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IS THERE A PRODUCER QUALITY WAGE PREMIUM SIMILAR TO THE EXPORTER WAGE PREMIUM?*

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Abstract

Exporter wage premium has been widely studied in the literature on international trade. The aim of this paper is analyze whether there is also a producer quality wage premium at firm level, and if so, analyze whether its origin is similar to the exporter wage premium. In other words, I test whether firms that increase their product quality become more productive and pay higher wages (as with the learning by exporting hypothesis, we can speak of learning by producing quality), or, in contrast, more-productive firms with higher wages opt to increase product quality because their higher productivity means these kinds of decisions and investments can be taken with more guarantees (self-selection hypothesis).

Keywords: Wage differentials, International trade, Exports, Product quality.
JEL Classification: F16, J31, J24.

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1. INTRODUCTION

Since the pioneering paper by Bernard and Jensen (1995) many papers on exporter wage premium have appeared. Wagner (2007, 2012) and Schank et al. (2010) mention most of them and summarize their contributions. The main motivation of this paper stems from Alcalá and Hernández (2010), where we build a theoretical model that suggests that wage premium of exporter firms and their higher human capital are due to their higher product quality. More-productive firms can overcome entry costs in international markets (although also national ones[1]) and they produce higher quality goods. This relation also generates a rise in human capital and in the average wage of the firm. However, the relation between wages and product quality could not be contrasted because the dataset used in this paper had no information about quality product. Therefore, this paper attempts to mitigate this shortcoming by analyzing the correlations between the quality of the product, the exports and the average wages of the firm.

There are several papers that have analyzed empirical positive correlations between exports, quality and productivity and wages in firms or establishments. Verhoogen (2008) finds that more-productive establishments produce higher-quality goods than less-productive establishments, and they pay higher wages to maintain a higher-quality workforce. In many cases, the arguments for this empirical relation are based on the literature on firm-size wage premium (Idson and Oi, 1999) and exporter wage premium (Bernard and Jensen, 1995). Kugler and Verhoogen (2011) use a measure of the scope for quality differentiation from Sutton (1998) and find that the output price-plant size and input price-plant size elasticities are greater in sectors with more scope for quality differentiation. Verhoogen (2008) finds that more-productive plants increase the export share of sales, wages and the likelihood of ISO 9000 certification more than less-productive plants. Guadalupe (2007) argues that increased product market competition leads to higher returns to skill, because high-skilled workers produce at lower costs, and there is stronger competition between firms to attract better workers. A similar point of view is taken by Bustos (2011), who finds that

[1] Similar effects are obtained between establishments in national-market versus local-market.

trade liberalization induces the most productive firms, usually exporters, to adopt skill-intensive production technologies[2].

Most of these papers suppose that firms that increase their product quality become more productive and pay higher wages, similar to the learning-by-exporting hypothesis for exporter firms. However, the causal relation could also be the opposite. Higher productivity in exporting firms is due to self-selection of more productive firms in export markets (self-selection hypothesis). This may also be applicable to firms that increase their product quality. More-productive firms with higher wages decide to increase product quality because their higher productivity means these kinds of decisions and investments can be taken with more guarantees.

There is a wealth of literature on which hypothesis is more relevant - learning-by-exporting or self-selection - in the case of exporter firms. Singh (2010) concludes that, at firm level, the studies supporting self-selection clearly outnumber the studies supporting learning-by-exporting. But, in the case of relations between product quality and productivity or wages, there are no studies which analyze their causality. Therefore, this paper has two aims: i) to ascertain whether a producer quality wage premium exists, and ii) to analyze whether firms that increase their product quality become more productive and pay higher wages (learning-by-producing-quality hypothesis), or, in contrast, more-productive firms with higher wages decide to increase their product quality (self-selection hypothesis).

To carry out the second of these aims I use the methodology proposed by Schank et al. (2010) in the context of exporter firms. These authors contrast the learning-by-exporting versus self-selection hypothesis using a dataset of German linked employer-employee and obtain empirical evidence for the latter. Papers that focus on the relation between firm heterogeneity and exports (Melitz, 2003 and Greenaway and Kneller, 2007) are the theoretical basis of this result. I also contrast these hypotheses with Spanish data. There are several papers which have analyzed this question in Spain, paying attention to the estimated total factor productivity. Delgado et al. (2003) obtain evidence in favour of the self-selection hypothesis, but Mañez et al. (2010) find

[2] Bernard et al. (2011) review this empirical evidence on firm heterogeneity in international trade.

evidence in favour of the learning-by-exporting hypothesis. Manjón et al. (2012) indicate that the assumptions used about the evolution of productivity and the role of export status turns out to be critical in finding evidence in favour of either hypothesis. The advantage of using an observed variable, such as wages, instead of estimated productivity to contrast these hypotheses is that we do not need to impose additional assumptions.

The Spanish dataset used to analyze the effect of product quality on wages is the *Encuesta Sobre Estrategias Empresariales* (Survey on Companies' Strategies, hereinafter, ESEE). With this dataset, I will use the measure for quality from Sutton (the R&D and advertising intensity) and information from a categorical variable which indicates whether the firm has carried out or contracted quality standardization and control works, because the dataset does not contain information about ISO certification. I will analyze whether the correlations of theses measures for quality with other variables are as expected. Subsequently, I estimate demand equations for skill workers and wages equations adding these measures for quality in order to contrast whether product quality generates the expected positive effects on human capital and average wages of the firm.

