

INTERNATIONAL COMPETITION, RETURNS TO SKILL AND LABOUR MARKET ADJUSTMENT

Rod Falvey*, David Greenaway* and Joana Silva**

**School of Economics and GEP, University of Nottingham.*

** *World Bank and GEP, University of Nottingham.*

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Abstract

Does increased import competition lead to higher returns to skill within an industry and, therefore, to greater incentives for skill acquisition? Does it also induce skill upgrading by the industry's existing workforce? To answer these questions we follow individual workers across skills/occupations, firms and industries using a longitudinal matched employer-employee dataset covering virtually all workers and firms in Portugal over the 1986-2000 period. To identify the effects of international competition we use two exogenous measures of changes in international competition at the industry-level. First, a quasi-natural experiment based on the strong appreciation of the Portuguese currency in 1989-1992 period and pre-existing differences in trade exposure across industries in a differences-in-differences estimation. Second, source weighted real exchange rates defined at the industry-level. Based on both empirical strategies, and on two different skill definitions, we show that international competition increases returns to skill and induces skill/occupation-upgrading within an industry.

Keywords: International trade, Skill acquisition, Labour market adjustment.

JEL Classification: F11, F16, J31, J62.

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1. Introduction

In recent decades the increased integration of national product markets has stimulated a large literature aiming to identify and explain its labour market consequences. Among the consequences of particular interest are adjustments in the market returns to different skills/occupations and changes in workers skill-acquisition decisions. The former were the early focus of this literature, in particular whether trade liberalisation was an important driver of the increased wage inequality between skilled and unskilled workers observed in many high-income countries. The general consensus emerging from this literature seems to be that trade liberalization contributed to increase the skill premium, but played a small role relative to skilled biased technological change (Slaughter 2000, Acemoglu 2002, Machin 2003).¹ Other recent contributions argue that organisational change (Caroli and Van Reenen, 2001; Black and Lynch, 2004; Garicano and Rossi-Hansberg, 2006) and declining unionisation (Machin, 1997; Card, 2001) have also played an important role.

Recent work by Guadalupe (2007) reports a previously unnoticed driver of the increase in returns to skill: changes in the degree of product market competition. Theoretically, she shows that if product markets are imperfectly competitive, fiercer competition increases the sensitivity of profits with respect to production costs. Provided that skilled workers are more productive than unskilled workers, this induces a rise in demand for skills, which translates into higher returns. The causal relationship between product market competition and returns to skill is then empirically confirmed by individual panel data for the UK.

In this paper we note that by increasing returns to skill fiercer international competition will also raise the incentives for skill acquisition. Indeed, recent theoretical work by Falvey et al. (2007) shows that a production or price shock that increases relative wages of skilled workers induces significant skill acquisition by the existing workforce.² Understanding the implications of increased competition for skill acquisition is important given the theoretical possibility of poverty traps generated by lack of education and occupational choice (Barham et al. 1995; Banerjee and Newman, 1993), and the role of human capital accumulation in growth. To date, however, this relationship has not been subject to empirical scrutiny. Furthermore, we note that by reducing monopoly rents increased competition may also

¹ An important exception to this consensus is Wood (1998). For recent surveys of literature on globalization and inequality see Greenaway and Nelson (2002), Feenstra and Hanson (2003), Bardhan (2005) and Goldberg and Pavcnik (2007).

² Modelling worker transitions induced by a trade shock is also the focus of Davidson and Matusz (2000, 2002 and 2004) and Long et al. (2007). However, whereas the first focuses on consequences of industry specific human capital for the adjustment process, the second focuses on firm specific human capital.

generate wage differentials between sectors (Krueger and Summer, 1988), and thereby increase workers' incentives to switch industry.

Our paper makes two contributions. We begin by providing further evidence on the impact of within-industry changes in competition on returns to skill using longitudinal matched employee-employer data for Portugal. The data we use cover virtually all workers and firms in the private sector over the 1986-2000 period, and are supplemented with industry-level information on imports by the country of origin. The worker and firm dimensions of our data are particularly important for our purposes, as they allow us to account for the role of firm characteristics and composition effects.³ Our identification strategy involves two exogenous measures of changes in international competition. First, following Cuñat and Guadalupe (2005) and Guadalupe (2007), we exploit a strong appreciation of the Portuguese currency in 1989-1992 (over 25%) and pre-existing differences in cross-industry trade exposure in a differences-in-differences estimation. Second, following Revenga (1992), Campa and Goldberg (2001) and Bertrand (2004), we make use of industry-specific real exchange rates, for which we have data for a later period (1991-2000). Based on both strategies, and on two different skill definitions, we find strong confirmation for the hypothesis that within-industry increases in international competition are an important determinant of rising wage inequality.

The second, and perhaps most important, contribution of this paper is to investigate whether changes in international competition also cause skill upgrading and industry switching. Using the aforementioned empirical strategies to identify exogenous changes in foreign competition, we estimate transition probabilities between skills and/or industries (controlling for worker, firm and sector characteristics) in a bivariate probit specification. We distinguish between four alternatives: no change; moving industry; skill upgrading; moving industry and skill upgrading. Our results provide strong support to the view that labour market adjustment to globalisation involves significant worker movements across sectors and skills. Specifically, we find that increased international competition induces skill acquisition, decreases skill downgrading, and induces workers to move industry.

The remainder of the paper is organised as follows. In Section 2 we outline the empirical methodology. In Section 3 we describe the data. Section 4 presents some descriptive statistics about workers' transitions. Section 5 discusses the empirical estimates, and Section 6 concludes.

³See Abowd and Kramarz (1999) and Abowd et al (2006) for a detailed discussion of the effects of the exclusion of these effects on earnings regressions.

3. Empirical Strategy

3.1. The effect of increased international competition on the returns to skill

Our analysis consists of two parts. First, we investigate whether increased import competition leads to higher returns to skill within an industry and, therefore, incentive for skill acquisition. Second, whether it also induces skill-upgrading by the industry's existing workforce.

In order to argue for a causal effect of international competition, we identify two exogenous changes in international competition at the industry level. First, we use a quasi-natural experiment consisting on the strong appreciation of the Portuguese currency in 1989-1992 and pre-existing differences in trade exposure across industries in a differences-in-differences estimation. Second, we make use industry level of source-weighted real exchange rates at the industry level where the weights are given by the import shares of different countries in the base period (1990). Appreciation of the home currency leads to increased international competition for national firms for two reasons: it reduces the prices that foreign competitors can offer in the home country market; and it encourages more entry by increasing the number of potential foreign firms that can sell in the home country. As argued by Revenga (1992), Bertrand (2004) and Guadalupe (2007), exchange rate movements are largely unpredicted and exogenous to the behaviour of firms and workers within each industry.

