in parentheses, clustered by sector and year;

* significant at 10%; ** significant at 5%; *** significant at 1%

Dependent variable: log real hourly wage. Sample: males in manufacturing sector 1982/1999, NES

Variables: CR5 is top5 concentr. ratio; Year*skill (Sector*skill) are fully interacted year (sector) and skill dummies

Ind*sector (Ind*firm) effects are fully interacted individual and sector (firm) dummies; includes age and tenure squared.

Table 6: Quantile regressions with top 5 concentration ratio, by skill groups and pooled

	10th perc.	25th perc.	50th perc.	75th perc.	90th perc.	Observations
Low Skill sample:						
CR top5	-0.001	0.0003	7.5E-06	-0.022	-0.125***	191624
	(0.023)	(0.019)	(0.018)	(0.019)	(0.027)	
Medium Skill sample:						
CR top5	-0.071***	-0.052***	-0.052***	-0.088***	-0.119***	178825
	(0.024)	(0.0192)	(0.019)	(0.022)	(0.034)	
High Skill sample:						
CR top5	-0.015	0.015	-0.011	-0.048	-0.109**	79113
	(0.042)	(0.034)	(0.033)	(0.040)	(0.054)	
All skills (full sample):						
CR top5	-0.049***	-0.062***	-0.064***	-0.11***	-0.144***	449562
	(0.016)	(0.012)	(0.012)	(0.015)	(0.020)	

Notes: Std errors in parentheses, ; ** significant at 5%; *** significant at 1%

Dependent variable log real hourly wage, Sample: males in manufacturing sector 1982/1999, NES

Variables: CR5 is top5 concentr. ratio; All regressions include age, tenure, their squares, sector and skill dummies.

Table 7: Goods Trade Balance

Periods	Exports	Imports	Balance
1992	107863	120913	-13050
1993	122229	135295	-13066
1994	135143	146269	-11126
1995	153577	165600	-12023
1996	167196	180918	-13722
1997	171923	184265	-12342
1998	164056	185869	-21813
1999	166166	195217	-29051
2000	187936	220912	-32976

Source: UK Office of National Statistics

Notes: Monetary variables in real terms, (base 1987)

In million UK pounds.

Table 8: Exchange rate experiment: 1996 appreciation, All sectors

	Difference estimates		Difference in Differences		
	All	Sector stayers	All, no indiv.eff.	All	Sector stayers
	(1)	(2)	(3)	(4)	(5)
Imp.*p96	-0.0145	-0.0336	0.0423	-0.0076	-0.0058
	(0.0230)	(0.0169)**	(0.0445)	(0.0214)	(0.0272)
Med. Skill*Imp.*p96	0.0610	0.0578	-0.0540	0.0283	0.0261
	(0.0192)***	(0.0117)***	(0.0507)	(0.0267)	(0.0370)
High. Skill*Imp.*p96	0.1444	0.1733	-0.0879	0.0902	0.1022
	(0.0274)***	(0.0152)***	(0.0765)	(0.0417)**	(0.0519)**
Med. Skill*p96			0.0212	0.0089	0.0058
			(0.0154)	(0.0075)	(0.0102)
High skill*p96			0.0506	0.0289	0.0138
			(0.0186)***	(0.0122)**	(0.0144)
Med. Skill*Imp.			0.0985	0.0167	0.0336
			(0.0830)	(0.0237)	(0.0591)
High. Skill*Imp			0.0744	-0.0316	-0.0514
			(0.1007)	(0.0384)	(0.0951)
Year dummies	yes	yes	yes	yes	yes
Sector dummies	yes		yes	yes	
Indiv. fixed eff.	yes		-	yes	
Ind*sector effects	-	yes	-	-	yes
Observations	64984	174135	174135	174135	174135

Notes: Robust std errors in parentheses, clustered by sector and year;

* significant at 10%; ** significant at 5%; *** significant at 1%

Dependent variable: log real hourly wage, Sample: males in manufacturing sector 1992/1999, NES

Variables: p96 is a dummy that takes value one after 1996, zero before; Imp. is mean import penetration in 1992/1995

All regressions include tenure, age and their squares.

Table 9: Exchange rate experiment, accounting for trade unions

	Full Sample		Low unionization sample	
	Diff. estimate	Diff in Diff	Diff. estimate	Diff in Diff
	(1)	(2)	(3)	(4)
Imp.*p96	-0.0293	-0.0075	0.1084	0.1473
	(0.0164)*	(0.0212)	(0.0432)**	(0.0697)**
Med. Skill*Imp.*p96	0.0476	0.0145	-0.0063	-0.1169
	(0.0114)***	(0.0254)	(0.0286)	(0.0936)
High Skill*Imp.*p96	0.1414	0.0904	0.0512	0.1073
	(0.0155)***	(0.0477)*	(0.0173)***	(0.0509)**
Union	0.0591	0.0581		
	(0.0318)*	(0.0321)*		
Med. Skill*Union	-0.0310	-0.0313		
	(0.0218)	(0.0223)		
High Skill*Union	-0.1019	-0.0933		
	(0.0307)***	(0.0322)***		
Med. Skillp96		0.0096		0.037
		(0.0073)		(0.0393)
High Skill*p96		0.0177		-0.028
		(0.0140)		(0.0214)
Med. Skill*Imp.		0.0298		0.262
		(0.0261)		(0.1016)***
High Skill*Imp.		-0.0092		-0.0505
		(0.0379)		(0.166)
Year dummies	yes	yes	yes	yes
Sector dummies	yes	yes	yes	yes
Indiv. Fixed eff.	yes	yes	yes	yes
Observations	127675	127675	6567	6567

