PRODUCT MARKET COMPETITION, RETURNS TO SKILL, AND WAGE INEQUALITY*

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Abstract

This paper examines the effect of product market competition on firms' willingness to pay for workers of different skills and on wage inequality within an industry. Using a large panel (1982-1999) of UK workers with complete work histories, I show that returns to skill within an industry increase with competition. I identify this effect using two quasi-natural experiments -that affected different sectors in different time periods- as exogenous measures of changes in competition. I investigate the mechanisms behind this relationship, and show that in addition to the indirect effects that operate through union bargaining and skill-biased technical change, there is evidence for a direct effect of competition beyond those channels. I provide an explanation for this finding based on the relationship between competition and the sensitivity of profits to cost reductions.

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

JEL Classification: J31, J33, L22, D21

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1 Introduction

The relationship between product market competition and the level of wages has long been recognized, with imperfectly competitive industries generating higher monopoly rents, which translates into higher wages through rent sharing.[1] However, little is known about the effects of competition on other aspects of the wage structure. In particular, it is unclear to what extent competition affects returns to skill and wage inequality. The literature on wage inequality has shown that skill-biased technical change, international trade, organizational change, and changes in unionization are all likely causes of the rise in inequality,[2] but there is hardly any evidence on the impact of product market competition. The closest related evidence comes from the effect of large U.S. deregulations on wages; generally, this literature shows that deregulation increased wage dispersion.[3] In this paper, I ask whether we can empirically identify a causal effect from increased product market competition to increased returns to skill and wage inequality, and I analyze the potential mechanisms for this relationship.

There are a number of theoretical mechanisms that could explain why increased product market competition leads to increased returns to skill and wage inequality. In particular, if product market competition leads to changes in union bargaining, investment in skill-biased technologies, or changes in organizational structure, then wage dispersion will change indirectly with competition through these variables. I also suggest a direct mechanism, based exclusively on the effect of competition on the distribution of profits (Boone, 2000; Vives, 2004) and the resultant impact on labor markets. According to this approach, as product markets become more competitive, the sensitivity of profits to costs increases. If high-skill workers produce at lower costs, then as product market competition increases, there is stronger competition among firms to attract better workers, which in turn raises the returns to skill.

To convincingly test the hypothesis that increased product market competition leads to higher returns to skill, one must overcome two difficulties. The first is finding an exogenous

[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.

[2] The papers in this area are too numerous to list. Seminal contributions include Berman et al. (1994), Juhn et al. (1993) and more recently Autor et al. (1998). Katz and Autor (1999) provide a survey and lay out the main issues. See Wood (1994) for the evidence on International trade and globalization. Evidence on the consequences of organizational change can be found in Caroli and Van Reenen (2001), Black and Lynch (2004) and Garicano and Rossi-Hansberg (2005). Some consequences of changes in unionization are discussed in Machin (1997) and Card (2001).

[3] Card (1986, 1996a) and Hirsch and Macpherson (2000) for the US airline deregulation; Black and Strahan (2001) and Wozniak (2006) for banking deregulation; Hirsch (1993) and Rose (1987) for trucking deregulation and Fortin and Lemieux (1997) for the deregulation of major industries.

source of variation in the degree of product market competition. The second is being able to provide estimates that account for individual unobserved heterogeneity and changes in industry composition, thereby using "within" variation in returns to skill following exogenous changes in competition.

For these purposes, I exploit the New Earnings Survey (1982-1999), 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 two quasi-natural experiments that the UK economy experienced in the nineties. These natural experiments affected different industries in different periods and arguably represent exogenous measures of increasing competition within sectors. The first is the implementation of the European Single Market Program in 1992, that implied a larger increase in competition for industries with high non-tariff barriers before that year. The second is the sharp appreciation of the British pound in 1996, that implied a larger increase in competition for industries that were more exposed to international trade.

Differences-in-differences estimates show that returns to skill increase because of higher competition from each of these sources. 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. I also find that these results are not exclusively due to the indirect effects of union wage compression, skill-biased technical change, or changes in the demand for different occupations. Each experiment raised the skill gap by 0.015 to 0.02 log points.

The finding that competition has a causal effect on returns to skill and inequality means that the general trend towards increasing competition in product markets[4] can be thought of as an explanation for the overall increase in inequality over the last twenty years 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 *within* sectors, mainly because the price of skills has changed over time (Blau and Kahn, 2005).

Although this study focuses exclusively on the impact of competition on returns to skill and inequality[5], the consequences of changes in competition on labor markets and organizations are likely to be numerous and sizeable[6]. Exploring further implications of such links is beyond

[4] Numerous sectors have been deregulated, economic integration of different geographic blocks (NAFTA, EU) has been pervasive and transportation and information transmission costs have been falling steadily. All these trends lead to more competition in product markets.

[5] A related effect that has been identified is the impact on the increased use of performance-related pay (Cuñat and Guadalupe, 2004 and 2005), which also may lead to higher dispersion in wages and possibly in returns to skill (if skilled workers perform systematically better).

[6] Other consequences of competition that are beyond the domain of this paper are its impact on employment (Bertrand and Kramarz, 2002) and 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

the scope of this paper but can yield fruitful insights into what determines the behavior of organizations and economic outcomes.

In the next section I discuss the potential theoretical mechanisms linking competition and returns to skill. Section 3 describes the data and presents the correlation between returns to skill and industry concentration. Section 4 presents the quasi-natural experiments and 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 the degree of competition that firms face in the product market may affect wage setting behavior and the wage distribution. From the literature on wage inequality, one could think of two potential indirect effects of product market competition on relative wages. By indirect effects I refer to mechanisms whereby changes in competition affect some intermediate factor (like union bargaining power or technological change) that in turn affects wages.

First, increasing competition can produce changes in rent sharing and union behavior. A number of papers have looked at the effect of deregulations on the level of wages and found significant effects (Rose, 1987; Hirsch, 1993; Card, 1996). As far as the dispersion of wages is concerned, if trade unions compress wages whenever there are rents to share, the increase in competition may weaken union power, imply a fall in rents and hence a reduction in wage compression. This is an indirect effect of competition through union behavior.

Second, competition may actually lead firms to change the form or technology of production. If competition fosters technological change (Aghion et al. 2005), and these changes are skill biased, then competition will raise the demand for skilled/managerial positions relative to unskilled/non-managerial ones. In this case competition has an effect on inequality through changes in the relative demand for skills because of their complementarity with the new production function. These two effects can interact and the effect of technical change can be amplified through the fall in unionization as in Acemoglu et al. (2001)

A more direct effect of product market competition on wage differentials can be derived from the results in Vives (2004) and Boone (2000) that analyze the effect of competition on

to increased effort exertion/efficiency. Bertrand (2004) argues that competition also alters the employment relationship by bringing it into a setting in which contracts are increasingly dominated by the market at the expense of implicit agreements. Finally, 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) relative profits and the incentives to invest in cost reducing technologies.[7]

Denote profits (gross of any fixed costs) by $\pi(c_i, \theta) = (p_i(\theta) - c_i)Y_i(\theta)$, where p_i are prices, c_i are costs, Y_i is output and θ captures the extent of competition[8]. Boone (2000) shows, for a number of different competitive scenarios, that an increase in competition when firms have different marginal costs, always raises the profits of a firm relative to those of a less efficient one.[9] This is the reallocation effect of competition whereby the most efficient firm captures a larger share of production. This effect implies that as competition increases, the mapping from costs to profits becomes steeper, the profits of two firms with different marginal costs move further apart and therefore $\frac{d\pi(c_i,\theta)/\pi(c_j,\theta)}{d\theta} < 0$ for $c_i < c_j$.[10]

This idea can easily be extended to the labor market and firms' willingness to pay for workers of different skill levels. If higher skilled workers are a quasi-fixed factor characterized by being able to lower unit costs c_i (Murphy and Welch, 1992), and if they are in limited supply, then the above result implies that more productive workers may be relatively more valuable as the product market becomes more competitive, because the value of a cost reduction increases.[11]

In a competitive labor market, under the assumption that skill is in limited supply and each firm hires one worker, firms compete for workers of different skills through their wage offers $w(c_i, \theta)$. Competition in the labor market implies that in equilibrium wages must be such that firms are indifferent between workers (skill levels) and make identical profits independently of who they hire, such that profits $\pi(c_i, \theta) = (p_i - c_i)Y_i(\theta) - w(c_i, \theta) = \widetilde{\pi}(c_i; \theta) - w(c_i, \theta)$

[7] Nickell (1996) shows that competition improves corporate performance.