Direction of causality will be analyzed using the definition of firms that start to export or firms that start to produce with higher quality, versus firms that do not export or firms that do not increase their product quality. The test analyzes how exports or higher product quality affect firms that start these actions in subsequent years. If exports or higher product quality increase wages and productivity, we would observe a wage rise and productivity rise in subsequent years after the decision to export or to increase product quality. In contrast, if the relevant hypothesis is that more-productive firms decide to export or to increase product quality, we would not observe statistically significant temporal effects.

The paper is organized as follows. Section 2 describes the dataset and the two indicators used in order to measure product quality: R&D and advertising expenditures over sales and carrying out or contracting standardization and control works. Section 3 estimates demand equations for skilled employees (college graduates and engineers) and wages equations. These estimations show positive correlations between exports, product quality and human capital and average wages of the firm. Section 4 studies the direction of the causality and tests the hypothesis that exports and higher product quality increase wages and productivities or whether more-productive firms decide to export or decide to raise product quality. Section 5 summarizes and concludes.

2. THE DATA

The ESEE (this survey has its origin in an agreement subscribed in the year 1990 between the Ministry of Industry and the SEPI Foundation, formerly the *Fundación Empresa Pública* (Public Firm Foundation)) is an unbalanced panel of Spanish manufacturing firms since 1990. This database contains information about an average sample of 1,800 firms every year, and includes information about activity, products and manufacturing processes, customers and suppliers, costs and prices, markets covered, technological activities, income statements, accounting balance sheets, employment and foreign trade. Firms with less than 10 employees were excluded from the survey. All firms which have over 200 employees are included along with a random sample of the rest (firms with 10 to 200 employees). Most of the variables included are yearly, but there are others where the information is only updated every four years, such as the percentage of college graduates and engineers of total employees and the information about works carried out or contracted by the firms on normalization and quality control.

Table A1 in the appendix gives a brief statistical description of some interesting variables. Averages wages of the firm are labour cost per employee (labour cost divided per yearly average of total employment). Exporter firms have higher wages and higher sales per employee than non-exporter firms, and are also larger. The percentage of exporter firms with more than 49 employees is 69.4%, whereas in non-exporters it is only 19.6%. The percentage of college graduates and engineers is 5.6% in exporter and 2.9% in non-exporter firms (38% of the firms do not have employees with theses degrees). The percentage of total sales exported (export propensity) is 28.9% for exporter firms. We also observe that the percentage of firms which control their quality is 55.5% within exporter firms, whereas within non-exporter firms it is only 27.1%. The percentage of R&D and advertising expenditures over sales is also higher in exporter firms - 2.7% versus 1.4% for non-exporter firms.

The ESEE does not contain information about whether a firm has any ISO certification of its product quality. Therefore, we use a measure for quality from Sutton (1998) –R&D and advertising expenditures over sales- and the information obtained every four years about whether a firm has carried out or contracted quality standardization and control works (quality control). We can observe in the following tables that these measures for quality behave as expected. Table 1 shows how in all the years where information about control quality is available there is a positive relation between this variable and the percentage of college graduates and engineers, the export propensity and the average wage of the firm. These same positive correlations are observed between R&D and advertising expenditures over sales and the percentage of graduates and the average firm wage (for all years between 1990 and 2010 in the latter case). The positive correlations between R&D and advertising expenditures over sales and export propensity are not significant only in 1991 and 1992

Insert Table 1 about here

Table 2 also shows a positive relation between these variables by industries. In the vast majority of cases theses correlations are significant. The correlations between R&D and advertising expenditures over sales and export propensity are not significant in Meat products, Food and tobacco, Paper and Computer products, electronics and optical.

Insert Table 2 about here

Table 3 shows several ratios by years between the measures of product quality, average firm wage, exporter status and percentage of college graduates and engineers of the firm. In the first three columns we can see that the firms which invest in R&D and advertising have higher percentages of college graduates, higher wages and greater export propensity than firms which do not invest, since all the ratios are higher than one. This same behaviour is observed the second three columns for firms which control their product quality versus firms which do not. Finally, the last two columns show that R&D and advertising expenditures over sales and quality control are higher in exporter than non-exporter firms.

Insert Table 3 about here

3. HUMAN CAPITAL, WAGES AND PRODUCT QUALITY

First I estimate demand equations for skilled employees in order to analyze the correlations between theses employees and product quality. A positive correlation between exports and human capital of the firm has been pointed to in many papers since Bernard and Jensen (1997). Alcalá and Hernández (2010) cite several of them. A positive correlation between product quality and demand for skilled employees has been recently suggested by Verhoogen (2008) and Bustos (2011).

In equation (1) the dependent variable e_{jt} is the percentage of collage graduates and engineers of the firm *j* in the year *t*, and I have chosen the *tobit* specification to estimate the correlations with the age of the firm, the firm size (employees), exporter status (a dummy equal to unity when the firm has exported) and the quality indicator:

$$\begin{aligned} e^*_{jt} = \alpha_0 + \alpha_1 Age_{jt} + \alpha_2 Size2_{jt} + \alpha_3 Size3_{jt} + \alpha_4 Exporter_{jt} + \alpha_5 Quality_{jt} + \\ \alpha_6 Industry_{jt} + \gamma_t + v_{jt} \end{aligned} \quad (1)$$

$$e_{jt} = \max(0, e^*_{jt})\ ;\ v_{jt} \sim \text{Normal}(0, \sigma^2),$$

where *Size2* is a dummy variable for firm size which corresponds to firms employing between 50 and 249 workers and *Size3* corresponds to firms with more than 249 workers. *Exporter* is the dummy for exporter status and *Quality* is the quality indicator, which can be the R&D and advertising expenses over sales suggested by Sutton (1998) or a dummy variable which takes the value one when firm has carried out or contracted quality standardization and control works (I will also estimate specifications with both quality indicators). Additionally, I include a vector of dummies for industries and another vector γ of dummies for years.