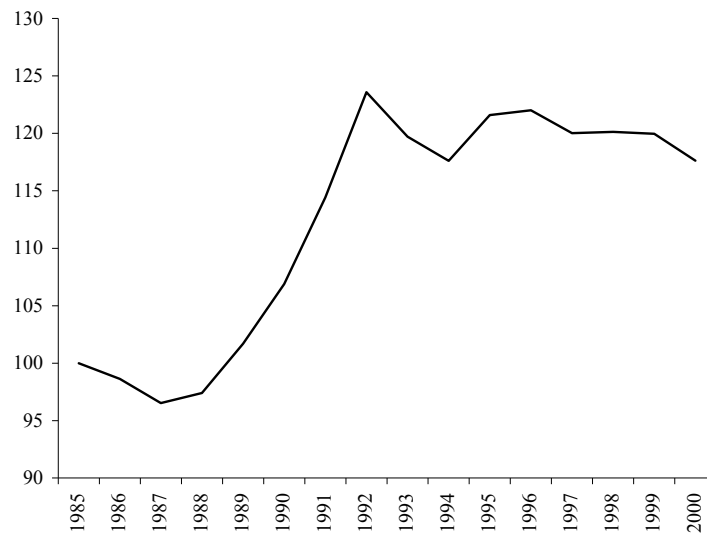
The first identification strategy has been employed by Guadalupe (2007) using UK data at the worker-industry level focusing on the effect of international competition on returns to skills. The data use is worker-industry level, therefore abstracting from potential effects of firm heterogeneity (e.g. in compensation and retention policies) on workers earnings and compositional effects that may arise from workers switching across firms. In this paper by exploiting the worker-firm-industry level of detail of the Portuguese data we are able to account for these effects by controlling for firm characteristics and include worker-firm fixed effects. This is important as whereas in individual fixed-effects models the effect is identified out of individuals who stay in the same firm as well as individuals who move after a shock, in firm-worker fixed-effects models the effect is identified out of variation over the time period in which the worker is employed in a given firm, thereby ensuring that unobserved changes to the industry composition of employment are not driving the results⁴. The richness of our data also allows us to use a more informative definition of skill level. In Guadalupe's study skills evaluation was exclusively based on workers' occupations; our data permits evaluation based

⁴ See Abowd and Kramarz (1999) and Abowd et al (2006).

on occupations and schooling levels. Given the focus of our analysis on foreign competition induced skill/occupation upgrading and its underlying incentives (returns to skills), it is particularly important to investigate whether results are robust to these different measures.

Figure 1 depicts the evolution of the real effective exchange rate against all currencies weighted by the respective country's relative importance in Portuguese imports. As this Figure makes clear, the Escudo appreciated sharply in 1989-1992, preceded and followed by a period of relative stability.

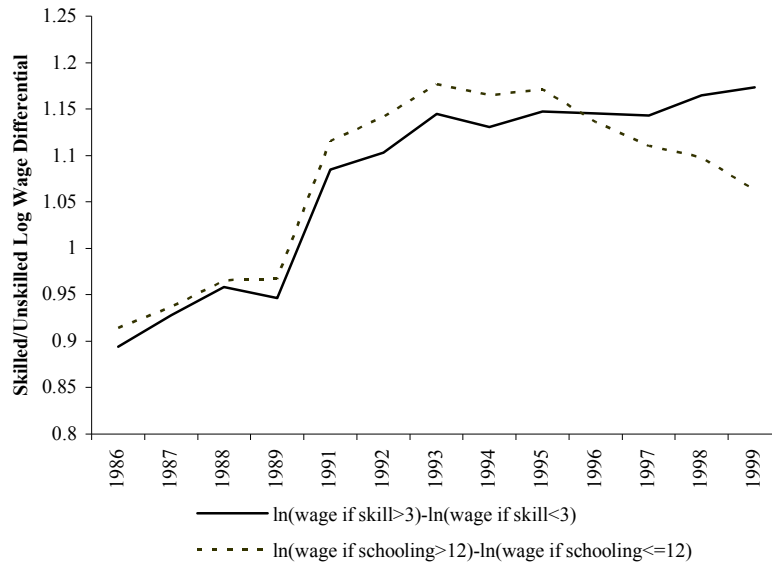
Figure 1: Real effective exchange rate, Portuguese Escudo (1985=100)



Source: Bank of Portugal.

In Figure 2 we plot the difference in mean log wages between skilled and unskilled workers of the manufacturing sector over our sample period. Whether we identify skill by schooling only or using the ILO's skill definition, between 1989 and 1992 this difference increased sharply.

Figure 2: High to low skill wage differentials of the manufacturing sector



Source: Author calculations from *Quadros de Pessoal*.

We use the pre- and post-appreciation period (1986-1988 and 1989-1992 respectively) and pre-appreciation differences between sectors in trade openness to identify exogenous changes in international competition in a difference in differences specification. The advantage of this is that it controls for pre-existing differences across industries and changes common to all industries. The hypothesis is that the appreciation represents a higher increase in the degree of product market competition in the sectors that are (ex-ante) more open (treatment group) relative to those fairly closed (control group). More specifically, we estimate:

$$\ln w_{it} = (\text{indop88}_K * \text{post89} * \text{skill}_{it})\lambda + \theta(\text{indop88}_K * \text{post89}) + (\text{post89}_t * \text{skill}_{it})\zeta + (\text{indop88}_K * \text{skill}_{it})\varphi + \text{skill}_{it}\beta + X_{it}\alpha + Z_{jt}\nu + \gamma hhi_{Kt} + \phi_{ij} + \tau_K + \mu_t + \Psi_{it} \quad (1)$$

where w_{it} is the wage of worker i at year t , indop88_K is the degree of openness to trade of industry K ⁵ and post89 is a dummy variable that takes the value zero in the pre-appreciation period (1986-1988) and one during the appreciation (1989-1992), skill_{it} is a vector comprising measures of the skill level of worker i at year t , X_{it} is a vector of individual characteristics (age, age squared, gender, tenure), Z_{jt} is a vector of characteristics of firm J at year t (size, labour productivity, age, proportion of foreign owned capital, regional dummy)

⁵ Defined as the ratio of total industry trade (imports plus exports) to domestic demand (industry sales plus net imports).

and ϕ_{ij} , τ_K and μ_t are, respectively, worker-firm, industry and time fixed effects⁶; and Ψ_{it} is an exogenous disturbance. Note that since trade openness may vary endogenously with real appreciation, the variable *indop88* is computed as the level of openness for 1988. In this specification λ is the differences-in-differences estimate of returns to skill and captures how these vary with international competition. To get this estimate it is necessary to control for differences in returns to skill before and after the experiment (captured by ζ) and differences in returns to skill between sectors with different degrees of openness (captured by φ).

The second identification strategy uses a more direct measure of exogenous change in competition: changes in the weighted average of the log real exchange rates of importing countries, where the weights are the shares of each trade partner in the industry's total imports in a base period. This index varies across industries based on the composition of imports by country of origin. To avoid potential endogeneity issues, the weights should be prior to the period under analysis. Given that the first years for which bilateral data on imports by industry is available are 1990 and 1991, the period under analysis is restricted to 1991-2000. This strategy was established in the literature by Revenga (1992) to investigate the effect of international competition on industry wages and employment in US manufacturing, and has been recently adopted by Campa and Goldberg (2001), Bertrand (2004) and Cuñat and Guadalupe (2006) to examine the effect of competition on, respectively, industry wages and employment, the sensitivity of wages to the unemployment rate, and provision of incentives to top managers inside the firm. Using this identification strategy we estimate the following equation:

$$\ln w_{it} = IC_{Kt} * skill_{it} \lambda + \theta IC_{Kt} + skill_{it} \beta + X_{it} \alpha + Z_{jt} \nu + \gamma hhi_{Kt} + \phi_{ij} + \tau_K + \mu_t + \Psi_{it} \quad (2)$$

where IC_{Kt} is the source-weighted real exchange rate of industry J at time t and the other variables are as above⁷. The main parameter of interest is λ , which reflects how returns to skill vary with international competition and we expect it to be positive.

We consider two different specifications of equations (1) and (2). In the first, the worker's level of skill is based on schooling, defined as the number of completed years of education (equation (2.1)). In the second, skill is computed using the International Labour Office's (ILO) correspondence Table between major groups of occupations in the 1988 International

⁶ Note that the model does not have a variable measuring openness on its own, nor a before and after dummy on its own because they are swept out by the industry and time dummies.

⁷ See Appendix A for a detailed description of how the variables are constructed.