[8] The competition variable will depend on the model assumed, and it can be number of firms, barriers to entry, elasticity of substitution etc.

[9] Boone (2000) shows that this is true for a variety of competition models that include Dixit-Stiglitz monopolistic competition, the Hotelling model, a switch from Cournot to Bertrand competition and a two stage entry game with firms competing in quantities. The paper models the increase in competition in a variety of ways as either the number of firms in the industry, relative costs of production, entry costs, the elasticity of substitution, or the intensity of interaction between firms.

[10] This can be easily illustrated for horizontal product differentiation, where consumers have CES demand functions and there are N differentiated goods in the economy. Denote by Y_i the quantity that firms produce and sell at a price p_i. c_i are the costs of production. Monopolistic competition (Dixit Stiglitz 1977) implies that $Y_i = (\frac{p_i}{p})^{-\sigma} * \overline{Y}$ where $\overline{Y}$ and p are index functions and $\sigma > 1$ ($-\sigma$ is the elasticity of substitution between products). Here, the competition parameter θ is the elasticity of substitution σ.

Firms maximize profits. $\underset{p_i}{Max}\ \widetilde{\pi}(c_i, \sigma) = (p_i - c_i) * Y_i = \overline{Y} p^{\sigma}(p_i^{1-\sigma} - c_i p_i^{-\sigma})$

First order condition yields $p_i = \frac{\sigma c_i}{\sigma - 1}$. Hence $\widetilde{\pi}(c_i, \sigma) = \overline{Y}(p/\sigma)^{\sigma}(c_i/(\sigma-1))^{1-\sigma}$,which is decreasing in c_i. The next step is to show how relative $\widetilde{\pi}$ change with σ. Take two costs i and j such that $c_i < c_j$. $\frac{\widetilde{\pi}(c_i)}{\widetilde{\pi}(c_j)} = (\frac{c_i}{c_j})^{1-\sigma}$ and $\frac{d(\widetilde{\pi}(c_i,\sigma)/\widetilde{\pi}(c_j,\sigma))}{d\sigma} = -\left(\ln \frac{c_i}{c_j}\right)\left(\frac{c_i}{c_j}\right)^{1-\sigma} < 0$

[11] Imperfect substitutability between skills is a also an implicit assumption, crucial to make any progress in explaining changes in wage differentials. A body of literature has studied imperfect substitutability (Sattinger, 1993; Kremer and Maskin, 1996) and there is empirical evidence for the relevance of such an assumption (Murphy and Welch, 1992).

are equalized across firms.[12] Each worker captures the surplus he generates. For N firms competing in the product market, that are identical prior to hiring a worker[13], profits are such that, $\widetilde{\pi}(c_i,\theta) - w(c_i,\theta) = \widetilde{\pi}(c_j,\theta) - w(c_j,\theta)$, for all i, j. And in particular this will be true for the firm hiring the Nth ability worker in the market, that gets his reservation wage (their highest and only outside option) $w(c_N,\theta) = b$, such that :

$$\widetilde{\pi}(c_i,\theta) - w(c_i,\theta) = \widetilde{\pi}(c_j,\theta) - w(c_j,\theta) = \widetilde{\pi}(c_N,\theta) - b \quad (1)$$

$$w(c_i,\theta) = \widetilde{\pi}(c_i,\theta) - \widetilde{\pi}(c_N,\theta) + b \quad (2)$$

This relates the wage offered to each skill level to profits gross of wages $\widetilde{\pi}(c_i,\theta)$. Note that $\frac{dw(c_i,\theta)}{dc_i} = \frac{d\widetilde{\pi}(c_i,\theta)}{dc_i}$, which is negative -increasing in ability. So the wage schedule is decreasing in c_i and has the same slope as the gross profit schedule but it is shifted down by $\widetilde{\pi}(c_N,\theta) - b$. It has a lower bound given by b.[14]

The sufficient condition in this setting for an increase in competition triggering an increase in wage dispersion is:

$$\frac{d^2 w(c_i,\theta)}{dc_i d\theta} = \frac{d^2 \widetilde{\pi}(c_i,\theta)}{dc_i d\theta} < 0 \quad (3)$$

Alternatively, it is sufficient to show that $\frac{d(\widetilde{\pi}(c_i,\theta)/\widetilde{\pi}(c_j,\theta))}{d\theta} < 0$ where c_j can be any arbitrarily chosen worker hired with $c_i < c_j$. This is the result in Boone (2000) for a number or parameterizations.[15]

In this setting, product market competition can have a direct effect on relative wages. When firms compete for workers in a perfectly competitive labor market where each skill level is in scarce supply, competition implies that profits must be equalized across firms hiring different workers, and therefore the firm offers workers the full change in revenue (the contribution margin) relative to hiring a different worker. As competition increases, if the relative marginal product between two given skill levels increases, returns to skill go up and so does wage inequality.[16]

In the empirical analysis, competition is measured at the industry level. For industry competition to affect relative wages, one needs to assume that skills are not fully transferable between sectors, either because there is a cost to changing industry or because the worker is

[12] Both firms and workers know perfectly the degree of competition θ and the skill level of all workers

[13] The only technology difference is given by the worker they hire.

[14] The last worker hired always gets b, although this is not necessarily the same worker.

[15] And illustrated in footnote 9 for Dixit Stiglitz competition.

[16] A related mechanism 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. The argument is that when the production technology has the characteristics of a public good, then 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 increase relative to the person that is just below him in ability terms. Wage dispersion is larger.

less productive in another industry than in the industry of origin (note that the same must be true for inter-industry wage differentials to emerge). In that situation, it is industry variation in competition that matters for individual wages and returns to skill. If this were not true, there would be no effect of within-industry competition on relative wages.

The remainder of the paper tests whether increasing product market competition has a causal effect on returns to skill and the wage structure and considers the potential mechanisms responsible for the results.

3 Data description and basic correlations

3.1 Data

To assess the link between product market competition and relative wages, I exploit a very large panel of workers, the New Earnings Survey (NES) to which I associate a number of variables that measure competition. Here I describe the worker panel and outline the competition measures used. Further details of the variables and sample definitions can be found in the appendix.

The NES is a very large sample survey of 1% of all individuals employed in the UK. Employers are bound by law to provide information on all individuals whose national insurance number ends in a certain two digits. These individuals constitute the NES sample. Since National Insurance numbers are issued randomly and are retained for life, it is a very long panel of a random sample of workers 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 on age, occupation, region, industry, and whether the individual was in the same job during the previous year. The sample is restricted to males working full time whose pay has not been affected by absence in the reference week. Unfortunately, it has no information on educational attainment, so I construct an observable skill variable from the occupational data. I define three skill groups (high, medium, and low skill) along the lines suggested by Elias (1995) and shown in Table 1. This is a somewhat more refined measure than the white-versus-blue-collar workers used in the literature, and has been used in the past (among others in Nickell and Quintini, 2003, and Bell et al., 2002). The measure of wages used is real weekly pay (excluding over-time) of workers whose pay was not affected by absence, divided by weekly hours excluding over-time hours. Table 2 describes the data, for the whole sample and by skill group. High skilled workers receive higher wages, and average tenure and age are similar across skill groups.

The advantage of using the NES versus other datasets for this purpose is that it is a very long panel that follows individuals throughout their working lives, providing enough individual variation for longitudinal, within-individual analysis. Furthermore, it is a large sample, from all economic sectors with very accurate hourly measures of wages, so one can isolate hourly wages excluding overtime, and abstract from the changes in hours worked.

To evaluate the effect of competition I follow three different strategies, in order to show that the effect is not restricted to one particular event and that it can be interpreted as causal. First, as a descriptive starting point, I use concentration ratios (the fraction of industry employment or output represented by the five largest firms) by industry (SIC 3 digit) and year. Then, I present results using two quasi-natural experiments. The first experiment is based on the implementation of the Single Market Program in 1992, and I exploit an index of the exposure of different industries to the reduction in non-tariff barriers. The second experiment exploits the appreciation of the pound in 1996, and I obtain trade information as a source of variation for the experiment. Details of the exact specification of the experiments can be found below, when the results are presented and discussed.

