Do innovation and human capital explain the productivity gap between small and large firms?

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Abstract:
Empirical evidence is compelling that large firms are more productive than small firms. The hypothesis in this paper is that the productivity differences between small and large firms are associated with two of the main determinants of a firm's performance: the human and technological capital that firms incorporate. We suggest that the contribution of these factors in explaining the productivity-size gap might not only be due to the fact that large firms make a more extensive use of them, but also because large firms obtain higher returns from their investment in human and technological capital. The evidence we obtain for a comprehensive sample of Spanish manufacturing firms (1990-2002) supports this hypothesis, which has important implications for the effectiveness of policies designed to improve productivity in SMEs by stimulating innovation and the use of more skilled workers.

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1. Introduction

Firm size has been considered a major source of heterogeneity, implying that small and medium-sized enterprises (SMEs) and large firms will show a marked disparity in their strategic decisions or in their productivity levels. Indeed, the evidence is compelling that large firms are more productive than SMEs. According to the literature, the main reason for this finding is a scale economies effect. SMEs encounter serious difficulties in achieving economic results that are as good as those recorded by large firms and in accessing the main factors that contribute to a firm's productivity. See for example, Bartelsman and Doms (2000) or Ruano (2002), who conclude that smaller firms tend to be less productive. However, SMEs are seen as new firms starting out on their economic activity, which involves a high degree of risk. Seen in this light, those that perform well survive and grow, while many others tend to disappear. The probability of survival is not high, but those that survive are highly productive and competitive, and represent an important source of economic growth and employment (Audretsch, 2002).

Arguments supporting the positive role played by innovation and human capital in a firm's productivity can be found in, for instance, Griliches (1979), Crépon et al. (1998), Griliches and Regev (1995), Haltiwanger et al. (1999) and Huergo and Jaumandreu (2004a). However, small firms are usually considered to innovate less than large firms and to employ fewer qualified employees (Schumpeter, 1942; Evans and Leighton, 1989; Acs et al., 1994; Zábojník and Bernhardt, 2001; Huergo and Jaumandreu, 2004b). The difficulties small firms face in accessing similar levels of innovation and human capital to those enjoyed by large firms may limit their ability to achieve higher productivity levels. In addition, it can be argued that the level of productivity is not only related to the efforts expended in technological activities and human capital (among other characteristics of the firm), but also to the returns that firms obtain from such efforts, in other words, to the impact of the use of innovation and human capital on a firm's productivity. Geroski (1998) argues that a firm's size may have an indirect effect on its productivity by conditioning the effect of other variables on productivity. That is, SMEs and large firms might present different patterns of behaviour in relation to innovation and human capital, the two variables of interest to us here. This author suggests controlling for this indirect effect by analysing the coefficients of small and large firms separately in the regression. Accordingly, differences in productivity levels between SMEs and large firms would be observed if returns were lower in the former, regardless of the intensity of use.

Building on these arguments, the hypothesis presented in this paper is that the productivity differences between SMEs and large firms are associated with two of the main determinants of a firm's performance: the human and technological capital that firms incorporate. In addition, we suggest that the contribution of these factors in explaining the productivity-size gap might not only be due to the fact that large firms make a more extensive use of them, but also because large firms obtain higher returns from their investment in human and technological capital. In other words, our assumption is that every innovation and every additional skilled worker incorporated in an SME provides returns which are lower than those obtained in a large firm. Thus, the lower return on these factors might also explain why small firms are less productive and why they have less incentive to use them.

The main purpose of this paper is therefore to provide evidence that supports this hypothesis for a representative sample of Spanish manufacturing firms. In this regard, it is worth mentioning that the situation presented by the Spanish economy is of interest when analysing the reasons behind productivity differentials between small and large firms, particularly because the economy is characterized by a smaller average firm size and a lower proportion of large firms than other advanced economies. According to the Observatory of European SMEs,[1] in 2000, only 0.1% of Spanish firms employed more than 250 workers. By contrast, the EU-15 average is 0.2% and some of the most advanced economies in Europe, such as Denmark, Finland, Sweden and the Netherlands, reach values between 0.4% and 0.5%. Although there are few firms with more than 250 employees, they account for 20% of Spanish employment. The EU-15 percentage, however, stands at 34% while, in the aforementioned advanced economies, between 40 and 50% of the workforce are employed in these large firms. These data reflect the importance of SMEs in Spain compared to other advanced economies.

As discussed above, small and large firms seem to obtain different economic results and take different strategic decisions. From this perspective, a large share of small firms in the economy could be associated with lower aggregate productivity, as well as lower innovative effort and investment in skilled workers. In this context, firm size, innovation and human capital may interact in accounting for the weak productivity performance in Spain. In fact, our hypothesis concerning the role of differences in returns implies that firm size conditions the effect of innovations and employees' qualification on productivity, so that size *indirectly* affects productivity. The confirmation of this hypothesis has important implications for the effectiveness of policies designed to improve productivity levels in SMEs through the stimulation of innovation and the use of more skilled workers. In line with our assumption, such policies would be more effective if they could simultaneously increase the returns that SMEs are able to obtain from the use of further quantities of these two factors. A firm in its initial stages, which is usually the case of SMEs, requires considerable levels of investment. This finance is often very difficult to obtain given the high risks associated with a preliminary project. Theoretically, the higher the risk is, the higher the returns from the investment will be. But in practice, this mechanism does not often work and high risk projects generate lower returns.[2] The results for our sample of Spanish firms reveal that many of the differences in productivity across firms of different size originate from differences in returns to innovations and human capital, thus, lending support to our hypothesis.