Table 4 shows the results. In column (1) we observe that exporting firms have a higher demand for college graduates and engineers (Alcalá and Hernández, 2010). The inclusion of R&D and advertising over sales in column (2) or the inclusion of the dummy for control quality in column (3), and even the inclusion of both variables in column (4), have a positive effect on demand for college graduates and engineers. Marginal effects show that firms which carry out or contract quality standardization and control works increase the percentage of college graduates and engineers by almost one percentage point. Moreover, a 10 percentage point increase in R&D and advertising over sales increases the percentage of college graduates and engineers by 1.2 percentage points. The results of interaction terms between quality indicators and export propensity and those between quality indicators and dummies for firm size are not reported as they are not statistically significant.[3]

Insert Table 4 about here

Table 5 shows the estimates of following wage equation, where the wage of the firm, w_{jt}, is the total labour cost divided per average yearly of total employment of the firm *j* in the year *t*.

$$\begin{aligned} \ln w_{jt} = \beta_0 + \beta_1 \, Age_{jt} + \beta_2 \, Size2_{jt} + \beta_3 Size3_{jt} + \beta_4 e_{jt} + \beta_5 Exporter_{jt} + \\ \beta_6 Quality_{jt} + \beta_7 Industry_{jt} + \delta_t + u_{jt} \end{aligned} \qquad (2)$$

In column (1) we observe the standard results about positive relations between the firm size (employees), the human capital of the firm (skilled employees), the exporter status and wages. Moreover, older firms pay higher wages. A one-year increase raises average firm wages by 0.31%. The exporter wage premium is 8.6% ($e^{(0.083)}$-1). This effect is only slightly lees than that obtained by Alcalá and Hernández (2010).[4]

Columns (2)-(6) include the product quality indicators. The wage effect of R&D and advertising expenses over sales is statistically significant only when the percentages of college graduates and engineers of the firm in column (4) are not included. Moreover, in this case, the wage effect is quite small. A 10 percentage point increase in the percentage of theses expenses only increases the average wage of the firm by 0.03 percentages points. However, the wage effect in column (5) of a dummy which takes the

[3] Results are available upon request.

[4] The exporting wage premium obtained with hourly wages with ESEE -9.3%- is very similar to the figure obtained with yearly wages, but I prefer to use yearly wages because the information about the number of yearly worked hours in 1990 is very scarce and it reduces the number of observations. Nevertheless, those estimates are available upon request.

value one when the firm has invested in R&D and advertising and zero otherwise has an important and statistically significant effect, because it represents a 4.4% wage increase. The dummy for quality control is also statistically significant and has a wage impact similar. According to column (3), the firms which control their product quality pay wages 4.7% higher than firms which do not carry out this control. In column (6) I include both dummies of product quality (R&D and advertising expenses and quality control) and we can see that both are statistically significant and have similar wage effects. As estimations of demand of college graduates and engineers, the interaction terms between quality indicators, exporter status, percentage of college graduates and engineers and dummies variables for firm sizes are not statistically significant.

Insert Table 5 about here

4. CAUSALITY

The direction of the causality between product quality and wages may not be as in the previous analysis, but it is possible that, instead of higher product quality increase productivity and wages of the firms, the more-productive firms –and the firms that pay higher wages- decide to increase their product quality.

To carry out this analysis I use the methodology proposed by Schank et al. (2010) in the context of exporter wage premium. Theses authors observe how firms behave in periods of 6 consecutive years. They start at a point in time when none of the firms exported, and end when some have been exporting for a while. According to these authors, using observation periods of 6 years, an exporter starter is defined as not exporting in t = 1, 2, 3 and exporting in t = 4, 5, 6. Moreover, if a firm has been observed more than six times in the sample, then in all observed years after t = 6 it must have been an exporter and in all the observed years before t = 1 it must have exports equal to zero. If this is not the case, the firm must be dropped from the sample. Obviously, non-exporters are firms that do not export in any of the years t=1,…, 6, nor in the observed years before t = 1 and after t = 6. Using the ESEE data from 1990 to 2010, we can define 6-year windows (from 1990 to 1995, from 1991 to 1996, …, from 2005 to 2010). Theses data for export starters and non-exporters are pooled over these sixteen cohorts. So, it is possible that a firm was first a non-exporter and then an export starter, but not vice versa.

Estimates of Schank et al. (2010) show that wages and labour productivity (sales per employee) of exporter starters are higher than non-exporter firms but that temporal effects are not statistically significant. That is, neither the difference in the wages nor the difference in productivity changes over the years; neither in the years before the starters begin to export (t = 2, 3) nor the years after starting to export (t = 4, 5, 6). According to these results, these authors conclude that firms with a higher productivity (and higher wages) self-select into export markets. This result is in line with the main idea of model of Melitz (2003), who emphasizes that firm heterogeneity is a phenomenon that can help explain the distribution of trade flows. Greeneway and Kneller (2007) state that only more-productive firms can bear the higher cost of entering international markets.