3.2 Industry concentration and returns to skill

As has been widely documented elsewhere, inequality has increased markedly in the UK over the past 20 to 30 years (Gosling et al., 2000). In my data (males in the manufacturing sector), inequality between the high and low skill groups increased by 0.28 log points between 1982 and 1999. The extent of competition also changed in this period. As a preliminary descriptive measure, I use industry concentration: Figure 1 shows the decline in top five concentration ratios as measured by output and employment in the UK manufacturing sector.

Figures 2 and 3 bring these two trends together and show the cross-sectional and time-series relationship between competition -measured by the inverse of employment concentration CR5[17]- and inequality. Figure 2 plots wage dispersion (measured by the 90/10 differential in wages) by industry between 1982 and 1999 against average concentration by industry for those years. The more concentrated industries have lower dispersion than the more competitive ones. Figure 3 plots dispersion by year against average concentration by year, again yielding a negative relationship. That is, concentration fell and inequality increased over time.

[17] This measure is better computed than concentration measured by output and therefore is less subject to measurement error. That is why I decided to use it throughout the paper. The correlation between the two measures is 0.92, and the 10th and 90th poercentile are almost identical, indicating that their distribution is very similar. However output concentration is substantially more noisy and the results using that measure although qualitatively similar, tend to be more insignificant, possibly due to attenuation bias. When I instrumented output concetration with employment concetration to deal with the measuremente error, the results were again large and significant. For simplicity, I show the cleaner measure of concentration here. The other results are available upon request.

Table 3 goes beyond the aggregate correlations and exploits the panel to document the correlation between concentration ratios as the (inverse) measure of competition and returns to skill. I regress the logarithm of wages of individual i in industry j, with skill level k, in year t ($\ln w_{ijkt}$) on concentration $CR5_{jt}$ and on concentration interacted with skill $CR5_{jt} * S_{it}^{k}$ (where the low-skill category is omitted).

$$\ln w_{ijkt} = \alpha + \gamma X_{ijkt} + CR5_{jt} * S_{it}^{k\prime}\theta + \lambda CR5_{jt} + S_{it}^{k\prime}\rho + d_t + d_j + \eta_i + \varepsilon_{ijkt} \qquad (4)$$

X_{ijkt} is a vector of individual characteristics (including age, tenure, and their squares). η_i is an unobserved permanent individual component. Time and industry dummies are given by d_t, d_j. ε_{ijkt} is a white noise.

The coefficient on the interaction between skill and concentration (the vector θ and each of its k elements θ_k) captures the extent to which returns to skill vary with industry concentration. I progressively saturate the model with dummy variables and their interactions in Columns (1) to (4).[18] Standard errors are adjusted for clustering by industry and year.

The coefficients of interest on the interaction of the skill variables with industry concentration show that when concentration falls (competition increases), the gap between high and low skill wages is higher, ceteris paribus. Column (1) presents results without individual fixed effects but controlling for observable characteristics. It is identified from the within industry variation in concentration and the results indicate that a one standard deviation reduction in concentration increases the relative wage of a high to a low skilled worker by 0.026. When controlling for individual fixed effects (column 2) the effect is reduced to 0.019.

Column (3) saturates the regression further with fully interacted year and skill dummies, which allows for changes in returns to skills over time in a non-restricted way. Column (4) accounts for the fact that some industries may have systematically higher returns to skill by fully interacting industry (2 digit SIC) and year dummies. The estimated change in returns to skill is smaller, possibly in part because if CR5 is persistent within industries, this will absorb much of the variation in returns to skills. In the most saturated specification, the coefficient on CR5*medium skill is -0.36 and the one on CR5*high skill is now -0.022 (both are significant but not statistically significantly different from each other). So even here it appears that returns to skills are increasing within industries as concentration falls.[19]

[18] Hausman tests of random versus fixed effects rejected the null of absence of correlation between the error term and the regressors.

[19] The results also indicate that more concentrated sectors pay lower wages -contradicting what is predicted by the inter-industry wage differentials hypothesis. This result has been found elsewhere in the literature and the most frequent explanation has been that concentration is a poor measure of competition. However, in a model with heterogeneous costs of production as we have in mind here, it is possible that as product market competition increases, inefficient firms drop out of the market, low skilled workers are laid off, and average

However, these results only suggest a correlation between actual competition and returns to skill because of a number of limitations associated with the use of concentration ratios. First, concentration ratios are often criticized from a conceptual point of view, because they may not be good measures of competition (Boone, 2000). Furthermore, from an econometric point of view, they may be endogenous (Schmalensee, 1989) or correlated with an omitted variable (like technical change). Thus, the estimates using concentration are purely descriptive and may not capture the causal effect of competition on changes in returns to skills. To be able to make a statement on causality I exploit two quasi-natural experiments: the introduction of the European Single Market Program in 1992 and the 1996 appreciation of the British pound. This is the concern of next section.

4 Two quasi-natural experiments

4.1 Specification

The main evidence in this paper comes from two exogenous and separate events that implied changes in product market competition. These are the implementation of the European Single Market Program in 1992 and the appreciation of the pound in 1996. The structure of both experiments is similar, since they are exogenous shocks that changed differently the exposure to competition of different industries, given some pre-existing characteristics (these are non-tariff barriers for the 1992 experiment and previous import penetration for the 1996). Therefore, to provide differences-in-differences estimates of changes in returns to observed skill levels for both events I define two periods, before and after the experiment, as captured by the variable $post_t$. This is a dummy variable that equals one after 1992 in the SMP experiment and after 1996 for the appreciation. The sample is defined by workers who, in the year of the experiment, are in a sector for which the experiment variable is non missing. I also define $sensit_j$, which indicates how sensitive a given industry was to the experiment. Because the measures of sensitivity may change endogenously they are computed prior to the experiment year and vary only by industry j. Differences-in-differences estimates allow us to evaluate the effect of the experiment by conditioning out any pre-existent differences across industries and any general changes common to all industries over time.

To assess whether returns to skill increased more after these experiments in more sensitive industries, I estimate:

$$\begin{aligned} \ln w_{ijkt} &= \gamma X_{ijkt} + (post_t * sensit_j * S_{it}^k)'\theta + \lambda(post_t * sensit_j) + S_{it}^{k\prime}\rho \\ &\quad + \lambda_k^0 \, post_t + \lambda_k^1 \, sensit_j + d_t + d_j + \eta_i + \varepsilon_{ijkt} \end{aligned} \tag{5}$$

profits (and wages) of the remaining actors are higher (see also Aghion and Shankerman, 1999).

where the dependent variable is the log wage of individual i working in industry j with skill level k at time t, S_{it}^{k} is a vector of k skill dummies where skill is defined as the skill level in the year of the experiment (to have a conservative estimate that avoids endogenous upskilling over time), and X_{ijkt} is a vector of individual characteristics (including age, tenure, and their squares). η_i is an unobserved permanent individual component. Time and industry dummies are given by d_t, d_j. ε_{ijkt} is a white noise.

The estimate of returns to skill, the vector θ (and each of its k elements θ_k), reflects how returns to different skill levels (k) vary with product market competition (in the regressions θ_k are the coefficients on the interaction between the medium, and high skill dummies and $post_t * sensit_j$ -I drop the low skill level interaction to avoid collinearity). λ reflects the effect of competition on average wages.

λ_k^0 and λ_k^1 are necessary to obtain a differences-in-differences estimate of changes in returns to skill, θ. λ_k^0 captures the differential returns to skill before and after the experiment. This controls for the fact that returns to skill may increase after the shock in all industries in a way that is correlated with competition, whether because of skill-biased technical change or any other reason.[20] λ_k^1 captures the differences in returns to skill between industries with different degrees of sensitivity to the shock. If there was a correlation between industry specific returns to skill and industry sensitivity, omitting this regressor would bias the results.[21]

To interpret the estimated coefficients, θ^k, as causal parameters, it is necessary that the event is exogenous to wage setting and that it has no other indirect effect on wages. I discuss these issues below.

Although the variation used to assess the effect of product market competition on wage dispersion is at the level of industry and time, exploiting the individual panel and using individual fixed effects allows us to deal with the patterns of mobility and sorting of workers across industries. First, it allows us to control for compositional changes in observable characteristics within industries over time. If the tenure, skill or age structure of a particular industry varies over time, this will be accounted for by using individual records.