The rest of this paper is outlined as follows. After this introduction, in which we have presented theoretical reasons to show how small and large firms adopt different patterns of behaviour in relation to productivity, innovation and human capital, we present, in section 2, the total factor productivity (TFP) measure computed in this paper and describe the database. Section 3 offers a descriptive analysis used in checking for differences in the TFP levels between SMEs and large firms conditioned by the use they make of innovation and human capital. In section 4 we further this analysis by estimating the impact of the knowledge variables in order to ascertain whether the returns that the subsamples of small and large firms obtain from innovation and human capital are different. The last section concludes with the paper's main findings and discusses some policy implications.

2. TFP Measure, Dataset and Variables

We use a sample of Spanish manufacturing firms drawn from the survey *Encuesta sobre Estrategias Empresariales* (ESEE). This survey is an unbalanced panel that covers the period 1990-2002 and reports information on strategic decisions and the behaviour of firms. Firms answered a comprehensive questionnaire every four years and a reduced questionnaire in the intervening years (covering those issues that allegedly change annually), so that complete information is available for 1990, 1994, 1998 and 2002. The reference population of the ESEE is a sample of firms with 10 or more employees, whose activity corresponds to divisions 15 to 37 of NACE-93, excluding division 23 (activities related to oil refinement and fuel treatment). During the initial period, all firms with more than 200 employees were required to participate (70% did). Firms with 10 to 200 employees were sampled randomly according to industry and four size strata, retaining about 5%, in order to guarantee representativity for every industry and firm size. The ESEE is designed to change as the composition of the industry evolves. Newly created firms are selected using the original criteria. Due to death and attrition, some firms were replaced by others in their industry and size group so as to maintain representativity.[3]

Between 1990 and 2002, the ESEE has 37,141 observations, for 3,462 different firms. However a number of these observations were lost in our analysis. First, because some firms do not respond to some of the fields in the questionnaire that are necessary for our analysis; and second, because we removed anomalous observations following the same criteria as those adopted in the study by Ornaghi (2006) using the ESEE. Eventually, we obtained a sample of 13,035 observations over 13 years (1990-2002), for 2,104 different firms. Given that we have an unbalanced panel, this means that we have around 800-1000 observations per year.

In our analysis we used TFP measured according to the index developed by Good et al. (1996), which is derived from a translog production function.[4] Its analytical expression for a firm *f* in period *t* is as follows:

$$\ln TFP_{ft} = (\ln Y_{ft} - \overline{\ln Y_t}) - \frac{1}{2}\sum_{i=1}^{n}(S_{ift} + \overline{S_{it}})(\ln X_{ift} - \overline{\ln X_{it}}) + \sum_{s=2}^{t}(\overline{\ln Y_s} - \overline{\ln Y_{s-1}}) - \frac{1}{2}\sum_{s=2}^{t}\sum_{i=1}^{n}(\overline{S_{is}} + \overline{S_{i,s-1}})(\overline{\ln X_{is}} - \overline{\ln X_{i,s-1}}) \quad (1)$$

where Y and X_i are respectively quantities of output and inputs $i=1 \ldots n$, S_i is the cost-based share of input *i* and the bar over the variables refers to their average. The first two terms on the right hand side of the equation are the deviation of the firm's output and inputs from those of a hypothetical firm, which is the reference point in year *t*. The last two terms are the cumulative change in the output and input reference points between year *t* and the initial year. This second part introduces a productivity differential for each year (as output, inputs and shares may change) and, therefore, accounts for possible technological changes. The productivity index for a given firm and year is expressed in relation to the hypothetical firm in the base period. Following Hall's (1990) suggestion, weights are calculated as the share of every input in the total cost of inputs. Appendix 1 provides a description of the measurement of the variables needed to construct this TFP index.

As discussed in the introduction, we seek to investigate the role played by innovative activity and human capital in the productivity levels of small and large firms. Many databases and studies consider SMEs as those firms with fewer than 250 employees. However, our database makes the distinction at 200 employees and uses different sampling schemes for the two groups. Therefore, we will consider SMEs as those with 200 or fewer employees. We consider it more appropriate to use the same criterion so as to guarantee representativity by size strata.[5]

In line with previous studies of Spanish manufacturing firms (Huergo and Jaumandreu 2004a), we use process innovation as the measure of a firm's innovative activity, on the assumption that it is process and not product innovation that improves the mechanisms through which inputs are transformed into output (Ornaghi, 2006).[6] Specifically, a firm's innovative activity is defined as a dichotomous variable (*Innovation*) that takes value 1 if the firm has implemented a process innovation. Process innovations are assumed to take place when the firm gives a positive response to the following request: "Indicate if your firm introduced some significant modification in the production process (process innovation). If the answer is yes, please indicate the means: (a) introduction of new machines; (b) introduction of new methods of organization; (c) both".

Human capital (*Skilled workers*) is measured in terms of the formal education of the labour force. This variable is defined as the ratio of skilled workers according to educational level. Specifically, it includes engineers, graduates, middle level engineers, experts and qualified assistants.