First, I perform the same analysis for exporter and non-exporter firms and I then apply this methodology in the context of the quality producer wage premium. Table 6 shows the labour productivity (sales per employee) and average firm wage for export starters and non-exporters with ESEE data from 1990 to 2010. We can observe that in the six periods considered the 110 export starters have higher levels of productivity and wages than the 3,982 non-exporters. These differences are statistically significant in all cases.

Insert Table 6 about here

Table 7 shows the estimates of wage and productivity equations with a subsample of export starters and non-exporters. Apart from the regressors include in equation (2), I have included a dummy variable for export starters and interaction terms between these and the six time periods considered. These equations are also estimated with another overlap sample of firms in order to avoid the problem of some firms' not being comparable to others due to lack of overlap in the distribution of firms' characteristics between exporters and non-exporters. I use the methodology proposed by Crump et al. (2009), who discard all firms with estimated propensity scores outside the range [0.1, 0.9]. Table A2 of appendix shows the *probit* model that estimates the probability of starting to export.

Insert Table 7 about here

All estimates obtained with the full sample and with the overlap sample point in the same direction. The export starters pay higher wages, whose increase ranges from the 12.4% obtained with the full sample to 20.1% with the overlap sample. The export starters also present higher labour productivity (sales per employee) than non-exporters with a 44% increase in full sample and a 31.6% in overlap sample. However, the interaction terms between this dummy variable and dummies for the six periods considered are not statistically significant in any case. Consequently, neither wages nor productivity shows significant increases in years before and after the decision to export. Therefore, the causality relation is not due to the learning-by-exporting hypothesis (exports generate a higher productivity and higher wages), but to the self-selection hypothesis. That is to say, more-productive firms manage to break into international markets because this higher productivity can bear the higher cost of entering entailed. Schank et al. (2010) obtain similar results for the German economy.

This same methodology can be applied to causality relation between product quality and wages. Similarly to previous analyses, we can define a set of firms which start to increase their product quality versus firms which never do. The test also analyzes the evolution of the labour productivity and wages of starters before and after the decision to control the quality. If this evolution shows a positive increase, we will conclude that higher product quality increases productivity and wages. However, if theses variables are not affected in the years after the increase in quality, although they are higher than those observed in firms which do not increase their product quality, we will conclude that more productive firms decide to improve their product quality and, therefore, the direction of causality is the opposite. In other words, product quality does not increase productivity, but the more productive firms do decide to improve their product quality.

This methodology has only been carried out in case of export starters and non-exporters when we use R&D and advertising expenses over sales as a measure of product quality (Sutton, 1998). We define a firm as starting to improve its product quality if in the six-year period considered it does not carries out R&D and advertising expenses in the three first years and has positive values for this variable in the three following. We define a firm as not improving its product quality when it presents zero values of this variable for all the six-year periods considered.

With the other measure of product quality –whether the firm has carried out or contracted quality standardization and control works- we can only ascertain the above for every four years (1990, 1994, 1998, 2002, 2006 and 2010). Therefore, in this case, the previous methodology has slightly been modified and I have defined three cohorts of 4 years (from 1990 to 2002, from 1994 to 2006 and from 1998 to 2010), where I have supposed that a firm starts to increase its product quality when it does not control it in the two first years but does in the two following years. A firm never increases its product quality if it does not control it in all the 4 years considered.

Table 8 shows the average labour productivity (sales per employee) obtained and average firm wages (labour cost per employee) and the statistic test which controls whether these averages are statistically identical between the firms which either start to invest in R&D and advertising or start to control their product quality, versus the firms which neither invest in R&D and advertising nor control their product quality.

Labour productivity and average wages of firms which start to invest in R&D and advertising are higher than in firms which do not invest. The wage differentials are statistically significant, but the differentials in labour productivity are not. In the case of firms which start carrying out or contracting quality standardization and control works, wages and labour productivity are higher than in firms which do not, and these differences are all statistically significant.

Insert Table 8 about here

Table 9 shows the results of estimated wages and productivity equations for investor starter and non-investor firms. The quality producer wage premium is 20.8% in the full sample and 27.6% in the overlap sample (estimated model of probability of starting to invest in R&D and advertising is in Table A2 of the appendix) and, as in the context of exporter firms, the interaction terms between the dummy of starting to invest and dummies for the six considered periods are not statistically significant in any case. Therefore, once again the wages do not show significant increases in the years before and after the decision to invest. In the case of the labour productivity equation, the firms which start to invest in R&D and advertising are only more productive in the full sample (statistically significant at 10%), and the temporal effects are not significant. In the overlap sample there are no statistically significant differences in any case.

Insert Table 9 about here

Table 10 shows the results when we use quality control as a measure of product quality. I include only 4 *t* periods because this information is only updated every 4 years. The results point in the same line. Firms which start to control their product quality are more productive and pay higher wages than firms which do not in both the samples. The quality producer wage premium is 12.6% in the full sample and 8.8% in the overlap sample (this last premium only is statistically significant at 10%), but the interactions terms between the dummies for starter firms and dummies for the 4 periods considered are not statistically significant, and neither is the wage equation nor the productivity equation. Consequently, as in the context of exporter firms, there is no evidence that firms that increase their product quality become more productive and pay higher wages (similar to the learning-by-exporting hypothesis, we could speak in this case that there is no evidence in favour of learning by producing quality). Therefore, I conclude that more-productive firms with higher wages decide to increase product quality because their higher productivity means these kinds of decisions and investments can be taken with more guarantees, so I find evidence for the self-selection hypothesis.