Standard Classification of Occupations (ISCO-88) and skill level (equation (2.2)). The ISCO-88 “is based on the nature of the skills required to carry out the tasks and duties of the job not the way these skills are acquired” (Hoffmann 2000, pp. 2), considering formal education, training and experience. Table 1 presents the correspondence Table and description of requirements associated with each skill level provided by Elias et al (1999)⁸. In the econometric analysis we aggregate skill groups 1 and 2 as low skilled workers, which is then used as the base category in the estimation of returns to skill.

Table 1: Definition of skill groups – ISCO 1988

Skill Level	ISCO-88 Major Groups Included	Description
4th	1. Legislators, senior officials and managers; 2. Professionals.	Normally requires a degree or an equivalent period of relevant work experience.
3rd	3. Technicians and associate professionals.	Requires a body of knowledge associated with a period of post-compulsory education but not to degree level.
2nd	4. Clerks; 5. Service workers and shop and market sales workers; 6. Skilled agriculture and fishery workers; 7. Craft and related workers; 8. Plant and machine operators and assemblers;	Requires knowledge as for first skill level, but in addition typically have a longer period of worker-related training or work experience.
1st	9. Elementary Occupations.	Competence associated with general education usually acquired by completion of compulsory education.

Source: International Labour Office (1990, pp. 2-3) and Elias et al. (1999) as in Upward and Wright (2007).

2.2. Increased international competition on skill acquisition and industry relocation

Krueger and Summer (1988) show that by decreasing monopoly rents, and therefore the ability of firms to pay higher wages, international competition may also generate wage differentials between sectors. Increased competition can therefore increase returns to skill (tested in this paper) and generate wage differentials between sectors for workers with the same skill. While higher returns increase the incentives for skill acquisition, inter-sectoral wage differentials increase the incentive to switch industry. To disentangle the effect

⁸ Using information for each worker schooling and tenure we have also checked the consistency of the described educational requirements with those in our data for each skill group and our results are in line with the Elias et al. description.

increased international competition on skill acquisition from that of industry relocation we estimate a bivariate probit model. The underlying assumptions are that moving skill and moving industry are two alternative routes for adjusting to increased competition, but they are related.

We adopt the following baseline two equation system:

$$\begin{cases} moveind_{it}^* = X_{it}\alpha_0 + \theta_0\Delta IC_{Kt} + Z_{Jt}v_0 + \gamma hhi_{Kt} + \tau_K + \mu_t + \Psi_{it} \\ skillup_{it}^* = X_{it}\alpha_1 + \theta_1\Delta IC_{Kt} + Z_{Jt}v_1 + \gamma hhi_{Kt} + \tau_K + \mu_t + \Lambda_{it} \end{cases} \quad (3)$$

where $moveind_{it}$ and $skillup_{it}$ are two observed binary indicator variables driven by the two equation system of latent propensities to move industry ($moveind_{it}^*$) and skill upgrading ($skillup_{it}^*$). ΔIC_{Kt} is the percentage change in competition in industry K . Ψ_{it} and Λ_{it} are exogenous disturbances (assumed to be correlated). The other variables are as before. The observability criteria for the two sets of observed binary outcomes are

$$\begin{cases} moveind_{it} = 1(moveind_{it}^* > 0) \\ skillup_{it} = 1(skillup_{it}^* > 0) \end{cases}$$

$moveind_{it}$ is equal to one if individual i in the subsequent observation is employed in a different industry and $skillup_{it}$ is equal to one if individual i in the subsequent observation has a higher level of skill. The main parameters of interest are θ_0 and θ_1 which reflect how the propensities to move industry and skill vary with competition and we expect them to be positive.

3. Data Description and Descriptive Statistics

3.1. The data set

Our data is from a longitudinal matched employer-employee dataset, “Quadros de Pessoal” [QP], collected by the Portuguese Ministry of Employment, which covers virtually all workers and firms in the Portuguese private sector over the 1986-2000 period, around 200,000 firms and more than 2 million workers each year. It provides comprehensive information on worker’s demographic characteristics (age, gender, schooling), occupation characteristics (occupational group, professional category, wage, hours worked) and plant tenure, along with employing firm ID codes. Firm-level characteristics includes sales, number of employees, equity, percentage of foreign capital, geographical location and date of constitution, along with industry code. This code allows us to merge this data set with very detailed trade data, disaggregated at the industry level with imports by country of origin,

collected by the Portuguese National Statistics Office (INE). Trade data is only available for manufacturing for the period 1988-2000. As the Portuguese classification of industries has been revised in 1994 to match the NACE-Rev 2, a concordance was needed and the analysis considers 74 manufacturing industries⁹.

There are two important characteristics that guarantee this data set's coverage and reliability. First, data is collected from a compulsory administrative census that the Ministry of Employment runs annually to check the firm's compliance with labour law. Second, and unique to this data base, firms are required by law to make the information provided to the Ministry available to every worker in a public place of the establishment. Another important advantage is its longitudinal nature that results from the fact that a unique identification number is attributed to each worker the first time he enters the data set. This is based on his social security number that does not change through time.

To control for any coding errors, we have performed extensive checks to guarantee the accuracy of the worker data using information on gender, date of birth and maximum schooling level achieved, as described in Appendix B. After these checks, we kept for analysis full-time wage earners, aged between 16 and 65, earning at least the national minimum wage, working in firms operating in mainland Portugal. The final panel used in the analysis contains information on 2,998,727 workers, 467,269 firms, imports and exports from 74 manufacturing industries over the period 1986-2000, yielding a total of 15,613,149 worker-year observations.

3.2. Workers Transitions: Variable Creation

An industry (skill) switcher is an individual that in the subsequent observation is employed in a different industry (has a different skill). The set of worker transitions contains five alternatives: the worker changes industry retaining the same skill; moves up the skill ladder while remaining in the same industry; moves down the skill ladder while remaining in the same industry; moves up the skill ladder and moves industry; moves down the skill ladder and moves industry. Skill classification follows the ILO's skill definition described in Section 2.1 and industry classification follows the NACE-Rev. 2 at the 2-digit level.

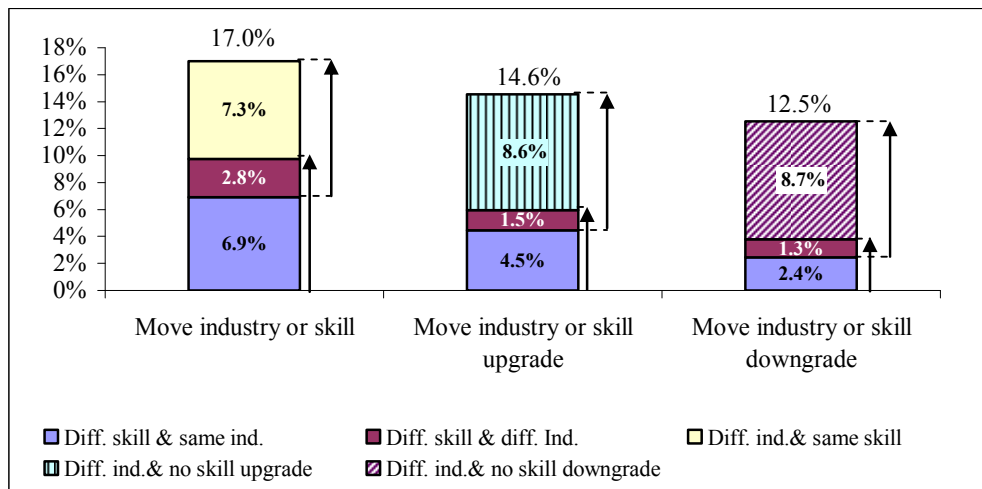
⁹ The concordance used can be found at www.ine.pt/Prodserv/nomenclaturas/CAE.html. Note that 56 industries have direct equivalents in the old and new classifications and are, therefore, defined at the 2-digit level of the NACE-Rev. 2. The remaining 46 categories of NACE-Rev. 2 do not have direct equivalents in the old classification and are aggregated into 18 sectors.