But more importantly, exploiting the panel helps us deal with potential biases arising from individual unobserved heterogeneity and the sorting of workers into different sectors. Table 4 shows regressions of the logarithm of industry employment on each of the measures of competition (the two experiments and concentration), plus industry and year dummies. The results indicate that the increase in competition led to larger employment declines in industries

[20] A vast literature suggests that skill-biased technical change is one of the main causes of the increase in wage inequality in the UK and the US. Card and DiNardo (2002) suggest that there are limitations to this explanation.

[21] This could arise, for instance, through a trade union effect if trade unions are stronger in industries that are less sensitive implying that wages are more compressed in those sectors.

more affected by the exchange rate appreciation and the SMP (with no significant effects of competition measured by concentration). This suggests that the composition of industries may be changing; hence it is important to control for individual fixed effects and explicitly address these changes in the regressions.[22]

To the extent that industry changes are not endogenous to the change in competition, it suffices to control for individual fixed effects to obtain unbiased estimates. However, since industry changes may be an endogenous result of changes in competition, the actual total change in skill returns in each industry will be a combination of a pure price effect (skill being more valuable as competition goes up) and job changes (voluntary and involuntary). Jacobson et al. (1993) show that job displacement leads to a fall in wages. Therefore if competition leads to job displacement, the estimates of returns to skill in equation 5 will be a combination of a price effect and a displacement effect.[23] In order to have a sense of the contribution of these different effects, I compare three sets of estimates that capture different aspects of this relationship.

First, I obtain the overall effect of competition by comparing wages over time of individuals in sectors affected by the experiment to those not affected, regardless of whether they changed industry. I assign to each individual the industry they worked in the year of the experiment, and keep it constant throughout the time the worker is observed. This gives the total effect of competition on wages and returns to skill. The effect is identified out of changes in wages for individuals in sensitive relative to less sensitive industries in the year of the shock regardless of whether they change jobs or industries. In particular, if an individual moves out of a sensitive industry, this estimation assumes that the wage change is due to the shock to the original industry of origin and its implied effect on wages, not to the industry change. Therefore, the original composition of the industry is kept constant.[24] To capture the overall effect of competition this regression does not include individual fixed effects.

Second, I exploit the panel and assign each worker the sector they actually belong to in each and every year. With individual fixed effects, the effect is identified out of individuals who stay in sectors that are affected by the shock, as well as individuals who move to an industry that is affected, after the shock. These results capture both the effect of competition on the pricing

[22]Bartel and Sicherman (1999), when analyzing the effect of technical change on returns to skill and wages, find that the results are qualitatively very different when they use the panel versus the cross section.

[23]Furthermore, there may be interindustry wage differentials, such that industries with more competition pay lower wages on average. This is a different problem from whether returns to skills (wage dispersion) 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 high-skilled workers, wages are lower because of the fall in rents. This means that the incentive to exit an industry is ambiguous and ultimately an empirical question.

[24]The only changes arise from individuals exiting the sample. Given that we have complete work histories, this occurs only when the worker goes out of the labor force or is permanently unemployed.

of skills and the actual change in wages from the industry change, i.e. it captures the change in wages from the sector change, not from the original shock. Even though the composition of the industry may change, the inclusion of individual fixed effects makes sure that unobserved changes to industry composition are not driving the results.

Third, I use the same setting as above, but instead of individual effects I include industry specific individual fixed effects. That is, if the worker changes industry, he is treated as a different individual and therefore the estimates do not capture the job change. Here, the effect is identified exclusively out of industry stayers -those who are in sensitive industries and affected by the shock-, and is the closest to a pure price effect. As before, the inclusion of individual fixed effects controls for changes in industry composition.

Note that I chose to present reduced form estimates of these experiments instead of two stage least squares instrumental variables estimates using concentration ratios as the endogenous regressor. This is because the t-statistics in the first stage were too low, causing potentially a weak instruments problem. The other reason is that the exclusion restriction is most likely not satisfied, since the experiments may well have an effect on wages that does not go through industry concentration.

Finally, to shed light on the potential mechanisms behind the estimated effects, I explicitly address the role of changing unionization and skill-biased technical change. To address the unionization mechanism, I control for union density in the industry (where data are available) or alternatively I restrict the sample to industries with low unionization. To address the potential indirect effect of competition through technological changes at the industry level, I control explicitly for R&D intensity and the associated changes in returns to skill. The standard errors are clustered throughout to account for the fact that the individual error term may be autocorrelated (Bertrand et al., 2004). I also show standard errors clustered at the industry level in square brackets.

4.2 The 1992 European Single Market Program (SMP)

The European Single Market Program (SMP) 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 roughly 300 measures aimed at achieving this. The actual implementation of these measures occurred between 1988 and 1992.

This experiment captures a higher threat of entry (through imports or direct investment and entry) into the UK market from other European firms, with similar skill intensity in production as the UK. The White Paper described 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: reducing transaction costs; lowering barriers that 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); and 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 its implementation. I apply the same industry classification as Griffith (2001) and Aghion et al. (2005), which is derived from Mayes and Hart (1994). They divide industries according to whether they had low, medium, or high non-tariff barriers prior to the SMP. It was expected that the introduction of the SMP would more strongly affect those with medium or high barriers who would see these reduced considerably. The classification is at the 3-digit SIC level and I consider those with medium or high barriers before the development of the single market as the industries in which competition increased more sharply. Two groups of industries are defined, those most and least affected by the SMP,[25] over two time periods: before and after 1992. I also restrict the sample to the period 1988-1996, where confounding trends from the announcement of the policy (pre-88) and the other experiment (post-96) are minimized. To assess the validity of the difference in difference set-up, I tested for placebo treatment effects (i.e. for potential effect of the experiment prior to the 1992 -1991 and 1990 in particular- that would invalidate the experiment), and found no significant effects.

To test the impact and validity of the program as an indicator of product market competition, one can look at whether it affected what we call high and low sensitivity industries differently before and after 1992. For this purpose, I regress concentration ratios by industry (3-digit SIC80) on a set of time and industry dummies and a variable (SENSAFT) defined as the interaction of the SMP group dummy (that equals one if the industry is classified as having moderate or high barriers before the SMP) and the post-92 period (1982-1999). The results are shown on Table 5. Employment top five concentration ratios fell by 3.3% more post-SMP in sensitive industries than in the industries that were expected to be least affected. Griffith (2001), who also uses this experiment, is able to test directly (using a comprehensive firm panel: 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 the sensitive sectors. This combined evidence indicates that the experiment is a good measure of differential changes in competitive pressure.

Table 6 presents individual regressions of log wages on individual characteristics (quadratics

[25] I used a simple dichotomous variable of low or high barriers for simplicity and consistency with the previous papers. Results using the three levels of barriers (low, medium or high) were similar.

in age and tenure), an interaction of the experiment variable (that takes value one for sensitive industries post-92 and zero elsewhere) and the skill levels. It follows the structure outlined above to get at the fraction of the estimate of returns to skill driven by movers and stayers.

I first define industry as the industry of origin in 1992, prior to the shock (SMP implementation). The coefficient on returns to high skill in the first column is 0.022; this implies that after the SMP introduction, returns to skill increased by 2 percentage points more in sensitive sectors. This effect is the *total* effect of competition to a worker in a sensitive industry relative to others in a non-sensitive industry after 1992, which includes changes in returns to skill within the industry and changes induced by the worker changing industry, either within the sensitive industries group ($sensit_{92} = 1$) or to an originally low sensitivity industry ($sensit_{92} = 0$).

Columns 2 and 3 use the actual industry where the worker is in each year. Column 2 has standard individual fixed effects and the estimate of returns to skill is 0.017, which is statistically indistinguishable from the one in column 1. This estimate is based on changes in returns to skill within the affected industries as well as changes from displacement, with changes in industry composition captured by the individual fixed effects. Column 3 introduces industry-specific individual effects to try and isolate the price effect from the industry change mechanism. The coefficient is slightly lower, 0.016, but again very similar.

Comparing column one, which gives us something closer to the total effect (0.022), to column 3, which is closer to the pure within industry price effect (0.016) suggests that most of the total effect (63%) arises from price changes while 27% can be attributed to the effect of job displacement.

In addition to having a sense of the magnitude of the effect of competition, one would like to assess the mechanism driving this change. In particular, is it a direct effect of competition, or an effect through technological change or union bargaining? Table 7 assesses these issues. Columns 1 and 3 use the specification with industry of origin (total effect), and columns 2 and 4 show the specification with individual fixed effects.