Insert Table 10 about here

5. CONCLUSIONS

The exporting wage premium has been widely tested in the literature. Many of the studies on this topic seek to ascertain whether firms which start to export are more productive and pay higher wages (the learning-by-exporting hypothesis) or, in contrast, higher productivity in exporting firms is due to self-selection of more productive firms to break into export markets (the self-selection hypothesis). The findings for pre-entry differences present evidence in favour of the latter, whereas findings supporting the learning-by-exporting hypothesis are mixed (Wagner, 2012). Singh (2010) concludes that, at firm level, the studies supporting self-selection clearly outnumber those supporting learning-by-exporting. Applying the methodology proposed by Schank et al. (2010) to the Spanish ESEE dataset (1990-2010) I also obtain evidence in favour of the second. However, the main finding of this paper is that there is a quality producer wage premium similar to exporter wage premium. Firms which carry out or contract quality standardization and control works increase their percentage of college graduates and engineers by almost one percentage point. Moreover, a 10 percentage-point increase in R&D and advertising in sales (Sutton's measure for product quality) increases the percentage of college graduates and engineers by 1.2 percentage points. Consequently, firms with greater product-quality pay higher wages. The estimated quality producer wage premium with this Spanish dataset is around 4.4%-4.7%, but it can reach more than 20% for firms which start to improve their product quality.

I have used the methodology proposed by Schank et al. (2010) in order to ascertain the origin of both the exporter wage premium and the quality producer wage premium. In both cases, the results point in the same line. I do not find evidence in favour of exporter firms, and firms which increase their product quality become more productive and pay higher wages. In other words, I find no evidence in favour of the learning-by-exporting hypothesis. All the results indicate that more-productive firms with higher wages manage to break into international markets and decide to increase product quality, that is, the evidence favours the self-selection hypothesis.

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APPENDIX

Table A1. Survey on Companies' Strategies 1990-2010

	All firms		Exporters		Non-exporters	
	Average	Observat.	Average	Observat.	Average	Observat.
Average wages	25655.8 (12416.6)	38549	29123.4 (12600.1)	23078	20443.3 (10095.9)	15364
Sales per employee	138957.7 (177153.2)	38559	172128.4 (203636.5)	23083	88936.8 (109084.6)	15371
Age	34.19 (21.76)	47442	39.07 (23.86)	22553	28.95 (17.14)	15371
Size (employees)						
Less than 50	0.504	38637	0.305	23083	0.804	15371
Between 50-249	0.248	38637	0.320	23083	0.142	15371
More than 249	0.247	38637	0.374	23083	0.054	15371
Percentage of graduates	4.550 (7.471)	47186	5.641 (7.147)	22360	2.914 (7.130)	15110
Export propensity	17.370 (25.380)	38671	28.953 (27.173)	23201		
R+D and advertising over sales (%)	2.175 (19.721)	38223	2.694 (4.848)	22781	1.404 (30.533)	15355
Quality control	0.434	47494	0.555	22548	0.271	15142

Standard deviations are in brackets.

Table A2. Probit models

	Probability of start to export	**Probability of start to invest in R&D and advertising**	**Probability of start to control the product quality**
Log (productivity)	0.533 (16.37)	0.288 (5.59)	0.774 (8.34)
Percentage of graduates	0.004 (1.47)	0.050 (4.78)	0.008 (1.17)
Size (employees)			
Between 50-249	0.549 (9.79)	0.428 (3.10)	0.576 (4.56)
More than 249	1.494 (16.52)	-0.602 (2.41)	2.269 (7.68)
Exporter		0.190 (1.75)	0.130 (1.25)
Age/10	-0.061 (4.67)	0.141 (4.96)	-0.129 (3.65)
Observations	23,045	3,659	2,369
Pseudo R^2	0.212	0.296	0.339

All estimated models include a constant, dummies for industries and years. $|z|$-statistics are in brackets.

Table 1. Correlations between the quality measures and the percentage of college graduates, the export propensity and the average firm wages by year

	Quality control			**R&D and advertising expenditures over sales (%)**		
	Percentage of graduates	Export propensity	Average firm wage	Percentage of graduates	Export propensity	Average firm wage
1990	0.1302*	0.1378*	0.2312*	0.2980*	0.0548*	0.1957*
1991					0.0332	0.2534*
1992					0.0324	0.2715*
1993					0.0436**	0.2614*
1994	0.2110*	0.2471*	0.3635*	0.3335*	0.0668*	0.3026*
1995					0.2663*	0.2779*
1996					0.1117*	0.2987*
1997					0.0814*	0.296*
1998	0.1688*	0.2683*	0.3502*	0.3360*	0.0845*	0.2927*
1999					0.1260*	0.2852*
2000					0.0801*	0.2602*
2001					0.0603*	0.2568*
2002	0.1761*	0.2131*	0.3160*	0.3174*	0.0806*	0.2447*
2003					0.0525*	0.2701*
2004					0.0634*	0.2974*
2005					0.2663*	0.0657*
2006	0.1156*	0.1166*	0.1837*	0.3370*	0.0709*	0.2505*
2007					0.0871*	0.2587*
2008					0.1002*	0.2251*
2009					0.1231*	0.2006*
2010	0.1711*	0.1940*	0.2367*	0.2364*	0.1171*	0.1705*

* Means significant at 5%. ** Means significant at 10%.