3.3. Descriptive Statistics

Moving industry and/or skill appear to be important forms of labour reallocation. Around 17 per cent of all worker-year observations are of some kind of switching. Figure 3 provides some detail on (average) rates of switching (expressed as a percentage of total number of observations). Switching by changing both industry and skill is least common, on average around 3 per cent of all worker-year observations are of this type. Switching in one dimension alone (either skill or industry) is more common. The rate of industry switching conditional on retaining the same skill is similar to that of changing skill conditional on staying in the same industry, on average around 7 per cent of all worker-year observations are of each of these types. Considering each of these forms of reallocation independently the (unconditional) switching rate raises to around 10 per cent (either for industry or skill).

As Figure 3 makes clear, moving up the skill ladder is more common than moving down, but both movements are important – the share of all workers who are upgraders and downgraders is 9 and 3.8 per cent, respectively. The difference is driven by differences in the fraction that moves skill whilst staying in the same industry. Whereas the unconditional rate of industry switching and its components are similar in both cases, the average rate of skill upgrading, conditional on staying in the same industry, is almost twice as much as that of skill downgrading conditional on staying in the same industry.¹⁰

Figure 3: Rates of switching, 1991-2000



¹⁰ Detailed tables of transition patterns across industries are available from the authors on request.

4. Estimation Results

4.1. Summary Statistics

Table 2 reports summary statistics for the main variables of interest over the 1986-2000¹¹ period. As can be seen, there is considerable variability of actual wage between industries. Moreover, worker transitions between skills and occupations are an important feature of the Portuguese labour market. In manufacturing the annual average share of workers moving industry is 10 percent and skill-upgrading 6 percent. Also significant is the change in the real exchange rate (the annual average change is 3 percent) and level of openness (the annual average level is 37 percent). Three other characteristics of Portuguese labour markers are worth noting: high female participation, low level of education and low share of population in very skilled occupations.

Table 2: Summary Statistics, 1986-2000

Variable	Mean	Standard Deviation
Actual Wage (ln)	11.57	0.44
Move ind	0.10	0.30
Move skill	0.10	0.30
Move skill-up	0.06	0.24
Move skill-down	0.01	0.11
Stayer	0.83	0.38
Real exchange rate	1.37	0.66
% change real exchange rate	0.03	0.67
Openness to trade in 88	0.37	0.27
Age	35.69	10.83
Age-square	1391.04	829.70
Tenure	9.97	8.80
Male	0.59	0.49
Schooling	5.52	3.01
Skilled (Schooling>12)	0.02	0.14
1st Skill Level	0.17	0.37
2nd Skill level	0.75	0.43
3rd Skill Level	0.06	0.24
4th Skill Level	0.02	0.15
Herfindal Index	840.27	1425.81
Firm size (ln)	4.88	1.64
Firm Average Labour productivity	8.83	1.18
Firm Age	24.24	21.15
Fraction of Foreign Capital	0.11	0.30
Number observations	5,561,687	

¹¹ Note that 1986 is the first year for which the QP dataset is available and the appreciation finishes in 1992. Baldwin (1988) and Dixit (1989) argue that the appreciation may permanently reshape the competitive structure of the product market and therefore the analysis should be restricted to the end of the episode. Moreover, there has been a recession in the Portuguese economy in 1993 that might contaminate the differences in differences estimate. The second strategy requires industry bilateral trade data prior to the period under analysis. This is only available from 1990.

4.2. International competition and the returns to skill

Table 3 presents the estimated results of equation (1) using the 1989-1992 appreciation as the exogenous change in international competition. Columns 1-4 present estimates for skill defined as the number of completed years of education, columns 5-8 report estimates for skill using the ILO's skill definition. For each, we start by estimating the difference results (columns 1-2 and 5-6) and proceed by estimating difference in differences results (columns 3-4 and 7-8). The dependent variable in each column is the log real hourly wage. Each regression includes regional and year dummies to control for disparities in the returns to skill across regions and macro-shocks, respectively. To control for unobservable industry characteristics we include a full set of industry-dummies: 74 industry fixed-effects. Additionally, we run each specification with individual fixed effects (where the effect is identified out of the within sector variation in competition) and proceed by estimating the models with spell (work-firm) fixed effects. Whereas in the first case identification comes from the within sector variation in competition, in the second it comes from within spell variation, that is, from variation over the period in which the worker is employed in a given firm. This procedure is important as we are interested in estimating the effect of within industry changes in international competition on relative wages.

The coefficient on the interaction of skill variables with *indop88* post89* is always positive and highly significant in all specifications. In addition, one can see that the difference in difference estimates of returns to schooling (columns 3-4) and high skill (columns 7-8) are lower than the difference estimates (columns 1-2 and 5-6, respectively) and that the coefficients associated with the two-way interaction of the skill variables with, inter alia, *indop88* and *post89* are statistically significant. This confirms the importance of accounting for the fact that more open sectors may systematically pay a lower skill premium to start with and that during 1989-1992 returns to skill increased throughout the economy. Controlling for these, results on column 3-4 and 7-8 show that, relative to the control group, the appreciation had a positive and significant effect on the skill premium of the treatment group, than in industries that are relatively shielded. In particular, the estimated coefficients in column 8 indicate that for an industry with average trade openness (0.37), the pre-appreciation return to skill was 4 percent and the post-appreciation return, 15.4 percent. The full effect of the appreciation is only captured by the estimated coefficient on the interaction between the skill and the experiment variable (0.024 on column 8), which indicates that for an industry with average exposure to trade in 1988, the effect of the appreciation was to increase the differential (in returns to skill) by 0.88 percent (relative to an industry with no trade prior to 1988).

Table 4 also presents estimated results of equation (2) identifying exogenous changes as source-weighted industry real exchange rate movements. Columns 1-2 present the estimates for skill defined as the number of completed years of education, columns 3-4 report estimates using the ILO's skill definition. Column 1 and 3 present the individual fixed effects estimates and column 2 and 4 the spell (worker-firm) fixed effects estimates. A full set of industry, year and regional dummies is included in all specifications. The coefficient on the interaction of skill variables with the exchange rate index is positive and highly significant in all specifications, confirming that when the exchange rate index increases the impact of skill acquisition on actual wage is higher. Note that, as pointed out by Bertrand (2004), this methodology, by simultaneously including individual fixed effects and industry dummies, estimates the relationship between changes (not absolute values) in international competition and returns to skill within industries.

Our results are therefore very much in line with Guadalupe (2007). This is particularly reassuring given that firm characteristics and work-firm fixed effects are highly statistically significant. Based on two different identification strategies and skill definitions, we find strong confirmation of the hypothesis that increased international competition is an important determinant of rising wage inequality between skilled and unskilled workers.