Columns 1 and 2 control explicitly for R&D intensity at the industry level. Arguably, to the extent that R&D measures are slow moving and noisy, just controlling for this variable is not a conclusive test of technological change being the mediating factor for the effect of competition. However, in the absence of better measures, it is a good proxy to have an estimate of the importance of such effect. If the experiments implied a higher increase in R&D investment in sectors where the increase in competition was larger, the coefficients would capture an indirect effect of competition through R&D. Including R&D expenditure divided by total production as a control, and interacting it with the skill dummies to allow for returns to skills to be determined by technological change, does not alter the coefficient of interest, suggesting that the coefficient of interest is not exclusively driven by skill-biased technical change.[26] The estimated effect of R&D is to increase returns to skill in column 2, although it is small and not highly significant.

I address the issue of unionization in Table 7 by restricting the sample to industries with union density below the mean in 1994 (below 28%).[27] For this group, Column 3 shows that after 1992, the overall effect of the SMP was similar to that for all industries (0.015), although it is not highly significant. In the regression that controls for individual fixed effects, the point estimate is lower (0.011) while the effect on low skilled wages is positive and significant (0.014). This suggests that for workers that start off in low unionized industries, the effect on returns to skill arises mostly from job displacement, and less so from the price change than in the full sample.

So, the evidence suggests that there is a causal effect of competition on returns to skill, and that the indirect role played by unions as the mechanism through which competition affects dispersion may have been significant in 1992. The evidence for the mediating role of technological change is weaker, although the test is less conclusive given the nature of the R&D variable.

4.3 Trade openness and the 1996 appreciation

The UK is a small open economy and fluctuations in the exchange rate are largely unpredictable and exogenous to the wage setting conditions within that country. Hence, sharp and sudden changes in the pound sterling can be viewed as a quasi-natural experiment.

In 1996, the pound sterling experienced an appreciation of over 20% (Figure 4). This can be seen as an exogenous shock that affected industries differently depending upon their openness to trade and, in particular, the level of import penetration (total imports divided by the sum of imports and total sector product).[28] The appreciation affected more deeply industries that were relatively open before 1996. Its direct effect was to reduce the prices that foreign competitors could offer in the UK market and to increase the number of potential foreign competitors who could sell in the UK. Put differently, it actually reduced the costs of foreign relative to UK firms, which reduced equilibrium prices proportionally to the extent of

[26] The sample size is reduced because of the limited avalability for certain industries of R&D data. The results were not sensitive to different specifications of R&D (levels and logarithms yielded similar results).

[27] Yearly data on union density are only available after 1994, so I cannot control directly for the degree of unionization here. That is why I only present evidence on the restricted sample of low unionization sectors.

[28] Verhoogen (2004), in a similar setting but with a very different identification strategy, uses the 1994 devaluation of the Mexican peso to show how quality upgrading of exporting firms raised the demand for white collar workers in Mexico. My identification relies on pre-exising differences across sectors in terms of import penetration and, if anything, the appreciation of the pound should reduce reduce export opportunities for UK firms.

the increase in competition. Dornbusch (1987) develops this argument and shows that under the Cournot, Dixit-Stiglitz, and Salop models of competition, the relative costs of domestic firms increase as the domestic currency appreciates, domestic prices fall, and they do more so in industries with high import penetration. So, an appreciation has a bigger impact on prices in industries with high levels of import penetration. In this situation, high-cost domestic firms are more likely to go bankrupt; there is a general increase in competitive pressure on domestic industries in which import penetration is important.

The appreciation also implied that firms that could not enter the market previously now had an advantage in doing so. Beyond the immediate effects on competition via relative costs and prices, several papers examine the theoretical relationship between structural changes in competition and exchange rates. In particular, Baldwin (1988) and Baldwin and Krugman (1989) show that a large appreciation may reshape the competitive structure of the local market in a permanent way.

Notice that the identification comes from the fact that high import industries ex ante, should experience larger falls in prices/more entry, and not from a change in import penetration to the sector, that is endogenous and would capture a trade effect.

Even though it is difficult to quantify the effect of the appreciation on the degree of competition (precisely because there is no unique and uncontroversial measure of "competition" levels), one can look at a number of indicators (profits, prices, quantities) to assess to what extent they changed as we would expect.

Figure 4 shows the evolution of the effective exchange rate for the British pound. Two different regimes, low and high exchange rates before and after 1996, are apparent. The appreciation generated a significant shock to UK exports and imports. Table 8 shows the aggregate effect on the balance of trade in goods. In 1997, there is a small positive effect on the balance of trade. This is natural if there is some inertia in the quantities exported and imported; the appreciation meant higher export prices and lower import prices, so the balance of payments initially could improve. However, from 1998 onwards, the quantity effect dominates and the balance of trade deficit nearly doubled, and in spite of the appreciation of the pound by almost 20%, the value of imports still went up after the appreciation. Gagnon (2003) estimates that UK firms absorbed about 40% of the impact by reducing their prices; the rest was absorbed by quantities. The same paper finds that profitability fell more in trading sectors. This is indirect evidence that the appreciation had an effect on competition. Cuñat and Guadalupe (2005) uses the same experiment and provides further evidence of its effect on profits. It also tests the exclusion restriction (the implicit assumption that the only thing that changed following the appreciation was competition). Using a panel of medium and large UK firms in the 1990s (the Bureau Van-Dijck FAME dataset), Cuñat and Guadalupe (2005) exploits firm-level information to assess whether companies changed their investments or asset levels according to their openness after the appreciation. These magnitudes did not seem to be changing, which validates the exclusion restriction.[29]

In sum, industries with high import penetration face a larger increase in competition after the appreciation of the pound; hence, the wage differential of high to low skill workers should increase more in those industries after 1996 than in the least open and low trading sectors.

Notice that here the identification is richer than with the previous pure difference-in-differences specification given by the SMP, since import penetration is continuous, not a dummy variable.

Table 9 presents the results. Column 1 keeps the industry of the worker constant (at the 1996 industry) regardless of whether he changed industry after the appreciation. The coefficient on the interaction of the skill and the experiment variables (Import penetration times the post-96 dummy) gives us the total effect of the appreciation on workers with different levels of import penetration in 1996. The estimated effect on returns to skill 0.061 indicates that for an industry with average import penetration (0.24), the effect was to increase the differential by 1.5% relative to an industry with no imports prior to 1996. As mentioned, this captures the overall effect, that includes changes in the price of skill of stayers and changes in wages for movers.

Columns 2 and 3 define industry as the industry the worker belongs to in each and every year. Column 2 controls for individual fixed effects. The coefficient on high skill is 0.056, which is statistically identical to the one in column 1, suggesting that there is not much difference in the ways we control for industry composition. Finally, column 3 includes industry specific individual fixed effects, and the coefficient is halved (0.025) and becomes not significant (although it is not statistically different from the estimate in column 3). This suggests that the pure price effect in this case is lesser than in the SMP and that at least half of the effect is due to job changes.

Table 10 assesses to what extent the effect of competition occurs through skill biased technological change (changes in R&D, columns 1 and 2) or a union effect (columns 3 to 6). The results in columns 1 (total effect) and 2 (price effect plus within industry changes), that controls for R&D, are statistically indistinguishable from the previous results. The same caveats as in the previous experiment apply to the use of R&D as a control variable to disentangle the mechanism for the estimated effect of competition. However, the fact that the coefficients are unchanged suggests that the result is not exclusively driven by an indirect effect through

[29] The placebo effects for the experiment test here yielded mixed results: in the full sample they were significant while in the manufacturing sector sample they were not. However, I found no evidence of pre-existing trends, which grants validity to the experiment.

skill biased technological change.[30] Columns 3 and 4 include a variable for the degree of union density in the industry (available from 1994) interacted with the skill dummies. Controlling for unionization, and for the degree of wage compression implied by union presence, the effect of competition on returns to skill remains significant and of the same magnitude as before. This suggests that it is not changing unionization *per se* that is driving the effect of competition and that there is a pure competition effect. The coefficients on the density variable and its interactions indicate that industries with more union density have lower returns to skill confirming, as found elsewhere, that unions tend to compress wages (Card, 1996). Columns 5 and 6 restrict the sample to low unionization industries. The overall effect in column 5 (0.069) is again indistinguishable from the previous estimates, which suggests that the overall effect is unlikely to be driven by unionization. However, the estimate in column 6, is reduced to 0.02 and loses statistical significance.