Table 2. Correlations between the quality measures and the percentage of college graduates, and the export propensity and the average firm wages by industries

	Quality control			R&D and advertising expenditures over sales (%)		
	Percentage of graduates	Export propensity	Average firm wage	Percentage of graduates	Export propensity	Average firm wage
1	0.2030*	0.1153*	0.2310*	0.3422*	-0.0282	0.4189*
2	0.2225*	0.1737*	0.2098*	0.2512*	0.0023	0.3059*
3	0.2124*	0.1059**	0.1448*	0.1824*	0.2297*	0.3894*
4	0.0903*	0.2381*	0.1941*	0.0771*	0.114*	0.1069*
5	0.1631*	0.1816*	0.1401*	0.0701*	0.1976*	0.1878*
6	0.1407*	0.0512	0.1578*	0.1649*	0.0506**	0.1146*
7	0.2112*	0.2965*	0.2266*	0.0838*	-0.031	0.1291*
8	-0.0804	0.1674*	0.1170*	0.4497*	-0.0905*	0.3046*
9	0.1352*	0.0087	0.1861*	0.3168*	-0.2047*	0.1781*
10	0.1844*	0.2345*	0.1812*	0.1986*	0.1142*	0.0739*
11	0.1569*	0.0942*	0.1998*	0.1112*	0.3648*	0.103*
12	0.1082*	0.0955**	0.1013*	0.0628*	0.1603*	-0.0738*
13	0.1475*	0.1996*	0.1534*	0.1113*	0.1717*	0.117*
14	0.1849*	0.2074*	0.1756*	0.1087*	0.1418*	0.0686*
15	0.0962**	0.1047**	0.0633	0.2809*	0.0186	0.1277*
16	0.0709**	0.1617*	0.1199*	0.1707*	0.1495*	0.1256*
17	0.1146*	0.1222*	0.0932*	0.1392*	0.1448*	0.0830*
18	0.1734*	0.1411*	0.1973*	0.3382*	0.1481*	0.1061*
19	0.2295*	0.1599*	0.2503*	0.1473*	0.168*	0.1640*
20	0.0875	0.1601*	0.1231*	0.0146	0.2509*	0.1623*

* Means significant at 5%. ** Means significant at 10%. The correlations of quality control only includes the years where information is available (1990, 1994, 1998, 2002 and 2006). Industries: 1 Meat products; 2 Food and tobacco; 3 Beverage; 4 Textiles and clothing; 5 Leather, fur and footwear; 6 Timber; 7 Paper; 8 Printing and Edition; 9 Chemicals products; 10 Plastic and rubber products; 11 Non-metal mineral products; 12 Basic metal products; 13 Fabricated metal products; 14 Machinery and equipment; 15 Computer products, electronics and optical; 16 Electric materials and accessories; 17 Vehicles and accessories; 18 Other transport equipment; 19 Furniture; 20 Other manufacturing

Table 3. Ratios

	Firms with R&D and advertising expenditures versus firms without these expenditures			Firms which control their product quality versus firms which do not			Exporter versus non-exporter	
	Percentage of graduates	Average firm wage	Export propensity	Percentage of graduates	Average firm wage	Export propensity	R&D and advertising expenditures over sales	Quality control
1990	2.25	1.31	1.93	1.66	1.25	1.72	2.11	1.84
1991		1.32	2.00				2.38	
1992		1.31	2.47				2.31	
1993		1.39	2.49				2.80	
1994	2.76	1.43	2.36	1.79	1.39	2.15	2.92	2.61
1995		1.39	2.28				3.20	
1996		1.38	2.14				3.02	
1997		1.33	1.88				2.76	
1998	2.09	1.29	1.82	1.57	1.36	2.11	2.91	2.32
1999		1.33	2.27				2.91	
2000		1.35	2.09				2.49	
2001		1.34	2.25				2.15	
2002	2.26	1.33	2.34	1.63	1.30	1.77	2.55	2.29
2003		1.28	1.72				2.32	
2004		1.26	1.83				2.49	
2005		1.24	2.04				2.55	
2006	1.96	1.19	1.96	1.42	1.17	1.39	2.37	1.71
2007		1.18	1.74				2.69	
2008		1.21	1.86				2.96	
2009		1.18	1.84				3.09	
2010	1.89	1.21	1.84	1.54	1.20	1.67	2.69	1.86

Table 4. Tobit estimates of the demand of skilled employees. Dependent variable: percentage of college graduates and engineers.