Table 3: Effect of international competition on return to skill: 1989-1992 appreciation

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variable								
age	0.617 (172)***	0.619 (83.2)***	0.497 (122)***	0.502 (65.9)***	0.656 (184)***	0.665 (90)***	0.652 (184)***	0.654 (90)***
age-square	-0.217 (50.8)***	-0.188 (41.8)***	-0.185 (43.1)***	-0.159 (35.2)***	-0.274 (64.4)***	-0.241 (53.9)***	-0.282 (66.4)***	-0.248 (55.6)***
tenure	-0.014 (13.4)***	-0.001 (0.6)	-0.014 (13.7)***	-0.002 (0.9)	-0.014 (13.5)***	-0.001 (0.4)	-0.014 (13.6)***	-0.001 (0.5)
indop88*post89	-0.184 (92.6)***	-0.174 (85.1)***	-0.083 (31.5)***	-0.085 (31.8)***	-0.082 (61.7)***	-0.080 (57.8)***	-0.073 (55.6)***	-0.072 (52.4)***
schooling	0.005 (9)***	0.002 (3.4)***	0.004 (5.4)***	0.002 (3.2)***				
indop88*post89*schooling	0.022 (77.1)***	0.020 (71.6)***	0.002 (4.5)***	0.003 (5.6)***				
indop88*schooling			-0.004 (2.9)***	-0.007 (4.9)***				
post89*schooling			0.012 (52.8)***	0.010 (45.9)***				
mskill					0.030 (16.2)***	0.022 (11.6)***	0.022 (6.7)***	0.017 (5.2)***
hskill					0.089 (20.5)***	0.073 (17.3)***	0.050 (6.6)***	0.049 (6.5)***
indop88*post89*mskill					0.142 (42.6)***	0.128 (38.3)***	0.041 (6.6)***	0.036 (5.6)***
indop88*post89*hskill					0.223 (31.3)***	0.202 (29.2)***	0.022 (1.7)*	0.024 (1.9)*
indop88*mskill							-0.029 (4.1)***	-0.033 (4.7)***
indop88*hskill							0.010 (0.6)	-0.023 (1.4)
post89*mskill							0.067 (23.3)***	0.060 (20.6)***
post89*hkill							0.118 (19.4)***	0.105 (17.5)***
hhi	-0.025 (26.9)***	-0.025 (27)***	-0.023 (24.2)***	-0.023 (24.6)***	-0.028 (29.7)***	-0.028 (29.6)***	-0.027 (28.7)***	-0.027 (28.6)***
firmsize	0.038 (66.8)***	0.066 (60.7)***	0.038 (67.2)***	0.066 (60.9)***	0.038 (66.2)***	0.065 (59.4)***	0.038 (66.4)***	0.065 (59.7)***
firmlabprod	0.006 (37.1)***	0.006 (33.7)***	0.006 (36.4)***	0.005 (33.1)***	0.006 (37.5)***	0.006 (33.8)***	0.006 (36.9)***	0.005 (33.3)***
firmage	-0.005 (10.7)***	-0.047 (7.7)***	-0.005 (10.6)***	-0.033 (5.5)***	-0.004 (10.4)***	-0.056 (9.4)***	-0.004 (10.4)***	-0.050 (8.4)***
%foreignK	-0.003 (2.2)**	-0.022 (14.9)***	-0.003 (1.8)*	-0.021 (14.3)***	-0.004 (3.1)***	-0.023 (16)***	-0.004 (3)***	-0.023 (15.7)***
Year+industry dummies	yes	yes	yes	yes	yes	yes	yes	yes
Regional dummies	yes	yes	yes	yes	yes	yes	yes	yes
Worker fixed effects	yes	-	yes	-	yes	-	yes	-
Worker-firm fixed effects	-	yes	-	yes	-	yes	-	yes
Obs.					2,300,567			
R-square	0.189	0.147	0.215	0.164	0.185	0.144	0.187	0.147

* significant at 10%; ** significant at 5%; *** significant at 1%. The period of analysis is 1986-1992. Absolute value of t-statistic in parentheses, based on robust standard errors clustered by individual. The variables age, tenure are divided by 10, and age-square and hhi by 1000. Dependent variable: log real hourly wage.

Table 4: Effect of international competition on returns to skill: exchange rate changes

	(1)	(2)	(3)	(4)
Variable				
age	0.411 (156.32)***			
age-square	-0.256 (83.7)***	-0.241 (74.78)***	-0.266 (87.67)***	-0.252 (78.38)***
tenure	0.014 (17.91)***	0.004 (2.26)**	0.013 (16.06)***	0.004 (2.16)**
exchrates	-0.119 (59.31)***	-0.110 (54.38)***	-0.089 (55.60)***	-0.077 (46.59)***
schooling	0.001 (2.22)**	-0.002 (2.98)***		
exchrates*schooling	0.006 (24.65)***	0.007 (28.29)***		
mskill			0.021 (8.36)***	0.009 (3.71)***
hskill			0.034 (7.23)***	0.012 (2.59)***
exchrates*mskill			0.018 (10.86)***	0.017 (10.42)***
exchrates*hskill			0.039 (12.03)***	0.038 (12.02)***
hhi	0.005 (1.82)*	0.008 (3.24)***	0.005 (1.79)*	0.008 (3.26)***
firmsize	0.037 (88.81)***	0.048 (66.38)***	0.037 (89.15)***	0.048 (66.39)***
firmlabprod	0.005 (31.58)***	0.004 (24.60)***	0.005 (31.57)***	0.004 (24.7)***
firmage	-0.007 (23.12)***	0.133 (9.44)***	-0.007 (23.22)***	0.131 (9.32)***
%foreignK	0.031 (30.45)***	0.009 (8.58)***	0.032 (30.55)***	0.009 (8.48)***
Year+industry dummies	yes	yes	yes	yes
Regional dummies	yes	yes	yes	yes
Worker fixed effects	yes	-	yes	-
Worker-firm fixed effects	-	yes	-	yes
Obs.		3,858,747		
R-square	0.226	0.005	0.001	0.003

* significant at 10%; ** significant at 5%; *** significant at 1%. The period of analysis is 1991-2000. Absolute value of t-statistic in parentheses, based on robust standard errors clustered by individual. The variables age, tenure are divided by 10, and age-square and hhi by 1000. Dependent variable: log real hourly wage.

4.3. International competition and skill upgrading

Using bivariate probit models, Table 5 reports the results for the two equation systems ((3.1) and (3.2)) presenting each of the different forms of relocation that may be induced by increased competition. The marginal effects on the probability of each potential outcome (when all variables are held at their mean) are presented¹². All regressions include industry fixed effects, year and regional dummies and standard errors are clustered by individuals (to

¹² Regression results can be found in Appendix C.

account for the fact that the individual error term may be autocorrelated). Columns 1-5 present estimates for the latent propensities of moving industry ($moveind^*$) and moving skill ($moveskill^*$), columns 6-10 report the estimates for the latent propensities of moving industry ($moveind^*$) and skill-upgrading ($skillup^*$). Columns 1-3 present each of the different forms of reaction to increased competition against the probability of no change in skill or industry, $\Pr(moveind_{iJKt} = 0, moveskill_{iJKt} = 0 | X_{it}, \Delta IC_{Kt}, Z_{Jt}, hhi_{Kt})$, that is:

$$\Pr(moveind_{iJKt} = 1, moveskill_{iJKt} = 1 | X_{it}, \Delta IC_{Kt}, Z_{Jt}, hhi_{Kt}),$$

$$\Pr(moveind_{iJKt} = 1, moveskill_{iJKt} = 0 | X_{it}, \Delta IC_{Kt}, Z_{Jt}, hhi_{Kt}),$$

$$\Pr(moveind_{iJKt} = 0, moveskill_{iJKt} = 1 | X_{it}, \Delta IC_{Kt}, Z_{Jt}, hhi_{Kt}), \text{ respectively.}$$