Overall, the results indicate that the increase in competition after the appreciation raised returns to skill and increased wage dispersion. This is partly through a change in prices, and partly through within industry job changes. As far as the mechanisms through which competition operates, controlling for R&D and unionization does not affect substantially the results, suggesting that there may be a direct effect of competition independently of these variables.[31] However, a precise understanding of the actual mechanisms at work would require a more direct analysis that is beyond the scope of this paper.

4.4 Contribution to changes in wage inequality

The analysis above indicates that product market competition increases returns to skill. Next, one would like to know the magnitude of this effect. Unfortunately there is no unique measure of "competition": actual competitive pressure operates through different channels, and the measures used here only identify one channel at a time. Furthermore, differences-in-difference estimates reflect "how much more" returns to skill increase in some industries than in others, controlling for a number of observables as well as unobserved ability. Therefore, I can evaluate the effect of these two experiments on relative changes in returns to skill, but not the contribution of all changes in competition to increased wage inequality.[32]

[30] Note that the coefficients on the R&D variables indicate a negative effect of R&D on low skilled wages (-0.019) and negative returns to skill. This is similar to the results in Bartel and Sicherman (1999) who show that much of the estimated effect of skill-biased technological change is a result of workers sorting on ability. Once they control for individual fixed effects, the effect of various measures of technological change on returns to skill is negative or insignificant.

[31] Allowing for an interaction of the R&D and unionization variables with a post-1996 dummy (or post -1992 in the previous section) did not change the results on the competition variable.

[32] The contribution of changes in concentration to inequality are negligible. Since concentration ratios have no causal interpretation, I focus on the contribution of the two experiments to inequality.

In my sample, the ratio of wages of high- to low-skilled workers increased by 0.15 log points between 1988 and 1996 (the SMP sample period). The effect of the SMP on relative wages was to raise by 0.02 the gap between high-and low-skilled workers. Taking into account the fact that 41% of the labor force was in a sensitive industry before 1992, this implies a change in returns to skill of 5% of the measured increase in the skill gap. The effect of the 1996 appreciation yields a difference of 0.015 log points at average import penetration which is 38% of the total increase in the skill gap (the skill gap increased by 0.04 points over the sample period, 1992 to 1999).

These are all non-negligible effects. Furthermore, competition has increased through many other sources; therefore, this estimate is possibly a lower bound of the contribution of competition to returns to skill. The size of the overall effect may be much larger.

5 Conclusion

This paper identifies product market competition as a source of increased returns to skill. Using an individual panel of UK male workers in the manufacturing sector, and two different quasi-natural experiments as indicators of competition, I show that skills are rewarded more (in relative terms) as competition increases. The first quasi-natural experiment exploits the introduction of the European Single Market program in 1992, which developed the European internal market by reducing a number of entry barriers. The second uses the large appreciation of the British pound in 1996. The effect of these experiments on returns to skill was identified in a differences-in-differences specification.

Overall, the results indicate a causal effect of competition on returns to skill within sectors. I find that most of the effect is due to changes in the prices of skills within sectors, rather than job or industry changes. Even though various mechanisms may drive this relationship, I find a positive effect of competition on returns to skill in sectors when controlling for R&D intensity as an indicator for potential skill-biased technical change; and also when controlling for union density, suggesting that the effect of competition may not be exclusively mediated by these variables. If I restrict the analysis to industries with low unionization -where trade unions are not likely to be the explanatory factor- the effect is still present although less strong, suggesting that some of the effect may operate through union wage compression.

Thus, the evidence is consistent with a direct causal effect of product market competition on returns to skill. I find little evidence that this effect operates exclusively through the main mechanisms proposed in the literature, such as technology and unionization. The effect of competition on returns to skill may therefore be a direct effect through a change in the sensitivity of revenues to cost reductions. Therefore, increasing product market competition may be a significant determinant of the increase in wage inequality that has taken place over the past 25 years. Further exploration of the precise channels through which competition affects the demand for skill as well as 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, are natural extensions that can yield interesting insights. These questions are left for future research.

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6 Data Appendix

Sample definition

I analyze three slightly different subsections of the data because of limitations in merging the datasets that cover different time periods. I deliberately chose to keep the three subgroups separate rather than restricting the analysis to one homogeneous subgroup by dropping observations. The sample size for the specification using concentration ratios has 449,562 observations representing 83,002 individuals. It contains all male workers in manufacturing industries (SIC 151 to SIC 372) for the years 1982 to 1999.

For the experiments, the sample is defined by workers who in the year of the experiment are in a sector for which the experiment variable is non missing. Their skill is defined as the skill category in that year (to have a conservative estimate that avoids endogenous upskilling over time). Then, for the different specifications I use different industry definitions (industry of origin or time varying). In the exchange rate experiment, the analysis is done on the whole economy for the years 1993 to 1999. The SMP analysis is for the 1988-1995 period, and the sample is limited to industries for which we have a classification of non-tariff barriers. The three samples do not differ substantially in terms of descriptive statistics.

Industry Concentration

I obtained concentration measures from the UK Office of National Statistics (ONS) based on the ARD dataset[33]. The results presented here correspond to the top five concentration ratio measured by employment. This measure of concentration reflects the percentage of total employment in the industry accounted for by its five largest firms. The sample used to compute this concentration ratio (CR5) was the population of UK manufacturing firms. This dataset goes back to 1982 but restricts the analysis to the manufacturing sector (SIC 1992 codes from 151 to 372).

Import penetration

Trade data were obtained from the “Imports and Exports data: MQ10 dataset”, elaborated by the ONS,[34] which 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

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

[34] Available online on the ONS website.

available yearly from 1990. To construct import penetration (imports divided by imports plus industry output), I use total production from the ARD/ONS. 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.

Single market program

I define two groups of industries in the NES according to their degree of sensitivity to the program -given by the level of non-tariff barriers prior to 1992- that follows the classification in Griffith (2001). Industries are defined by their SIC80 3-digit code.

Union Density

I obtain measures of union density by industry from the UK 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 forward. I also generate a low-unionization sample, defined as industries that were below median (29%) unionization in 1994.

R&D

I construct a measure of R&D intensity using the OECD-STAN Dataset. This is defined as total R&D expenditure divided by total industrial production by industry and year. I merge the data to the 3 digit SIC 1992 industries. Where R&D intensity is defined at a more disaggregated level, I take the average of all the subcategories within SIC code. Data are available from 1987.

7 Tables and Figures

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 Other occ. in agriculture, forestry, fishing	80-89, 90
	Other elementary occupations	91-95,99

Source: Based on Elias (1995)

Table 2: Descriptive statistics

	All skill groups	Low skill	Med skill	High skill
ln real hourly wages	1.48 (0.45)	1.31 (0.34)	1.47 (0.40)	1.92 (0.48)
Real hourly wages	4.91 (3.04)	3.94 (1.44)	4.71 (2.43)	7.73 (4.89)
Age	39.30 (12.41)	39.21 (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	4.87 (4.17)	4.86 (4.17)	4.96 (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 (0.19)	0.242 (0.19)	0.244 (0.2)	0.271 (0.20)
CR5 employment	0.230 (0.19)	0.229 (0.186)	0.225 (0.19)	0.244 (0.19)
Import penetration*	0.24 (0.14)			
Union Density*	0.30 (0.14)			
R&D expend. /production*	0.16 (0.38)			
Observations	449551	191597	178822	79111

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

*mean is computed on observations with non-missing values in this sample

Table 3: Effect of concentration on returns to skill

	Indust. eff..	Industry and indiv. effects	With year return	With indus. ret.
	(1)	(2)	(3)	(4)
Med. skill	0.1675	0.0461	0.0192	0.0499
	(0.0035)	(0.0027)	(0.0045)	(0.007)
High skill	0.5617	0.149	-0.0066	0.0392
	(0.0068)	(0.0046)	-0.0059	(0.011)
CR top5	-0.0231	-0.0987	-0.077	-0.0817
	-0.0277	(0.0212)	(0.0209)	(0.021)
CR top5*Med. skill	-0.0534	-0.0387	-0.0299	-0.0367
	(0.0124)	(0.0074)	(0.0078)	(0.009)
CR top5*High skill	-0.1421	-0.1004	-0.0513	-0.0218
	(0.0198)	(0.0143)	(0.0112)	(0.012)
Indiv. Fixed eff.	-	yes	yes	yes
Year*skill	-	-	yes	yes
Sector*skill	-	-	-	yes
Observations	449562	449562	449562	449562
R-squared	0.38	0.37	0.37	0.38

Notes: Robust std errors in parentheses, clustered by industry and year; Dependent variable: log real hourly wage. Sample: males in manufacturing industry 1982/1999, NES. Variables: CR5 is top5 concentr. ratio; Year*skill (Sector*skill) are fully interacted year (sector) and skill dummies. Ind*industry (Ind*firm) effects are fully interacted individual and industry (firm) dummies; All regressions include year and industry dummies, age, tenure and their squares.