Notes: Robust std errors in parentheses, clustered by sector and year;

* significant at 10%; ** significant at 5%; *** significant at 1%

Dependent variable: log real hourly wage,

Sample: males in manufacturing sector 1992/1999 in columns (3) and (4) 94/99 in columns (1) and (2)

Low unionisation sample are sectors with less that 10% union density in 1994

Variables: p96 is a dummy that takes value one after 1996, zero before; Imp. is mean import penetration in 92/95

Union is level of union density in the sector, available from 1994; All regressions Include tenure, age and their squares;

Table 10: The effect of the SMP experiment on concentration

	CR top 5
SENSAFT	-0.033* (0.019)
Year dummies (82/99)	yes
Sector dummies	yes
Observations	1698

Notes: Robust t statistics in parentheses; std. errors clustered by sector

*significant at 10%

Dep. variable is concentration ratio

SENSAFT is the interaction dummy for sensitive*dummy for after92

Unit of observation is year-sector, regressions are unweighted

Table 11: European Single Market Program experiment, 1992

	Difference estimate		Difference in Differences	
	All	Sector stayers	All	Sector stayers
	(1)	(2)	(3)	(4)
SENSAFT	-0.0112	-0.0107	0.0112	0.0083
	[0.0096]	[0.0112]	[0.0086]	[0.0105]
Med. skill*SENSAFT	0.0207	0.019	-0.004	-0.0025
	[0.0055]***	[0.0065]***	[0.0059]	[0.0073]
High skill*SENSAFT	0.0974	0.0808	0.0184	0.0179
	[0.0084]***	[0.0113]***	[0.0106]*	[0.0128]
Med. skill*sensitive			-0.0002	0.0043
			[0.0043]	[0.0063]
High skill*sensitive			-0.0179	-0.013
			[0.0085]**	[0.0117]
Med. skill*after92			0.0345	0.0274
			[0.0040]***	[0.0047]***
High skill*after92			0.1216	0.0926
			[0.0085]***	[0.0091]***
Year dummies	yes	yes	yes	yes
Sector dummies	yes		yes	
Indiv. fixed eff.	yes		yes	
Indiv*sector eff.	-	yes	-	yes
Observations	415306	415306	415306	415306

Notes: Robust std. errors in parentheses, clustered by sector

*significant at 10%; ** significant at 5%; *** significant at 1%

Dependent variable: log real hourly wage, sample are males in manufacturing sector 1982/1999

Variables: sensitive is a dummy that takes value one for sectors that were classified as having high non-tariff barriers; after92 is a dummy that takes value 1 after 1992; SENSAFT is the interaction betw. sensitive and after92

Regressions also include skill dummies and tenure, age and their squares.

Table 12: SMP experiment and unions

	Low unionization sample	
	Difference	Difference in Differences
	(1)	(2)
SENSAFT	0.0487	0.0575
	(0.0174)***	(0.015)***
Med. skill*SENSAFT	0.0381	0.0286
	(0.0124)***	(0.0088)***
High skill*SENSAFT	0.053	0.0042
	(0.053)***	(0.0159)
Med. skill*sensitive		-0.0055
		(0.0171)
High skill*sensitive		-0.0317
		(0.0388)
Med. skill*after92		0.0176
		(0.0113)
High skill*after92		0.0749
		(0.0183)***
Year dummies	yes	yes
Sectors dummies	yes	yes
Individual fixed eff.	yes	yes
Observations	20062	20062

Notes: Robust std. errors in parentheses, clustered by sector

*significant at 10%; ** significant at 5%; *** significant at 1%

Dependent variable: log real hourly wage. Sample: males in manufacturing sector 1982/1999, NES

Low unionisation sample are sectors with less that 10% union density in 1994

Variables: sensitive is a dummy that takes value one for sectors that were classified as having high non-tariff barriers; after92 is a dummy that takes value 1 after 1992, zero before; SENSAFT is the interaction betw. sensitive and after92

Regressions also include skill dummies and tenure, age and their squares.

Table 13: Quantile regressions with SMP experiment

	10th perc.	25th perc.	50th perc.	75th perc.	90th perc.	Observations
Low Skill:						
SENSAFT	-0.005	0.007**	0.011***	0.013***	0.011*	176664
	(0.004)	(0.003)	(0.004)	(0.004)	(0.005)	
Medium Skill:						
SENSAFT	-0.003	0.011***	0.010***	0.013***	0.014**	165196
	(0.005)	(0.004)	(0.004)	(0.004)	(0.067)	
High Skill:						
SENSAFT	-0.003	-0.006	0.007	0.019**	0.030***	73445
	(0.009)	(0.007)	(0.007)	(0.008)	(0.111)	
All Skills:						
SENSAFT	0.003	0.015***	0.024***	0.027***	0.035***	449562
	(0.003)	(0.003)	(0.003)	(0.003)	(0.005)	
All skills low union:						
SENSAFT	-0.011	0.007	0.033*	0.056**	0.051*	20062
	0.021	0.016	0.018	0.020	0.029	

Notes: std errors in parentheses;

*significant at 10%; ** significant at 5%; *** significant at 1%

Dependent variable: log real hourly wage. Sample: males in manufacturing sector 1982/1999

SENSAFT is the interaction betw. dummy for sensitive and dummy for after92

Regressions include quadratics in tenure and age, year and sector dummies