In addition, Columns 4-5 present bivariate probit estimates of the marginal effects of each of the covariates on the following unconditional probabilities:

$$\Pr(moveind_{iJKt} = 1 | X_{it}, \Delta IC_{Kt}, Z_{Jt}, hhi_{Kt}),$$

$$\Pr(moveskill_{iJKt} = 1 | X_{it}, \Delta IC_{Kt}, Z_{Jt}, hhi_{Kt}), \text{ respectively.}$$

Similarly, Columns 6-8 present each of the different forms of reaction to increased competition against the probability of no skill-upgrading or switching industry, $\Pr(moveind_{iJKt} = 0, skillup_{iJKt} = 0 | X_{it}, \Delta IC_{Kt}, Z_{Jt}, hhi_{Kt})$, that is:

$$\Pr(moveind_{iJKt} = 1, skillup_{iJKt} = 1 | X_{it}, \Delta IC_{Kt}, Z_{Jt}, hhi_{Kt}),$$

$$\Pr(moveind_{iJKt} = 1, skillup_{iJKt} = 0 | X_{it}, \Delta IC_{Kt}, Z_{Jt}, hhi_{Kt}),$$

$$\Pr(moveind_{iJKt} = 0, skillup_{iJKt} = 1 | X_{it}, \Delta IC_{Kt}, Z_{Jt}, hhi_{Kt}), \text{ respectively.}$$

In addition, Columns 6-10 present bivariate probit estimates of the marginal effects of each of the covariates on the following unconditional probabilities:

$$\Pr(moveind_{iJKt} = 1 | X_{it}, \Delta IC_{Kt}, Z_{Jt}, hhi_{Kt}),$$

$$\Pr(skillup_{iJKt} = 1 | X_{it}, \Delta IC_{Kt}, Z_{Jt}, hhi_{Kt}), \text{ respectively.}$$

The marginal effect of interest on the variable $indop88^*apprec$ is always positive and highly significant. Results therefore indicate that the propensity to switch (industry and/or skill) in response to the appreciation is higher in sectors more open to trade. In addition, results in column 1-6 show that the effect of increased competition on skill acquisition and industry relocation is similar (columns 5 and 6). However, the effect on the probability of changing in one dimension only is stronger than the effect on the probability of changing both skill and industry (coefficient in columns 2-3 is higher than in 1). Furthermore, results on the

second specification (column 6-10), show that increased international competition in the 1989-1992 appreciation also increases significantly the propensity to skill-upgrade, whether remaining in the same industry or changing industry, though the effect on the latter is weaker. In particular, the estimated coefficients on trade exposure, the post-appreciation dummy and their interaction (columns 9) indicate that for an industry with average trade exposure in 1988 (0.37), appreciation increased the propensity to move industry by 0.23 percent and, this effect was 0.05 percent higher than in an industry with 10 percentage point lower trade exposure in 1988. Similarly, column 10 indicates that for an industry with average trade exposure in 1988 (0.37), appreciation increased the propensity to skill-upgrade by 0.1 percent and, this effect was 0.03 percent stronger than in an industry with 10 percentage point lower trade exposure in 1988.

In addition, all signs of the coefficients of the control variables are as expected. Worker covariates indicate that moving between skills and industries is significantly less frequent in older workers but the effect of an additional year of age is higher in younger than older workers. High tenured workers also switch industry and/or skill less frequently. Skilled workers tend to be more mobile than unskilled workers. Male workers move more frequently than female workers. Moreover, industry covariates show that a high degree of industry concentration is associated with higher switching rates. Finally, firm covariates indicate that elevated firm size, labour productivity and participation of foreign capital predict lower switching rates, whereas firm's age increases this rate.

Table 6 presents bivariate probit estimates using source-weighted industry real exchange rate fluctuations to identify changes in competition¹³. Results are in line with those previously obtained and confirm the association between increased international competition and additional skill acquisition and industry relocation. For a worker who is average on all characteristics, employed in a firm that is average in all characteristics that belongs to an industry that has the average level of the Herfindahl-Hirschman index, a 1 percentage point increase in the exchange rate index is associated with a probability to move industry 0.03 percentage points higher and probability to skill-upgrading by 0.02 percentage points higher. The effect on skill upgrading while remaining in the same industry is more than twice as large as the effect on skill upgrading and moving industry simultaneously.

¹³ Regression results can be found in Appendix C.

Table 5: Marginal effects of international competition on the probability of skill-upgrading and/or moving industry: 1989-1992 appreciation

	Move industry (ind.) and/or move skill					Move industry (ind.) and/or move skill-up					
	Propensity to move		skill only	Propensity to move ind.		Propensity to Move			Propensity to move ind.		Propensity to skill-up
	ind.&skill	ind.only		move ind.	move skill	ind.&skill-up	ind. only	skill-up only	move ind.		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	
Predicted Propensity	2.63%	5.95%	6.71%	8.58%	9.35%	1.15%	7.43%	4.23%	8.58%	5.38%	
Variables											
age	-0.036 (83.5)***	0.007 (7.36)***	-0.111 (106.66)***	-0.029 (23.51)***	-0.146 (111.49)***	-0.024 (101.24)***	-0.003 (2.82)***	-0.096 (131.61)***	-0.027 (21.98)***	-0.120 (136.2)***	
age-square	0.032 (57.95)***	-0.027 (21.97)***	0.124 (90.19)***	0.005 (2.98)***	0.156 (90.07)***	0.023 (78.55)***	-0.021 (14.34)***	0.107 (113.19)***	0.002 (1.5)	0.130 (113.97)***	
tenure	-0.014 (106.36)***	-0.023 (88.18)***	-0.014 (42.74)***	-0.036 (107.3)***	-0.027 (66.65)***	-0.008 (112.25)***	-0.028 (93.45)***	-0.016 (69.67)***	-0.037 (107.06)***	-0.024 (86.25)***	
skilled	0.032 (32.15)***	0.011 (8.54)***	0.065 (30.26)***	0.043 (21.51)***	0.097 (35.2)***	0.019 (31.56)***	0.023 (14.39)***	0.049 (31.68)***	0.042 (20.99)***	0.068 (34.66)***	
indop88*post89	0.002 (4.6)***	0.003 (3.16)***	0.003 (2.25)**	0.005 (3.96)***	0.005 (3.23)***	0.001 (4.57)***	0.004 (3.59)***	0.002 (2.33)**	0.005 (4.01)***	0.003 (2.99)***	
indop88	0.002 (1.35)	0.004 (1.25)	0.002 (0.53)	0.006 (1.36)	0.004 (0.89)	0.001 (1.37)	0.004 (1.16)	0.002 (0.69)	0.005 (1.25)	0.003 (0.91)	
post89	-0.003 (10.64)***	-0.001 (1.36)	-0.007 (11.31)***	-0.004 (4.66)***	-0.010 (12.24)***	-0.003 (17.21)***	-0.001 (1.48)	-0.010 (18.79)***	-0.004 (4.52)***	-0.012 (19.38)***	
male	0.007 (39.63)***	0.009 (26.08)***	0.009 (21.04)***	0.016 (33.91)***	0.015 (28.49)***	0.003 (41)***	0.012 (29.93)***	0.007 (24.25)***	0.016 (34)***	0.011 (29.59)***	
hhi	0.006 (11.8)***	0.006 (5.52)***	0.010 (8.42)***	0.012 (8.17)***	0.016 (10.4)***	0.003 (9.39)***	0.010 (7.72)***	0.005 (4.63)***	0.013 (8.62)***	0.007 (5.96)***	
firmsize	-0.002 (43.46)***	-0.005 (39.99)***	-0.002 (12.61)***	-0.007 (45.81)***	-0.004 (23.4)***	-0.001 (31.14)***	-0.006 (45.06)***	0.000 (0.28)	-0.007 (45.72)***	-0.001 (7.24)***	
firmlabprod	-0.002 (31.5)***	-0.005 (41.26)***	0.000 (2.07)**	-0.007 (42.46)***	-0.001 (8.22)***	-0.001 (22.53)***	-0.006 (43.87)***	0.001 (6.93)***	-0.007 (43.43)***	0.000 (0.52)	
firmage	0.001 (13.92)***	0.002 (21.12)***	0.000 (3.07)***	0.002 (21.14)***	0.000 (1.8)*	0.000 (10.11)***	0.002 (22.2)***	0.000 (5.73)***	0.002 (21.59)***	0.000 (2.31)**	
%foreignK	-0.006 (20.17)***	-0.023 (36.4)***	0.009 (12.91)***	-0.029 (34.55)***	0.003 (3.63)***	-0.002 (13.67)***	-0.027 (36.65)***	0.008 (15.95)***	-0.029 (34.92)***	0.006 (9.69)***	
Observations			2,300,567					2,300,567			
rho			0.475					0.299			
%Correctely predicted			0.999					0.999			
McFadden's pseudo R2			0.052					0.066			