	Coefficients				Marginal effects			
	(1)	**(2)**	**(3)**	**(4)**	**(1)**	**(2)**	**(3)**	**(4)**
Percentage of R&D and advertising expenses over sales		0.260 (13.94)		0.251 (13.55)		0.126		0.121
Quality control			1.858 (9.52)	1.686 (8.67)			0.905	0.813
Exporter	2.894 (12.88)	2.664 (11.91)	2.674 (11.92)	2.475 (11.09)	1.411	1.287	1.302	1.194
Size (employees)								
50-249 employees	4.568 (19.38)	4.391 (18,76)	4.194 (17.79)	4.056 (17.32)	2.227	2.121	2.042	1.957
More than 249 employees	6.046 (22.44)	5.616 (20,86)	5.496 (20.23)	5.132 (18.91)	2.947	2.7132	2.676	2.476
Age	0.027 (5,95)	0.023 (5.16)	0.026 (5.88)	0.023 (5.09)				
Observations	11,240	11,115	11,223	9132				
Firms	4,660	4,639	4655	4009				

Only observations of years where information about percentage of college graduates and engineers and quality control is updated is included: 1990, 1994, 1998, 2002, 2006 and 2010. All estimated equations include a constant and dummies for industries and years. $|t|$-statistics are in brackets.

Table 5. OLS estimates of wage equation. Dependent variable: logarithm of average firm wage.

	(1)	(2)	(3)	(4)	(5)	(6)
Percentage of R&D and advertising expenses over sales		0.0006 (0.62)		0.003 (2.13)		
Dummy=1 if R&D and advertising expenses>0					0,043 (4,81)	0,038 (4,18)
Quality control			0.046 (6.81)			0.043 (6.26)
Size (employees)						
50-249 employees	0.199 (17.82)	0.198 (17.79)	0.189 (16.89)	0.212 (18.10)	0.195 (17.52)	0.187 (16.69)
More than 249 employees	0.332 (25.88)	0.332 (25.75)	0.318 (24.70)	0.359 (25.85)	0.327 (25.53)	0.315 (24.49)
Percentage of college graduates and engineers	0.012 (15.09)	0.012 (14.69)	0.012 (15.24)		0.012 (14.90)	0.012 (15.06)
Exporter	0.083 (8.62)	0.083 (8.51)	0.077 (8.05)	0.091 (8.95)	0.076 (7.85)	0.072 (7.41)
Age/10	0.031 (14,35)	0.031 (14.42)	0.031 (14.34)	0.032 (14.30)	0.030 (14.20)	0.030 (14.21)
R^2	0.640	0.641	0.641	0.619	0.641	0.642
Observations	11,235	11,110	11,218	11,193	11,235	11,218
Firms	4,659	4,638	4,654	4,649	4,659	4,654

Only observations of years where information about percentage of college graduates and engineers and quality control is updated is included: 1990, 1994, 1998, 2002, 2006 and 2010. All estimated equations include a constant and dummies for industries and years. $|t|$-statistics are in parentheses. Standard errors are corrected for heteroskedascity and for the clustered sampling scheme.

Table 6. Descriptive statistics for export starter and non-exporter firms.

	Export starters (N=110)	Non-exporters (N=3,982)	Prob-value for differences of means = 0
Labour productivity (in €)			
t = 1	76,804.1	49,398.3	0.00
t = 2	80,736.8	49,632.9	0.00
t = 3	82,433.2	50,082.9	0.00
t = 4	87,084.0	50,199.6	0.00
t = 5	89,702.1	50,236.2	0.00
t = 6	94,321.8	50,240.9	0.00
Average wage (in €)			
t = 1	15,332.8	12,599.9	0.00
t = 2	15,463.8	12,685.6	0.00
t = 3	15,750.6	12,817.7	0.00
t = 4	16,254.5	12,869.4	0.00
t = 5	16,443.8	12,921.0	0.00
t = 6	16,605.5	13,038.3	0.00

Wages and sales are deflated by the aggregate consumer price index.

Table 7. Export starters and non-exporters. Dependent variables: logarithm of average firm wage and logarithm of firm labour productivity (sales per employee)

	log (wage)		log(productivity)	
	Full sample	Overlap sample	Full sample	Overlap sample
Export starter	0.117 (3.99)	0.189 (4.29)	0.365 (5.66)	0.275 (3.04)
(*t* = 2)*export starter	-0.002 (0. 50)	-0.009 (0.14)	0.009 (0.10)	0.064 (0.53)
(*t* = 3)*export starter	0.003 (0.08)	-0.048 (0.82)	0.009 (0.10)	0.023 (0.19)
(*t* = 4)*export starter	0.026 (0.61)	-0.021 (0.34)	0.069 (0.73)	0.160 (1.27)
(*t* = 5)*export starter	0.036 (0.88)	0.026 (0.44)	0.099 (1.06)	0.124 (0.91)
(*t* = 6)*export starter	0.037 (0.92)	-0.018 (0.30)	0.117 (1.26)	0.147 (1.08)
Size (employees)				
50-249 employees	0.186 (26.03)	-0.018 (0.89)	0.184 (14.00)	-0.477 (13.23)
More than 249 employees	0.327 (21.37)	-0.060 (2.14)	0.482 (11.05)	-0.969 (17.70)
Percentage of college graduates and engineers	0.010 (25.14)	0.016 (15.29)	0.017 (19.22)	0.014 (7.28)
Age/10	0.049 (38.40)	0.069 (15.74)	0.055 (20.94)	0.066 (7.83)
R^2	0.389	0.586	0.348	0.588
Observations	24,370	2,531	24,375	2,531
Firms	4,092	1,940	4,092	1,940

Wages and sales are deflated by the aggregate consumer price index. Only observations of years where information about percentage of college graduates and engineers is updated are included: 1990, 1994, 1998, 2002, 2006 and 2010. All estimated equations (OLS) include a constant and dummies for industries, years and periods *t*. |*t*|-statistics in parentheses. Standard errors are corrected for heteroskedascity and for the clustered sampling scheme