3. Differences in the use of Innovation and Human Capital and their effect on TFP

Using the variables described in the previous section and the index in expression (1), we calculate TFP for a sample of Spanish manufacturing firms over the period 1990-2002. We will first show that there are significant differences in the TFP levels between SMEs and large firms. Then we will seek to verify whether these differences are conditioned by the use firms make of innovation and human capital.

3.1 TFP levels by Firm Size

With regards to average TFP, the figures in Table 1 clearly confirm that productivity in large firms is higher than that in their smaller counterparts, with differences being statistically significant in each year (the t-test of equality of means in the last column of the table rejects the null hypothesis that small and large firms have the same average TFP). However, differences in TFP between small and large firms tend to become less pronounced over time and the gap is narrower at the end of the period under analysis. This reflects the higher pace recorded by the productivity growth of small firms since the mid nineties. The general evolution in TFP for small and large firms shows an increase over time although there is a deceleration during the second half of the nineties. In contrast with the first half of the nineties, in which growth rates in small and large firms were quite similar (yearly average of 2.44% and 2.66% respectively), since the mid nineties small firms became more dynamic (an annual TFP growth rate of 0.9% versus 0.4% in large firms). Thus the deceleration in productivity growth was much more marked in the case of large firms.

[Insert Table 1 about here]

It can also be observed how the dispersion in the distribution of TFP, as measured by the standard deviation, is higher for SMEs than it is for large firms, and that it increases over time, corroborating the belief that SMEs constitute a highly heterogeneous group. Interestingly, the figures reveal that there are SMEs with TFP levels that are even higher than those in the most productive large firms. This can be explained by the existence of high-growth firms or gazelles, which are in the spotlight of industrial policies. And this feature seems to be increasing over time. In sharp contrast, the TFP levels for the less productive SMEs are well below those of the less productive large firms, indicating that SMEs face major difficulties and that some of them might end up exiting the market. And here as well, the gap seems to be widening over time. In conclusion, it seems clear that on average large firms are more productive. However, it should be borne in mind that i) dispersion in the TFP distribution for both firm types increases over time, which can be read as an indication of the boosting of the firms' heterogeneity as regards their level of TFP, and ii) the less productive firms in the Spanish manufacturing industry are SMEs, yet some of these firms in fact perform better than the most productive large firms.

3.2. Innovation, Human Capital and TFP by Firm Size.

The share of firms in the total sample and in the two groups that introduced at least one process innovation in each of the years under analysis is reported in Table 2. It can be observed that around one third of the firms in our sample introduced new processes and that this proportion did not seem to increase over time. Differences in innovative activity by firm size can also be clearly deduced: around half the large firms obtained process innovations, compared to just a quarter of small firms and these differences are statistically significant (as shown by the test of equality of proportions). This result is consistent with the general finding that large firms are more innovative.[7] Table 2 also reports the share of firms that employ a proportion of skilled workers above the median.[8] In this case too, the figures reveal that SMEs make a significantly less intensive use of skilled labour (as confirmed by the significance of the test of equality of means), and that the difference in favour of large firms remains stable in the period under analysis. The average percentage of qualified workers for the total sample is around 8% at the beginning of the period and increased over time reaching 10% by the end. For small firms, the percentage increased from 7 to 9%, and for large firms from 10 to 12%. This result is in line with the general finding that large firms employ more qualified employees.

[Insert Table 2 about here]

The figures in Table 2 thus confirm that small firms made a less intensive use of innovation and human capital. If these two factors affected the level of productivity, we would observe higher TFP in firms that made a more intensive use of the two factors, and smaller differences in TFP between SMEs and large firms for firms using the factors with similar intensity. The first panel in Tables 3 and 4 provides evidence concerning this first issue for innovation and human capital respectively. The other two panels in these tables verify whether there are significant differences between SMEs and large firms when the intensity in the use of factors is controlled for.

In the case of innovation, in accordance with the theoretical arguments and previous empirical evidence, Table 3 shows that firms which obtained process innovations were more productive. In fact, the t-tests of equality of means strongly reject the null that innovating and non-innovating firms had equal TFP levels, indicating that innovative firms were significantly more productive. Thus, the lower innovative propensity in SMEs explains, in part, the lower productivity levels for these firms. However, when comparing innovative SMEs and large firms, some differences in TFP remain after controlling for innovative propensity. But the gap was narrower than that observed for non-innovative SMEs and large firms, and decreased over the period in such a way that in 2002 it was only significant at 10%. The evidence thus suggests that differences in TFP associated with size are more important in the group of non-innovative firms than they are in that of innovative firms. Seen in this light, innovation seems to mitigate the differences in TFP between small and large firms.

[Insert Table 3 about here]

Similarly, it is interesting to investigate the effect of process innovations on TFP when controlling by firm size. In order to do so, we compared the productivity of SMEs that obtained new process innovations and those that did not. The second and third panels in Table

3 show that the average TFP of small innovative firms is much higher than that of small, non-innovative firms, and that the differences are significant throughout the period. Thus, small firms obtaining a process innovation were able to achieve higher TFP levels than those SMEs that did not innovate. In sharp contrast, the TFP gains derived from obtaining a process innovation in the case of large firms was almost negligible. In fact, the TFP gap between large innovative and non-innovative firms is not significant, except in 1998 at 5%. Since the gains in productivity associated with process innovation are more important in small than they are in large firms, these results suggest that obtaining process innovations may be a key element in helping small firms increase productivity and become more competitive.