Table 4: Effect of the different competition measures on employment

	lnEmployment	lnEmployment	lnEmployment
	(1)	(2)	(3)
Concentration	-0.388		
	(0.347)		
ImpPenetr.*Post96		-0.416	
		(0.128)	
SENSAFT			-0.202
			(0.044)
Year dummies	yes	yes	yes
Industry dummies	yes (SIC 92)	yes (SIC 92)	yes (SIC 80)
Observations	1687	789	1806

Based on NES employment, males in the manufacturing sector. Dependent variable is ln(employment) by industry and year. Imp.Pen. is mean import penetration in 1993/1995; Post96 equals one after 1996, zero before;SENSAFT is the interaction dummy for SMP sensitive and dummy for after92. Sample periods: (1) and (3) 1982-1999 (2) 1992-1999

Table 5: Effect of the 1992 SMP experiment on concentration

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

Notes: Std. errors in parentheses, clustered by industry. Dep. variable is concentration ratio, Unit of observation is year-industry SENSAFT is the interaction dummy for sensitive*dummy for after92

Table 6: Effect of the SMP experiment on returns to skill

	Overall effect	Overall +FE	Stayers
	(1)	(2)	(3)
SENS*Post92	-0.0022	0.0037	0.0043
	(0.0057)	(0.0037)	(0.0037)
	[0.0098]	[0.0070]	(0.0073)
Med Skill*SENS*Post92	0.0029	0.002	-0.0005
	(0.0077)	(0.0047)	(0.0047)
	[0.0108]	[0.0049]	(0.0056)
High Skill*SENS*Post92	0.0218	0.0175	0.0161
	(0.0105)	(0.0061)	(0.0062)
	[0.0150]	[0.0069]	[0.0078]
Med Skill*SENS	0.0107	0.0029	
	(0.0075)	(0.0117)	
	[0.0158]	[0.0106]	
High Skill*SENS	0.0369	-0.0083	
	(0.0125)	(0.0140)	
	[0.0199]	[0.0110]	
Med Skill*Post92	0.009	0.0129	0.0128
	(0.0049)	(0.0031)	(0.0032)
	[0.0062]	[0.0039]	(0.0045)
High Skill*Post92	0.0159	0.0307	0.0257
	(0.0076)	(0.0044)	[0.0045)
	[0.0095]	[0.0056]	[0.0060]
Industry definition	origin	time-varying	time-varying
Industry dummies	yes	yes	yes
Individual FE		yes	yes
Indiv.*industry FE			yes
Observations	131635	131635	131635
R-squared	0.37	0.16	0.15

Notes: Robust standard errors, clustered at the individual level (in parenthesis), and at the industry level [in brackets]. Dependent variable: log real hourly wage, Sample: NES males in all industries, in 92-99 subject to the 96 shock. Variables: Post92 is a dummy equal to one after 1992, zero before; SENS are high non-tariff barrier industries in 92. Union Dens. is % of workers unionized,; R&D is (total R&D expenditure)/(tot. production), both by ind. year. All regressions include skill dummies, year dummies, tenure, age and their squares.

Table 7: SMP, RD and Unions

	Overall effect	Overall +FE	Overall effect Low Union Sample	Overall +FE Low Union Sample
	(1)	(2)	(3)	(4)
SENS*Post92	-0.002	0.0006	0.0012	0.0135
	(0.0061)	(0.0039)	(0.0100)	(0.0063)
	[0.0096]	[0.0063]	[0.0096]	[0.0129]
Med Skill*SENS*Post92	-0.0003	0.0021	0.0014	0.0049
	(0.0082)	(0.0049)	(0.0132)	(0.0074)
	[0.0110]	[0.0049]	[0.0165]	[0.0068]
High Skill*SENS*Post92	0.0224	0.0171	0.015	0.011
	(0.0115)	(0.0064)	(0.0187)	(0.0094)
	[0.0150]	[0.0072]	[0.0232]	[0.0083]
R&D	0.0004	0.0094		
	(0.0052)	(0.0031)		
	[0.0063]	[0.0053]		
Med Skill*R&D	0.025	0.0003		
	(0.0086)	(0.0050)		
	[0.0187]	[0.0046]		
High Skill*R&D	0.0159	0.0086		
	(0.0109)	(0.0052)		
	[0.0149]	[0.0044]		
Industry definition	origin	time-varying	origin	time-varying
Industry dummies	yes	yes	yes	yes
Individual FE		yes		yes
Observations	121685	121685	49724	49686
R-squared	0.37	0.17	0.39	0.16

Notes: Robust standard errors, clustered at the individual level (in parenthesis), and at the industry level [in brackets]. Dependent variable: log real hourly wage, Sample: NES males in all industries, in 92-99 subject to the 96 shock, Variables: Post92 is a dummy equal to one after 1992, zero before; SENS are high non-tariff barrier industries in 92. Union Dens. is % of workers unionized,; R&D is (total R&D expenditure)/(tot. production), both by ind. year. All regressions include skill dummies, year dummies, tenure, age and their squares, as well as the interaction of skill dummies with SENS and Post92.

Table 8: Goods Trade Balance

Year	Exports	Imports	Balance
1992	107,863	120,913	-13,050
1993	122,229	135,295	-13,066
1994	135,143	146,269	-11,126
1995	153,577	165,600	-12,023
1996	167,196	180,918	-13,722
1997	171,923	184,265	-12,342
1998	164,056	185,869	-21,813
1999	166,166	195,217	-29,051
2000	187,936	220,912	-32,976

Source: UK Office of National Statistics

Notes: All in real terms, million UK pounds.(base 1987)

Table 9: Effect of the 1996 appreciation on returns to skill

	Overall effect	Overall +FE	Stayers
	(1)	(2)	(3)
Imp.Pen.*Post 96	0.0042	0.009	0.0075
	(0.0094)	(0.0086)	(0.0102)
	[0.0192]	[0.0247]	[0.0288]
Med Skill*Imp.Pen.*Post 96	0.0198	-0.0029	-0.0104
	(0.0149)	(0.0131)	(0.0159)
	[0.0198]	[0.0226]	[0.0298]
High Skill*Imp.Pen.*Post 96	0.061	0.0559	0.0245
	(0.0210)	(0.0168)	(0.0208)
	[0.0308]	[0.0292]	[0.0358]
Med Skil*lPost 96	0.0077	0.0119	0.0153
	(0.0026)	(0.0023)	(0.0027)
	[0.0050]	[0.0060]	[0.0077]
High Skill*Post 96	0.0079	0.0249	0.0301
	(0.0033)	(0.0028)	(0.0033)
	[0.0073]	[0.0076]	[0.0098]
Med Skill*Imp.Pen.	-0.3217	-0.0528	
	(0.0202)	(0.0192)	
	[0.0842]	[0.0191]	
High SkillImp.Pen.	-0.2857	-0.0912	
	(0.0282)	(0.0227)	
	[0.1006]	[0.0206]	
Industry definition	origin	time-varying	time-varying
Industry dummies	yes	yes	yes
Individual FE		yes	yes
Indiv*industry FE			yes
Observations	381008	380007	380007
R-squared	0.38	0.14	0.11

Notes: Robust standard errors, clustered at the individual level (in parenthesis), and at the industry level [in brackets]. Dependent variable: log real hourly wage, Sample: NES males in all industries, in 92-99 subject to the 96 shock. Variables: Post96 is a dummy that takes value one after 1996, zero before; Imp.Pen. is mean import penetr. in 93/95. All regressions include skill dummies, year dummies, tenure, age and their squares.