Table 8. Labour productivity and average wages

	R&D and advertising expenses over sales			Carrying out or contracting quality standardization and control works		
	Starters (N=32)	Non-investors (N=616)	Prob-value for differences of means=0	Starters (N=58)	Non-controllers (N=603)	Prob-value for differences of means=0
Labour productivity						
t = 1	118,668.4	80,765.2	0.10	76,158.8	48,840.7	0.00
t = 2	120,281.6	84,240.1	0.14	82,850.6	48,270.5	0.00
t = 3	128,452.1	87,812.0	0.16	102,815.6	51,608.9	0.00
t = 4	109,520.6	92,715.6	0.37	116,937.8	52,135.5	0.00
t = 5	108,935.6	96,665.7	0.41			
t = 6	102,707.9	102,689.6	0.50			
Wages						
t = 1	16,193.1	12,243.9	0.00	15,912.0	12,101.5	0.00
t = 2	15,821.5	12,309.5	0.00	15,803.8	12,222.1	0.00
t = 3	16,464.8	12,411.8	0.00	17,252.3	12,663.8	0.00
t = 4	16,512.2	12,462.9	0.00	17,813.5	13,309.2	0.00
t = 5	15,615.3	12,495.1	0.00			
t = 6	16,087.3	12,621.3	0.00			

Wages and sales are deflated by the aggregate consumer price index.

Table 9. Firms which start to invest in R&D and advertising and firms which do not. Dependent variables: logarithm of average firm wage and logarithm of firm labour productivity (sales per employee)

	log (wage)		log(productivity)	
	Full sample	Overlap sample	Full sample	Overlap sample
Starter	0.189 (3.35)	0.244 (3.69)	0.319 (1.76)	0.132 (0.69)
(t = 2)*Starter	-0.044 (0.61)	-0.067 (0.69)	0.015 (0.07)	-0.125 (0.48)
(t = 3)*Starter	-0.001 (0.02)	-0.012 (0.13)	0.076 (0.34)	-0.058 (0.22)
(t = 4)*Starter	0.024 (0.32)	-0.133 (1.36)	0.159 (0.70)	-0.199 (0.77)
(t = 5)*Starter	-0.049 (0.69)	-0.122 (1.42)	0.040 (0.19)	-0.324 (1.35)
(t = 6)*Starter	-0.067 (0.98)	-0.080 (0.87)	-0.075 (0.36)	-0.222 (0.89)
Size (employees)				
50-249 employees	0.144 (8.40)	0.139 (2.59)	0.261 (5.58)	0.087 (0.73)
More than 249 employees	0.334 (15.11)	0.570 (6.03)	0.615 (8.99)	0.112 (0.66)
Percentage of college graduates and engineers	0.022 (17.72)	0.009 (2.28)	0.064 (20.03)	0.015 (1.99)
Exporter	0.253 (18.76)	0.193 (5.41)	0.741 (19.54)	-0.060 (0.79)
Age/10	0.042 (11.26)	0.014 (1.21)	-0.039 (3.26)	0.041 (1.54)
R^2	0.561	0.655	0.544	0.651
Observations	3827	486	3827	486
Firms	648	325	648	325

Wages and sales are deflated by the aggregate consumer price index. All estimated equations (OLS) include a constant and dummies for industries, years and periods *t*. $|t|$-statistics are in brackets. Standard errors are corrected for heteroskedascity and for the clustered sampling scheme.

Table 10. Firms which start to control their product quality and firms which do not. Dependent variables: logarithm of average firm wage and logarithm of firm labour productivity (sales per employee)

	log (wage)		log(productivity)	
	Full sample	Overlap sample	Full sample	Overlap sample
Starter	0.119 (2.93)	0.084 (1.58)	0.251 (3.24)	0.151 (1.82)
(t = 2)*Starter	0.003 (0.06)	0.010 (0.15)	0.049 (0.50)	0.086 (0.82)
(t = 3)*Starter	0.027 (0.52)	0.025 (0.39)	0.146 (1.41)	0.120 (1.14)
(t = 4)*Starter	-0.038 (0.69)	-0.066 (0.88)	0.161 (1.57)	0.140 (1.32)
Size (employees)				
50-249 employees	0.157 (7.21)	0.142 (4.68)	0.244 (6.08)	-0.089 (1.94)
More than 249 employees	0.260 (7.51)	0.083 (1.63)	0.223 (2.91)	-0.408 (3.93)
Percentage of college graduates and engineers	0.010 (7.05)	0.009 (4.74)	0.010 (5.42)	0.0002 (0.09)
Exporter	0.082 (6.37)	0.020 (0.81)	0.384 (13.91)	-0.034 (0.86)
Age/10	0.035 (9.65)	0.044 (4.95)	0.015 (2.65)	0.038 (3.04)
R^2	0.403	0.483	0.346	0.553
Observations	2480	599	2481	599
Firms	661	429	661	429

Wages and sales are deflated by the aggregate consumer price index. Only observations of years where information about percentage of college graduates and engineers is updated are included: 1990, 1994, 1998, 2002, 2006 and 2010. All estimated equations (OLS) include a constant and dummies for industries, years and periods *t*. $|t|$-statistics in brackets. Standard errors are corrected for heteroskedascity and for the clustered sampling scheme