* significant at 10%; ** significant at 5%; *** significant at 1%. The period of analysis is 1986-1992. Absolute value of t-statistic in parentheses, based on robust standard errors clustered by individual. All specifications include a full set of industry dummies (74 industry fixed-effects), year and regional dummies. Marginal effects are computed at the mean of each variable. The variables age, tenure are divided by 10, and age-square and hhi by 1000.

Table 6: Marginal effect of international competition on the probability of skill-upgrading and/or moving industry: exchange rate fluctuations

	Move industry (ind.) and/or move skill						Move industry (ind.) and/or move skill-up					
	Propensity to move			Propensity to stay	Propensity to move		Propensity to Move			Propensity to stay	Propensity to move	
	ind.&skill	ind. only	skill only	to stay	move ind.	move skill	ind.&skill-up	ind. only	skill-up only	to stay	move ind.	skill-up
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Predicted Propensity	2.10%	6.18%	6.47%	85.24%	8.29%	8.58%	0.95%	7.35%	3.9%	87.80%	8.30%	4.85%
Variables												
age	-0.032 (115.61)***	-0.010 (13.6)***	-0.100 (127.1)***	0.142 (121.14)***	-0.042 (46.35)***	-0.132 (135.92)***	-0.020 (130.33)***	-0.021 (24.94)***	-0.081 (157.86)***	0.122 (119.04)***	-0.041 (44.97)***	-0.101 (165.53)***
age2	0.032 (89.19)***	-0.001 (0.56)	0.112 (106.18)***	-0.144 (92.39)***	0.032 (26.4)***	0.144 (110.99)***	0.021 (107.02)***	0.009 (8.31)***	0.091 (133.44)***	-0.121 (89.32)***	0.030 (25.03)***	0.112 (137.66)***
tenure	-0.009 (110.1)***	-0.016 (82.4)***	-0.013 (55.19)***	0.039 (113.34)***	-0.025 (102.07)***	-0.022 (74.29)***	-0.005 (118.02)***	-0.020 (88.69)***	-0.013 (80.47)***	0.039 (131.76)***	-0.025 (102.08)***	-0.019 (94.39)***
skilled	0.018 (40.42)***	0.007 (8.38)***	0.048 (39.71)***	-0.072 (46.99)***	0.024 (22.41)***	0.065 (44.2)***	0.008 (34.78)***	0.016 (16.64)***	0.023 (31.52)***	-0.047 (37.15)***	0.024 (21.84)***	0.031 (34.56)***
Δexchrate	0.008 (4.8)***	0.019 (4.53)***	0.006 (1.38)	-0.033 (4.76)***	0.027 (5.01)***	0.014 (2.47)**	0.007 (7.21)***	0.021 (4.41)***	0.018 (5.01)***	-0.046 (7.15)***	0.028 (5.21)***	0.024 (5.66)***
male	0.003 (29.78)***	0.010 (33.9)***	0.001 (3.98)***	-0.014 (29.23)***	0.013 (36.2)***	0.005 (11.15)***	0.002 (32.87)***	0.011 (34.85)***	0.002 (10.68)***	-0.015 (37.1)***	0.013 (36.57)***	0.004 (16.13)***
hhi	0.000 (19.82)***	0.001 (24.46)***	0.000 (0.03)	-0.001 (19.54)***	0.001 (25.34)***	0.000 (5.58)***	0.000 (17.6)***	0.001 (24.32)***	0.000 (1.71)*	-0.001 (22.13)***	0.001 (24.94)***	0.000 (5.12)***
firmsize	0.000 (8.28)***	0.000 (1.6)	-0.001 (11.04)***	0.001 (8.44)***	0.000 (1.23)	-0.002 (11.12)***	0.000 (1.6)	0.000 (1.84)*	0.000 (0.36)	0.000 (1.86)*	0.000 (1.92)*	0.000 (0.65)
firmlabprod	-0.001 (19.21)***	-0.004 (33.86)***	0.001 (9.35)***	0.004 (18.64)***	-0.005 (32.74)***	0.000 (2.22)**	0.000 (14.91)***	-0.005 (34.88)***	0.001 (9.91)***	0.004 (23.65)***	-0.005 (33.98)***	0.001 (5.06)***
firmage	0.000 (0.9)	0.000 (2.49)**	0.000 (1.14)	0.000 (0.85)	0.000 (2.28)**	0.000 (0.68)	0.000 (1.7)*	0.000 (2.97)***	0.000 (0.36)	0.000 (2.34)**	0.000 (2.96)***	0.000 (0.07)
%foreignK	-0.002 (11.07)***	-0.006 (13.9)***	0.000 (0.09)	0.008 (10.88)***	-0.008 (14.4)***	-0.002 (2.98)***	-0.001 (6.27)***	-0.008 (14.97)***	0.002 (5.13)***	0.007 (10.02)***	-0.008 (14.47)***	0.001 (2.87)***
Observations				3,858,747						3,858,747		
rho				0.409						0.267		
% correctly predicted				0.963						0.999		
McFadden's pseudo R2				0.053						0.065		

* significant at 10%; ** significant at 5%; *** significant at 1%. The period of analysis is 1991-2000. Absolute value of t-statistic in parentheses, based on robust standard errors clustered by individual. All specifications include a full set of industry dummies (74 industry fixed-effects), year and regional dummies. Marginal effects are computed at the mean of each variable. The variables age, tenure are divided by 10, and age-square and hhi by 1000.

6. Conclusions

This paper confirms international competition as a source of increased returns to skill. Using a large panel (1986-2000) of matched employer-employee data for the Portuguese manufacturing sector, two different skill definitions, and two different identification strategies of exogenous changes in international competition, we show that returns to skill within an industry increase with competition. Furthermore, we identify increasing international competition as a significant determinant of skill upgrading. This result is valid both when workers stay in the same industry and when they move. It indicates that skill acquisition is an important part of the adjustment process to a policy change or shock (exogenous to the wage setting conditions within the country) that changes relative wages, and suggests that policy attention to the consequences of increased competition for human capital accumulation seems merited.

Appendices

APPENDIX A: Variable description

Wage data is the log deflated monthly earnings actually received including the base wage, tenure-related and other regularly paid components. Wages are deflated using the consumer price index.

Worker covariates: Tenure is defined as the number of years with the same firm, schooling as the number of completed years of education and skilled as having a number of completed years of education higher than 12 (that marks the end of high-school in Portugal).