The results of an analogue analysis for the use of human capital are summarised in Table 4. It can be observed from the first panel in the table that the differences in TFP between firms that have a high proportion of skilled workers (above the median) and those employing a low proportion (below the median) are quite important. As expected, firms that employ more skilled labour are significantly more productive (as confirmed by the t-tests of equality of means). However, the TFP gap between firms of different size does not vanish when considering firms that make an intensive use of skilled workers. The second panel of Table 4 shows that among firms that employ a high proportion of qualified workers, large firms are significantly more productive than their smaller counterparts. However, this statement should be qualified: the differences in TFP seem to decrease over time and they are appreciably smaller than those observed for the group of firms with a low proportion of qualified workers (third panel of Table 4). Finally, a comparison of TFP figures in the second and third panels in Table 4 confirms that the employment of skilled labour plays a role in explaining TFP differentials within SMEs and, in contrast with the case of innovation, also within large firms.

[Insert Table 4 about here]

From the descriptive analysis conducted to this point we can conclude that differences in the use of innovation and human capital between SMEs and large firms alone cannot fully account for the productivity-size gap. The fact that after controlling for the amount of innovation and human capital, SMEs are still significantly less productive than large firms supports our hypothesis that they might be obtaining lower returns from the use of these factors. But this conclusion is not definitive as differences related to size within groups of firms with similar innovative activity and similar levels of employment of skilled labour might well be caused by other well-known determinants of a firm’s productivity.

4. Differences in Returns to Innovation and Human capital

In this section we further the analysis by investigating whether the returns to the use of innovative activity and human capital differ between SMEs and large firms. In so doing we simultaneously account for the effect of these two factors, and for a number of others that have been shown to affect a firm's productivity. Our empirical specification is quite similar to that adopted in Griliches and Regev (1995), where they estimate a production function at the firm level by including measures of human and technological capital. Instead of the production function, we use the TFP index described in (1) as our dependent variable and innovation and skilled labour as the explanatory variables, whose effects on productivity we wish to evaluate. Hence, the empirical model can be expressed as follows:

$$ln\,TFP_{ft} = \beta_0 + \beta_1 INN_{ft-1} + \beta_2 HK_{ft-1} + Z_{ft}\gamma + u_{ft} \qquad (2)$$

where $lnTFP_{ft}$ is the logarithm of the total factor productivity index in firm f in year t, INN_{ft-1} is a dummy variable that takes value one if firm f reports to have obtained a process innovation in year $t-1$, HK_{ft-1} is the proportion of skilled labour for firm f in year $t-1$, and Z_{ft} is a set of standard control variables: firm size[9], age, industry and year effects, and u is an error term. Firm size *(Size)* is defined as the log of the total number of employees. The age (*Age)* is defined as the number of years since the firm was set up, whereas the sectoral heterogeneity is controlled for by a set of 20 dummy variables (*Sector dummies)* according to the NACE-93 classification, where the omitted category is "Other manufacturing industries". Finally, a set of year dummies is included to control for exogenous technical progress and effects of the business cycle that are common to all firms (*Year dummies*).

The possible endogeneity problems in labour, capital and materials that appear in the production function estimations are avoided when calculating a TFP index and using input prices instead of estimating their returns to calculate the participation of each input in the production function. Still, the exogeneity of innovative activity and human capital in a specification such as that in (2) can be questioned. In the absence of appropriate available instruments, we have used the lag of the variables instead of their contemporaneous value to mitigate the effect of endogeneity.[10] Specifically, for innovation and human capital we have considered the values in the previous year.[11]

In addition to the baseline specification described in (2), we have also estimated the returns to our variables of interest from a specification that includes additional control variables. The idea is to capture other sources of observed heterogeneity in a firm's performance. The variables included in *Z* for the robustness analysis are basically controlling for the ownership structure, for the degree of competition faced by the firm and its market orientation, the productive capacity used by the firm, for the region in which it is located and for the economic cycle. As variables related to the ownership structure of the firm, we introduce the proportion of foreign-owned capital of the firm (*Foreign capital*), the proportion of publicly-owned capital of the firm (*Public capital*) and a dummy as to whether the firm belongs to a group of firms (*Group*). To approximate the competition faced by the firm, we include a set of dummy variables on the geographical scope of the firm's main market (*Market dummies*). This considers whether the market is local, provincial, regional, national, international and a category that includes all the previous categories, which is the omitted category. Exports are measured as the log of the value of exports expressed in 1990 constant pesetas (*Exports*). The productive capacity of the firm is a question directly put to firms in the survey (*Productive capacity*). The region of the firm is a set of 17 dummy variables for the NUTS II regions (*Region dummies*). The omitted category is "La Rioja". Finally, it should be mentioned that all the estimates include random effects to account for unobservable heterogeneity among firms.[12]