Table 10: 1996 appreciation, RD and Unions

	Overall effect	Overall +FE	Overall effect	Overall +FE	Overall effect Low Union Sample	Overall +FE Low Union Sample
	(1)	(2)	(3)	(4)	(5)	(6)
Imp.Pen.*Post 96	-0.0179	0.0108	-0.0113	-0.0027	-0.0423	-0.0233
	(0.0105)	(0.0093)	(0.0096)	(0.0089)	(0.0182)	(0.0169)
	[0.0279]	[0.0263]	[0.0210]	[0.0258]	[0.0206]	[0.0240]
Med Skill*Imp.Pen.*Post 96	0.0148	-0.0048	0.0328	-0.001	0.0723	0.0127
	(0.0173)	(0.0145)	(0.0153)	(0.0137)	(0.0277)	(0.0247)
	[0.0268]	[0.0257]	[0.0221]	[0.0239]	[0.0277]	[0.0266]
High Skill*Imp.Pen.*Post 96	0.0727	0.0564	0.0526	0.07	0.069	0.0195
	(0.0246)	(0.0182)	(0.0211)	(0.0175)	(0.0371)	(0.0292)
	[0.0383]	[0.0345]	[0.0337]	[0.0302]	[0.0411]	[0.0382]
R&D	0.0417	-0.0189				
	(0.0062)	(0.0050)				
	[0.0159]	[0.0088]				
Med Skill*R&D	0.0013	-0.002				
	(0.0088)	(0.0071)				
	[0.0151]	[0.0060]				
High Skill*R&D	0.0026	-0.0128				
	(0.0108)	(0.0069)				
	[0.0131]	[0.0087]				
Union Density			0.1165	0.0354		
			(0.0167)	(0.0144)		
			[0.0651]	[0.0445]		
Med Skill*Union Dens.			-0.1585	-0.0363		
			(0.0174)	(0.0154)		
			[0.0977]	[0.0145]		
High Skill*Union Dens.			-0.1276	-0.0198		
			(0.0215)	(0.0190)		
			[0.1142]	[0.0232]		
Industry definition	origin	time-varying	origin	time-varying	origin	time-varying
Industry dummies	yes	yes	yes	yes	yes	yes
Individual FE		yes		yes		yes
Observations	317245	317248	287109	290391	129862	116934
R-squared	0.39	0.15	0.37	0.13	0.35	0.15

Notes: Robust standard errors, clustered at the individual level (in parenthesis), and at the industry level [in brackets]. Dependent variable: log real hourly wage, Sample: NES males in all industries, in 92-99 subject to the 96 shock. Variables: Post96 is a dummy that takes value one after 1996, zero before; Imp.Pen. is mean import penetration in 1993/1995. Union Dens. is % of workers unionized,; R&D is (total R&D expenditure)/(tot. production), both by ind. year. All regressions include skill dummies, year dummies, tenure, age and their squares, as well as Skill dummies interacted with Imp.Pen and Post96

Figure 1: Employment and output concentration ratios for the UK manufacturing sector

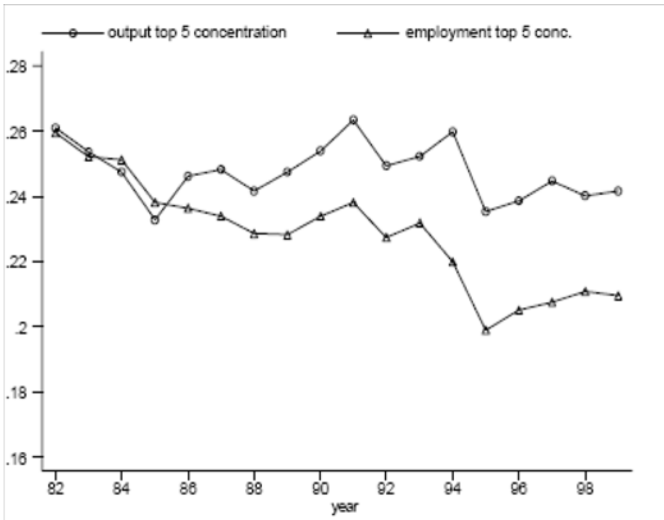


Figure 2: Between sector correlation CR5 employment and wage dispersion

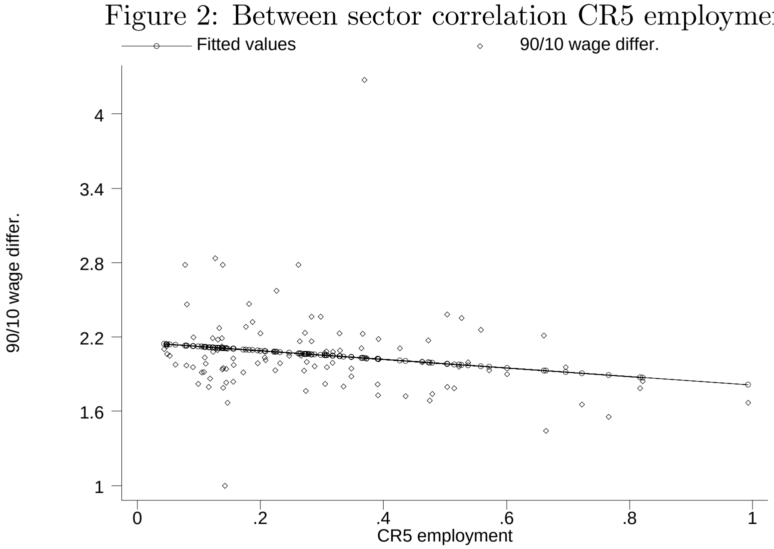


Figure 3: Time series correlation between CR5 employment and wage dispersion

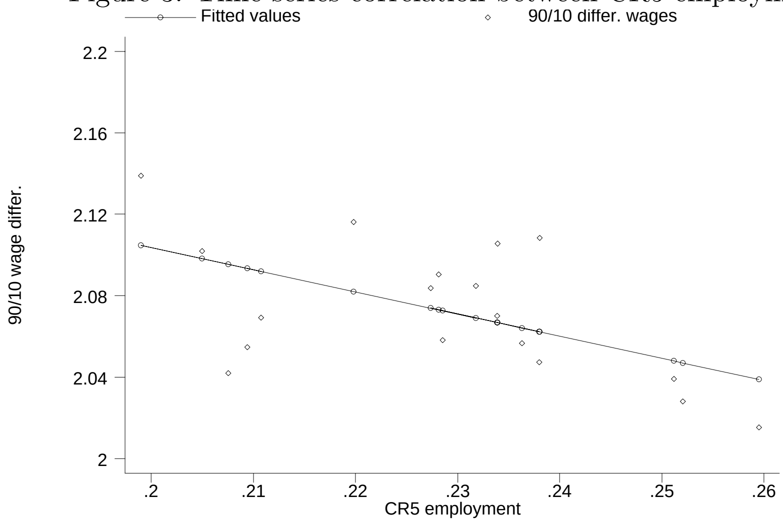
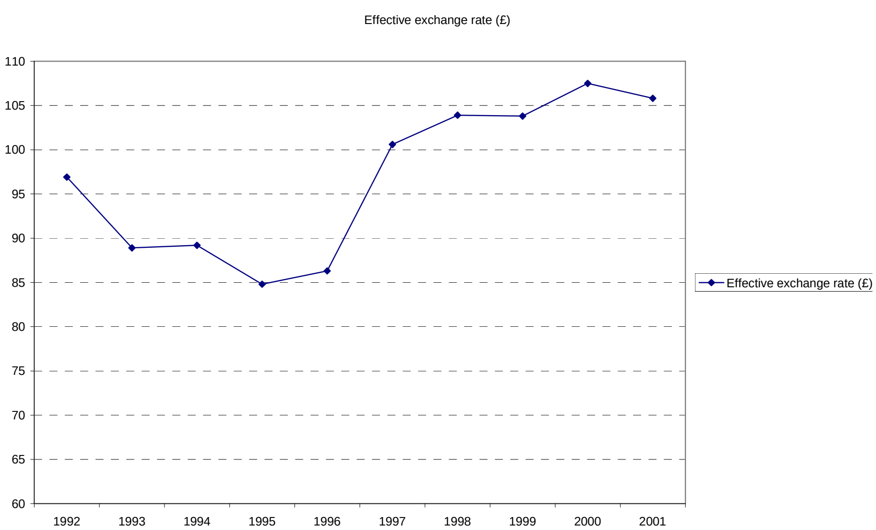


Figure 4: Effective exchange rate, Pound Sterling (1990=100)



Source: Bank of England