Sector covariates: The Herfindahl-Hirschman index of industrial concentration in industry K is defined as $hhi_K = \sum_{J \in K} (mshare_J)^2$ where $mshare_J$ is the market share of firm J of industry K defined as firm sales over total industry sales. The level of openness for industry K in 1988 (*indop88*) is defined as the ratio of total industry trade (imports plus exports) to domestic demand (industry sales plus net imports).

Source weighted industry real exchange rate index: is defined as the weighted average of the log real exchange rate of each of the importing countries. The weights are the shares of each foreign country's imports in industry total imports in a base period (1990-1991). Real exchange rates are nominal exchange rates (expressed in foreign currency per escudo) multiplied by the Portuguese consumer price index and divided by the foreign country consumer price index. Nominal exchange rates have been provided by the Bank of Portugal and foreign consumer prices index's from the International Financial Statistics of the International Monetary Fund.

Firm covariates: The firm size is defined as the number of employees, firm (nominal average) labour productivity as the ratio of firm sales to number of employees, firm age as current year minus year of creation of the firm, and percentage of foreign capital as share of foreign capital in equity.

APPENDIX B: Consistency checks to the information on the employer-employee dataset

We have performed a number of consistency checks on the information provided by “Quadros de Pessoal” to guarantee the accuracy of the data used.

a) Elimination of invalid or duplicated worker identification codes in a given year: According to the Ministry of Employment valid worker’s ID codes have 6 to 10 digits. In each year, observations with codes with less than 6 or more than 10 digits were not considered. Observations with duplicated identification codes were also eliminated. These restrictions led to dropping an average 8.93 percent and 4.51 percent of the observations in the original yearly datasets, respectively.

b) Consistency check of data for each worker across years: We have merged the yearly information and identified inconsistencies when gender, date of birth or year of hiring (for the same firm) were reported changing, or the highest schooling level was reported decreasing (or was missing) over time for the same worker.

(b1) Correcting missing values when reported data for the rest of the period was absolutely consistent by assigning the reported value for the remaining period. This changed 0 percent¹⁴, 2.25 percent, 0.71 percent and 0.23 percent of the observations in the initial panel for gender, age, schooling and tenure firm, respectively.

(b2) Correcting inconsistent data across years by taking information reported over half of the times as correct¹⁵. Inconsistent values on gender were replaced by the value reported over half of the cases the worker has been observed, provided that the year of birth in that observation is the same as that reported in more than 50 percent of the cases for that worker. Similar procedures have been implemented for year of birth and schooling. This affected 0.87 percent, 1.77 percent, 6.65 percent and 1.68 percent of the initial panel for gender, year of birth and schooling, respectively. The whole information on a worker has been dropped when inconsistencies persisted after this correction. This restriction led to dropping 8.4 percent, 1.08 percent and 6.28 percent of the observations for gender, year of birth or schooling, respectively.

¹⁴ Two observations.

¹⁵ Note that this is a more demanding criterion than simply using the modal value as replacement.

(b3) Dropping workers with remaining missing data on gender, age or schooling: 0 percent, 0.15 percent, 0.99 percent due to missing data on gender, age and schooling, respectively. The checked panel included 22,686,298 worker-year observations and 3,525,485 workers.

Table B.1: Shares of regions and years

Variable	% of Total
Region	
North Coast	31.88
Central Coast	14.24
Lisbon	44.28
Inland	7.18
Algarve	2.42
Year	
1986	5.06
1987	5.5
1988	5.47
1989	5.19
1991	6.42
1992	6.72
1993	6.74
1994	6.86
1995	7.76
1996	8.21
1997	8.8
1998	8.74
1999	9.3
2000	9.23
Observations	15,613,149

APPENDIX C: Regression results on the effect of international competition on skill acquisition and industry relocation

The estimated results of the two equation systems ((4.1) and (4.2)) presented in Section 4.3 are marginal effects. Appendix Table C.1 displays the regression results instead.

Table C.1: Effect of international competition on skill acquisition and industry relocation: regression results

Variables	Stay in the same industry and skill as base				Stay same ind and no skill up as base			
	Propensity to move ind.	Propensity to move skill	Propensity to move ind.	Propensity to move skill	Propensity to move ind.	Propensity to skill-up	Propensity to move ind.	Propensity to skill-up
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
age	-0.184 (23.58)***	-0.876 (111.2)***	-0.275 (46.36)***	-0.844 (134.36)***	-0.172 (22.04)***	-1.094 (138.04)***	-0.268 (44.98)***	-1.008 (164.66)***
age2	0.031 (2.98)***	0.934 (90.03)***	0.208 (26.41)***	0.921 (110.12)***	0.016 (1.5)	1.193 (115.15)***	0.198 (25.03)***	1.114 (137.06)***
tenure	-0.232 (105.24)***	-0.163 (65.14)***	-0.165 (100.59)***	-0.141 (73.01)***	-0.233 (104.98)***	-0.222 (82.35)***	-0.166 (100.56)***	-0.187 (91.08)***
skilled	0.238 (24.67)***	0.445 (43.59)***	0.145 (24.47)***	0.338 (52.85)***	0.233 (24.02)***	0.446 (45.47)***	0.142 (23.81)***	0.256 (41.27)***
indop88*post89	0.034 (3.96)***	0.028 (3.23)***			0.035 (4.01)***	0.028 (2.99)***		
indop88	0.038 (1.36)	0.022 (0.89)			0.035 (1.25)	0.024 (0.91)		
post89	-0.023 (4.66)***	-0.061 (12.25)***			-0.023 (4.52)***	-0.111 (19.41)***		
Δexchrate			0.174 (5.01)***	0.087 (2.47)**			0.181 (5.21)***	0.243 (5.66)***
male	0.102 (33.37)***	0.094 (28.09)***	0.085 (35.95)***	0.030 (11.12)***	0.103 (33.44)***	0.098 (29.05)***	0.087 (36.31)***	0.041 (16.05)***
hhi	0.079 (8.17)***	0.098 (10.39)***	0.004 (25.37)***	0.001 (5.58)***	0.084 (8.62)***	0.067 (5.96)***	0.004 (24.97)***	0.001 (5.12)***
firmsize	-0.045 (45.97)***	-0.025 (23.42)***	-0.001 (1.23)	-0.010 (11.12)***	-0.045 (45.87)***	-0.008 (7.24)***	-0.002 (1.92)*	-0.001 (0.65)
firmlabprod	-0.041 (42.39)***	-0.009 (8.22)***	-0.031 (32.75)***	0.002 (2.22)**	-0.042 (43.32)***	0.001 (0.52)	-0.032 (33.98)***	0.006 (5.06)***
firmage	0.014 (21.14)***	0.001 (1.8)*	0.001 (2.28)**	0.000 (0.68)	0.015 (21.59)***	-0.002 (2.31)**	0.002 (2.96)***	0.000 (0.07)
%foreignK	-0.183 (34.47)***	0.019 (3.63)***	-0.055 (14.38)***	-0.012 (2.98)***	-0.186 (34.84)***	0.053 (9.69)***	-0.055 (14.46)***	0.012 (2.87)***
Year+Regional dummies	yes	yes	yes	yes	yes	yes	yes	yes
Industry fixed effects	yes	yes	yes	yes	yes	yes	yes	yes
Observations	2,300,567		3,858,747		2,300,567		3,858,747	
rho	0.475		0.409		0.299		0.267	
McFadden's pseudo R2	0.052		0.053		0.066		0.066	

* significant at 10%; ** significant at 5%; *** significant at 1%. The period of analysis is 1986-1992 in Column 1-2 and 5-6 and 1992-2000 in Column 3-4 and 7-8. Absolute value of t-statistic in parentheses, based on robust standard errors clustered by individuals. The variables age, tenure are divided by 10, and age-square and hhi by 1000.

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