Table 5 summarises the results of the estimation of the aforementioned specifications for the total sample of firms and for the group of SMEs and large firms separately. In all cases, the Lagrange Multiplier test rejects its null hypothesis of absence of unobservable firm heterogeneity, confirming the appropriateness of the random effects estimation over a specification excluding those effects. Controls for sector, region and year are clearly significant as well. Results obtained by using the total sample of firms —column (i)— confirm that the effect of the two variables of interest, innovative activity and skilled workers is positive and significant. This confirms that in our sample of firms the knowledge capital acquired by a firm improved the mechanism by which inputs are transformed into output. Process innovations reduced the unitary cost of production, and then caused productivity increases. However, the effect seems to be modest: shifting from being a non-innovative to innovative firm increased the TFP by 2%.[13] The positive and significant coefficient for human capital proves that a more intensive use of skilled labour increases productivity because workers can do any task that requires something more than just the simple workforce in a more efficient manner. In fact, a one-point increase in the ratio of skilled workers increases TFP of the average Spanish manufacturing firm by 15%.[14] The estimate of the effect of both variables is quite robust to the inclusion of additional controls for a firm's heterogeneity, as deduced from the results in column (iv). The only change worth mentioning is the decrease in the estimate of the returns to human capital. However, it should be borne in mind that most of the control variables ought to capture the channels by which human capital contributes to increase the productivity, thus causing a reduction in the estimate of its effect.

[Insert Table 5 about here]

As for the difference in the estimated effect of innovation and human capital between SMEs and large firms, results in columns (ii) and (iii) clearly indicate that the strength of their contribution to productivity enhancement varies in each group of firms. Whereas the coefficient of innovation in large firms is much higher than that estimated for the total sample, the effect of this variable for the SMEs seems to be negligible. Large innovative firms have TFP levels that are almost 4% higher than those of the large firms that do not report having adopted any innovations. In sharp contrast, our results reveal that once we control for other variables that affect a firm's productivity, the TFP gap between innovative and non-innovative SMEs is not significantly different from zero.

Differences in the estimated effect of human capital between SMEs and large firms are remarkable as well, although in this case the return to skilled labour remains significant in SMEs. A one-point increase in the ratio of skilled workers in an SME increases its TFP by 12%. But this increase rises to 20% if it is a large firm that increases its ratio of skilled labour.

The results from a formal test (not reported here for reasons of space) confirm these arguments.[15] The test rejects the null hypothesis of homogeneity in the effect of innovation and human capital in the SMEs and in the large firms with a p-value of 9%. Individual tests for the significance of the effects of each of the variables in isolation reveal that the evidence against similar returns in firms of different size is stronger in the case of innovation (significant at 5%) than in that of human capital (significant at 10%).

The inclusion of additional controls in columns (v) and (vi) only modifies the estimated effect of human capital in SMEs and in large firms. In small firms, the estimate of the effect falls dramatically (becoming not significant). A decrease is also recorded for large firms, although of a much lower magnitude. In any case, the difference between the point estimate of the parameter of skilled labour in SMEs and in large firms is even larger than in the baseline specification. Therefore, we can conclude that the difference in the estimated returns to innovation and human capital between firms of different size should not be assigned to the omission of other observable variables affecting a firm's productivity.

As in the baseline specification, a formal test rejects the null hypothesis that returns to innovation and human capital are the same in SMEs and in large firms. And in this case the evidence seems to be stronger as the p-value of the Wald test statistic is now 5%.

To summarize, both innovation and human capital seem to play a role in enhancing a firm's productivity, though the evidence suggests that the magnitude of these effects is very closely related to firm size. In fact, after controlling for a large set of conditioning variables and accounting for firm heterogeneity, the empirical evidence in this section suggests that the effect of innovation and human capital on productivity is only marginal in the case of the SMEs, while it is far from negligible for large firms. Thus, it seems that SMEs do not only make a less intensive use of these knowledge factors, but they also obtain much lower returns from them. As a consequence, it can be concluded that some of the TFP gap between SMEs and large firms might well be caused by the difference in their returns to innovation and human capital.

5. Conclusions

Starting with the generally accepted belief that innovation and human capital play a crucial role in improving a firm's performance, this paper analyses whether the two factors have a different impact on SMEs and large firms, and might therefore be identified as a possible explanation for differences in TFP levels between these two firm types.

The descriptive analysis conducted here supports the hypothesis that the TFP differences between small and large Spanish manufacturing firms are due not only to differences in the level of use of knowledge capital, but also to differences in the effect that this capital has on TFP. The fact that after controlling for innovation and human capital, SMEs are still significantly less productive than large firms seems to suggest that the former might be obtaining lower returns from the use of these factors. But we cannot draw a definite conclusion as differences related to size among groups of firms with similar innovative activities and similar levels of employment of skilled labour might well be caused by other well-known determinants of a firm's productivity, which should be analysed by conducting a regression analysis.

After controlling for a large set of conditioning variables and accounting for firm heterogeneity, both innovation and human capital seem to play a role in enhancing a firm's productivity. However, small and large firms follow different patterns of behaviour in relation to innovation and human capital: large firms obtain positive and significant returns on their investments in relation to these factors, which are significantly higher than they are for small firms. As a consequence, it can be concluded that some of the TFP gap between SMEs and large firms might well be caused by the difference in their returns on innovation and human capital.

The effect of innovations on small firms was found to be only marginal and not statistically significant when including additional control variables. The higher returns on innovation in the case of large firms might be explained by the easier appropriability of returns on innovation in the case of these firms. According to Klepper (1996) and Cohen and Klepper (1996), the larger the firm, the more output over which process R&D fixed costs can be averaged, implying that returns to process innovations are higher, which encourages additional innovative effort. In this view, economic policies focused on increasing the innovative activity for small firms are important, as we have observed how the productivity gap between small and large firms becomes narrower for innovative firms. However, it would only have a relevant impact if SMEs improved their returns on innovation; otherwise an additional innovation in an SME would have a smaller impact on TFP than in a large firm and a certain gap would remain.

On the other hand, the returns derived from employing qualified workers are larger in the case of large than small firms. These higher returns to human capital in large firms can be explained by the fact that the costs of communication related to the absorption of new information can be somehow attenuated by specialization, and large firms are more likely to specialize (Bolton and Dewatripont, 1994). Thus, economic policies focused on stimulating the more intense use of qualified labour force in small firms would only make sense if the returns on human capital in these firms could be improved, that is, if they could take more advantage of their investment in human capital.

Finally, these results can be added to the previous literature that has analysed the role of technological and human capital in improving productivity, with our additional emphasis on the role of returns derived from investments in these two factors. In agreement with the literature reporting on the technological gap between Spain and its European neighbours, we find that innovation may play an important role and increase technological levels, leading to productivity improvements for the industry as a whole. Our results are also in line with the recommendation of the National Reform Program in the Lisbon Agenda that Spain increase its human capital levels. We find that increasing human capital in small firms can improve their productivity, but not to the same degree as in large firms. Thus, obtaining additional innovations and increasing the proportion of qualified workers in small firms would only have a positive impact on productivity if the returns of these firms increased. If this is not the case, this effort would have a limited impact on a small firm's productivity and, thus, on the industry as a whole.

Appendix. Variables Involved in the TFP Index

All the quantities used to compute the TFP index are expressed in thousands of constant pesetas of 1990, except for labour, which is measured as the number of hours worked.

We follow the same criteria as that used by Martín-Marcos and Suárez-Gálvez (1997), Suárez-Gálvez (2001), Martín-Pliego et al. (2001), Delgado et al. (2002), Aw et al. (2003), Huergo and Jaumandreu (2004a) and Huergo and Moreno (2006).

The output is defined as the production of the firm (measured as sales plus the variation of stocks for sale). To deflate the nominal production, we construct a firm-specific price index. The ESEE offers information on the price increases in the five main markets where firms operate. The price index for output is calculated on the basis of the weighted sum of the price increases in the different markets where the firms operate, where weights are the sales in each market.

Labour input. It is calculated as the total effective hours of work, which is obtained by multiplying the total number of employees (full time employees plus part time employees divided by two plus the number of temporary employees) by the effective hours worked during the year (normal hours plus overtime minus hours paid but not worked).

Capital Input. To obtain an estimation of the stock of capital at replacement cost we use the permanent inventory method, which consists of calculating the stock of capital for an initial year and, for the subsequent years, subtracting the depreciation, adjusting the prices to take inflation into account, and finally, adding the flows of gross fixed capital formation that have taken place over the year under consideration. The stock of capital in the initial year is calculated on the basis of the balance sheets. More detail on methodology can be found in Martín-Marcos and Suárez-Gálvez (1997).

Intermediate inputs. The amount of intermediate inputs in nominal terms includes the purchases (acquisition of raw materials purchases, energy, etc.) and external services minus the variation in stocks of purchases. To deflate these nominal quantities, we use a firm-specific price index, which is calculated on the basis of the price increases of these inputs (weighted by the share of their cost on the total cost).

To calculate the shares of inputs we use the percentage of their cost on the total cost of inputs. The *cost of labour input* is calculated as the personnel costs of firms, which is deflated using the consumer price index. *The cost of capital* is measured as the user cost of capital, that is, the price of every unit of capital (interest rate minus the price increase plus the depreciation rate) multiplied by the units of capital, considering both equipment and constructions. The nominal interest rate is the interest rate paid by the firm to banks or other creditors. As usual in the literature, *the cost of intermediate inputs* is the expenditure on intermediate inputs.

Notes

[1] Observatory of European SMEs (http://www.eim.nl/Observatory_7_and_8/en/stats/2001/var2/1cou_size.html, 1st January 2007).

[2] Two possible explanations for the problems associated with this mechanism are the fragmentation of the market and, hence, the lack of sectoral expertise (EC, 2006).

[3] See Fariñas and Jaumandreu (1999) for further details.

[4] Similar indices have been used by Delgado et al. (2002), Aw et al. (2003) and Máñez et al. (2005).

[5] Delgado et al. (2002), Fariñas and Ruano (2004), and Máñez et al. (2004) use the same criterion when using data from the ESEE.

[6] The literature suggests a wide variety of variables for measuring innovative activity at the firm level. On the one hand, R&D expenditure is a measure of innovative inputs or the R&D effort of firms. On the other hand, the innovative capacity can also be measured by process and product innovations, which are a measure of the innovative output or the innovative effort that effectively becomes an innovation. Among these, as process, rather than product, innovations improve the mechanisms through which inputs are transformed into output, we select these as our measure of innovation. In fact, our own results obtained by using product innovations confirm that they do not significantly affect a firm's TFP, be they SMEs or large firms.

[7] Buesa and Molero (2001) find similar results. They comment that the industrial sector is the most innovative and that the probability of innovating is much higher in large firms. Huergo and Jaumandreu (2004b) find that process innovations are strongly associated with firm size.

[8] The median is specific of each period and common for the group of small and large firms.

[9] The variable on firm size controls for the existence of a possible scale economies effect (for which we are not controlling in the TFP index itself) as well as other effects associated with size that are not controlled by the other explanatory variables in equation (2).

[10] Hall and Mairesse (1995) comment on the likely endogeneity of the R&D stocks in the production function and Sianesi and Van Reenen (2003) highlight the endogeneity of human capital accumulation in the economic growth context. They suggest using lags of these variables as instruments given that, as suggested in the literature, there is an absence of appropriate instruments to approximate these variables.

[11] The conclusions from the results in this section are quite robust to the inclusion of alternative lags of these variables.

[12] The random effects model assumes that individual heterogeneity is part of a compound error term. In the case of micro-databases, where firms in the sample are selected randomly from a larger population, it is quite common to estimate a random effects model, rather than a fixed effects model (Barrios et al., 2003; Máñez et al.,

2004; Licandro et al., 2004). In addition, notice that we also control for some specific firm effects including, for instance, region and sector.

[13] Our results are fairly similar to those reported by Huergo and Jaumandreu (2004a), who find an impact of process innovations on productivity growth of around 1.5%.

[14] The average percentage of skilled workers is around 8-10% (Table 2), which means that a one-point increase in skilled labour represents more than a 10% increase in this variable.

[15] This is a standard Wald test of the null hypothesis of similar coefficients for SMEs and large firms for the variables of interest in a Random Effects model.

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Table 1. Evolution of the TFP index (1990-2002).

year	**Subsample of small firms**							**Subsample of large firms**							Test Eq means
	No of obs	Avg size (workers)	Mean	Std dev	Min	Max	Growth rate TFP	No of obs	Avg size (workers)	Mean	Std dev	Min	Max	Growth rate TFP	
1990	507	41.10	-0.0970	0.1884	-0.6900	0.6317		292	545.38	-0.0182	0.1705	-0.5493	0.5552		6.05***
1991	704	37.90	-0.0679	0.2152	-1.2269	0.9201	0.0291	380	522.53	-0.0139	0.1823	-0.6084	0.7276	0.0043	4.36***
1992	812	40.42	-0.0529	0.2260	-1.4085	0.8033	0.0150	357	534.68	0.0095	0.1919	-0.6271	0.6150	0.0234	4.84***
1993	762	41.27	-0.0355	0.2470	-1.1763	1.0418	0.0174	290	499.71	0.0461	0.1919	-0.5829	0.6009	0.0366	5.67***
1994	731	40.08	-0.0095	0.2366	-0.9287	0.8966	0.0260	265	491.53	0.0823	0.1931	-0.6042	0.6966	0.0362	6.23***
1995	699	40.19	0.0193	0.2515	-1.3614	1.3002	0.0288	235	486.22	0.1130	0.2044	-0.3615	0.6891	0.0307	5.71***
1996	694	39.96	0.0496	0.2578	-1.1243	1.2660	0.0303	216	484.22	0.1415	0.2224	-0.5234	1.0710	0.0285	5.10***
1997	833	40.01	0.0401	0.2468	-1.1401	1.2310	-0.0095	227	497.46	0.1322	0.2345	-0.5400	1.1308	-0.0093	5.18***
1998	847	42.78	0.0594	0.2603	-1.1804	1.1318	0.0193	229	561.66	0.1314	0.2309	-0.7116	1.0397	-0.0008	4.07***
1999	831	42.27	0.0684	0.2729	-1.1255	1.4117	0.0090	218	591.74	0.1339	0.2376	-0.6843	1.0414	0.0025	3.51***
2000	822	42.08	0.0739	0.2771	-1.1024	1.4261	0.0055	234	551.81	0.1605	0.2321	-0.4633	1.1680	0.0266	4.81***
2001	769	41.52	0.1099	0.2719	-0.8044	1.4838	0.0360	217	503.10	0.1661	0.2234	-0.4161	0.8096	0.0056	3.11***
2002	678	40.60	0.1054	0.2762	-0.8573	1.4501	-0.0045	186	509.85	0.1657	0.2281	-0.3073	0.8682	-0.0004	3.04***

Note: the test of equality of means compares the values for the subsample of small and large firms; (***) denotes significant at 1%.

Table 2.Percentages of innovative and skilled workers intensive firms by size.

	Innovation				Skilled workers			
Year	Total sample	SMEs	Large Firms	Test eq prop	Total sample	SMEs	Large Firms	Test eq mean
1994	35.45%	28.34%	54.55%	7.108***	7.99%	7.04%	10.53%	4.614***
1998	34.40%	29.92%	50.97%	5.642***	9.08%	8.19%	12.36%	4.529***
2002	30.32%	25.36%	48.39%	6.049***	9.74%	8.96%	12.58%	3.875***

Note: test of equality of proportions and test of equality of means: (***) denotes significant at 1%.

Table 3. TFP by innovation and size

		Innovative		**Non-innovative**				
Year	#Firms	Mean	Std dev	Mean	Std dev	Eq mean Total (a)	Eq mean Small (a)	Eq mean Large (a)
1994	852	0.0624	0.2218	-0.0030	0.2345	4.01***	2.99***	0.86
1998	968	0.1326	0.2369	0.0446	0.2622	5.75***	4.30***	1.82**
2002	864	0.1503	0.2301	0.1045	0.2814	2.74***	1.93**	0.63
		Small innovative		**Large innovative**				
Year	#Firms	Mean	Std dev	Mean	Std dev	Eq mean (b)		
1994	302	0.0438	0.2339	0.0884	0.2018	1.77**		
1998	333	0.1184	0.2443	0.1637	0.2180	1.81**		
2002	262	0.1364	0.2256	0.1768	0.2375	1.45*		
		Small non-innovative		**Large non-innovative**				
Year	#Firms	Mean	Std dev	Mean	Std dev	Eq mean (b)		
1994	550	-0.0189	0.2409	0.0661	0.1917	3.88***		
1998	635	0.0331	0.2649	0.1056	0.2395	2.74***		
2002	602	0.0949	0.2909	0.1553	0.2198	2.33***		

Note: (***), (**) and (*) denotes significant at 1%, 5% and 10%. (a) Test of equality of means that compares TFP in innovative and non-innovative firms within each size group; (b) Test of equality of means that compares TFP in small and large firms.

Table 4. TFP by workers' skills and size

		High % of Skilled		**Low % of Skilled**				
Year	#Firms	Mean	Std dev	Mean	Std dev	Eq mean Total (a)	Eq mean Small (a)	Eq mean Large (a)
1994	852	0.0701	0.2216	-0.0300	0.2318	6.44***	4.74***	3.55***
1998	968	0.1338	0.2346	0.0160	0.2652	7.32***	6.10***	3.03***
2002	864	0.1559	0.2394	0.0807	0.2886	4.17***	3.48***	1.70**
		Small - high % of Skilled		**Large - high % of Skilled**				
Year	#Firms	Mean	Std dev	Mean	Std dev	Eq mean (b)		
1994	429	0.0483	0.2315	0.1111	0.1961	2.96***		
1998	484	0.1194	0.2407	0.1714	0.2139	2.31***		
2002	433	0.1444	0.2408	0.1861	0.2341	1.64**		
		Small - low % of Skilled		**Large - low % of Skilled**				
Year	#Firms	Mean	Std dev	Mean	Std dev	Eq mean (b)		
1994	423	-0.0417	0.2403	0.0186	0.1858	2.48***		
1998	484	0.0069	0.2679	0.0677	0.2449	1.92**		
2002	431	0.0720	0.2996	0.1285	0.2135	1.84**		

Note: (***), (**) and (*) denotes significant at 1%, 5% and 10%. (a) Test of equality of means that compares TFP in firms with a ratio of skilled workers above and below the median. (b) Test of equality of means that compares TFP in SMEs and in large firms.

Table 5. Results for the random effects estimation. Dependent variable: lnTFP

	Baseline Specification			**Robustness Analysis**		
	(i) Total	**(ii) SMEs**	**(iii) Large Firms**	**(iv) Total**	**(v) SMEs**	**(vi) Large Firms**
Innovation	0.0190**	0.0132	0.0379***	0.0162**	0.0102	0.0355***
	(0.0081)	(0.0101)	(0.0134)	(0.0080)	(0.0099)	(0.0129)
Skilled workers	0.1475***	0.1203***	0.2051***	0.0912**	0.0569	0.1626*
	(0.0430)	(0.0489)	(0.0891)	(0.0424)	(0.0494)	(0.0865)
Controls						
Size	0.0090**	0.0063	-0.0032	-0.0050	-0.0102	-0.0065
	(0.0040)	(0.0070)	(0.0155)	(0.0053)	(0.0081)	(0.0156)
Age	0.0009***	0.0009***	0.0009**	0.0006**	0.0005	0.0008**
	(0.0003)	(0.0004)	(0.0004)	(0.0003)	(0.0004)	(0.0004)
Sector dummies	yes	yes	yes	Yes	yes	yes
Year dummies	yes	yes	yes	yes	yes	yes
Additional controls						
Productive capacity				0.1159***	0.1224***	0.1166**
				(0.0312)	(0.0360)	(0.0534)
Foreign capital				0.0506***	0.0391	0.0518***
				(0.0154)	(0.0278)	(0.0190)
Group				-0.0101	0.0137	-0.0373**
				(0.0130)	(0.0192)	(0.0184)
Public capital				-0.0866*	-0.1546	-0.0897
				(0.0486)	(0.0761)	(0.0625)
Exports				0.0014**	0.0016***	0.0010
				(0.0006)	(0.0007)	(0.0013)
Market dummies				Yes	yes	yes
Region dummies				yes	yes	yes
constant	0.0686*	0.0726	0.1572	0.0782	0.0644	0.2412
	(0.0374)	(0.0442)	(0.1156)	(0.0713)	(0.0817)	(0.1518)
No of obs	2684	2061	623	2684	2061	623
No of firms	1585	1211	415	1585	1211	415
H_0: Random effects$_t$=0	616.81***	476.95***	70.85***	571.58***	423.35***	58.99***
H_0: Sector$_t$=0	254.02***	185.27***	984.90***	205.54***	156.51***	145.11***
H_0: Year$_t$=0	134.41***	91.93***	44.05***	115.77***	81.86***	30.59***
H_0: Market$_t$=0				12.05**	10.80**	5.46
H_0: Region$_t$=0				62.54***	50.67***	33.98***

Note: robust standard deviation in parentheses; (***), (**) and (*) denote significant at 1%, 5% and 10%.