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IS HUMAN CAPITAL A SIGNIFICANT DETERMINANT OF PORTUGAL'S FDI ATTRACTIVENESS?*

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ABSTRACT

The paper tests whether human capital is a relevant foreign direct investment (FDI) determinant. Drawing on a large-scale survey of firms located in Portugal, and controlling for firms' structural (i.e. size, age and industry), strategic (R&D and export intensities) and linkages (density of university contacts) variables, our key finding is that, indeed, human capital exerts a positive and significant influence on FDI attraction. Relevant policy implications emerge from the results of this study, at two main levels: (i) policies intended to stimulate human capital formation; and (ii) as regards FDI-focused policies. These policies are discussed in the light of the Portuguese case.

Keywords: Foreign direct investment (FDI), multinational enterprises (MNEs), human capital, education, skills, R&D-performing firms.

JEL Classification: J24; F23.

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Both authors contributed equally to the paper.

1. Introduction

Foreign Direct Investment (FDI) and human capital are, beyond any doubt, two aspects of paramount relevance to the economic growth and prosperity of any developed nation. These topics have been widely studied, and commanded two very rich bodies of literature. The links between these two 'engines of growth' have been less explored, though. It is widely acknowledged that there is a potential two-way causality between FDI and human capital (Blomström and Kokko, 2003) – i.e. FDI may promote human capital formation (Slaughter, 2002), and human capital availability may boost a country's attractiveness as a recipient of FDI projects (Noorbakhsh, Paloni and Youssef, 2001).

In a former paper (Tavares and Teixeira, 2005), using the same sample of firms, we reviewed thoroughly this literature, and studied the impact of foreign ownership on human capital intensity, concluding that foreign ownership impacts on firms' human capital intensity, both in a direct way (general, education-related, and specific, skills-related human capital). In that same piece, we also concluded that R&D has an important mediating role in that positive relationship between FDI and human capital intensity.

In the present study, the focus is on the opposite direction of causality, that is, we aim to unveil whether human capital is a valid determinant of FDI attractiveness. We respond to a relative scarcity of empirical studies specifically delving on the importance of human capital as a FDI determinant.

Moreover, we chose an empirical setting that is under-researched in terms of multinationals' activities, Portugal. For Portugal, to the best of our knowledge, no similar study exists. The themes of FDI and human capital development are particularly relevant to Portugal. The country has been encouraging FDI inflows (lately more proactively, through various and sizeable FDI incentives); at the same time, it is a country with a recognised deficit in qualifications, and with some of the poorest education indicators in Europe and in the developed world. Portugal's sluggish economic growth, prevalence of low value-added activities, its difficulties and challenges as a FDI host economy, and relatively low stock of human capital make this study timely, by tackling these critical issues for the country's development.

The remainder of the paper is structured as follows. The next section will contain a literature review on human capital as a FDI determinant, deriving the main hypothesis tested in the paper. Section 3 will be focused on the methodology, explaining the data, the proxies for the variables used in the econometric models estimated, and providing descriptive statistics. The fourth part will elaborate on the model specification adopted, and the results will be presented in Section 5. Section 6 will synthesise the key findings of the paper, and discuss relevant policy implications.

2. Human Capital as a Relevant FDI Determinant: Literature Review and Hypothesis

Human capital has often been recognised as a relevant location advantage (Dunning, 1977; Michie, 2001). The level of education and skills of the workforce is bound to influence both the magnitude of FDI inflows, and the activities undertaken by MNEs in the host country (Dunning, 1988).

The empirical literature also emphasizes the relevance of human capital as a FDI determinant. Zhang and Markusen (1999) propose a model where the availability of skilled labour in the host economy affects directly the volume of FDI inflows. Hanson (1996) provides further evidence in support of the hypothesis that the level of human capital in host economies may influence the geographical distribution of FDI.

Various studies have focused the case of developing countries. The hypothesis that human capital is a determinant of foreign investment in such type of host country has been put forward in theoretical literature (Noorbakhsh *et al*., 2001). In another study, Lucas (1990) conjectured that lack of human capital discouraged foreign investment in less-developed countries. This latter finding contrasts with a former result, also for a sample of developing countries, obtained by Root and Ahmed (1979), who did not find human capital as an important FDI determinant. However, here the period used as a basis for the empirical analysis may yield the key to understand these conflicting results, as Root and Ahmed's study focused in the period 1966-1970, and it could be fairly hypothesised that in the 1960s human capital did not have the same importance as a location advantage as it has more recently (in an era *par excellence* where created assets matter considerably as sources of competitive advantage).

Noorbakhsh *et al*. (2001) stress that countries (in particular, developing), may enhance their attractiveness as FDI locations by pursuing policies that raise the level of local skills and build up human resource capabilities. Their empirical findings are that a) human capital is a statistically significant determinant of FDI inflows; b) human capital is one of the most important determinants; and c) its importance has become increasingly greater through time. Their sample is composed only of developing countries, nonetheless.

Some other recent studies focused both the cases of developed and developing countries. For instance, Narula (1996) estimated the determinants of the FDI stock, for several economies, with distinct characteristics. He found that human capital is not significant as a FDI determinant for developing countries, even though it came up with a positive sign. The conclusions of tend to be very different in the case of developed countries (where Portugal is included). Narula (1996) states that FDI into developed economies is increasingly aimed at seeking complementary created assets. Therefore, the availability of human capital plays an increasingly relevant role as countries move along the ladder of development. However, this is not to claim that it is the only determinant, or necessarily the most important.

The motivations underlying FDI are dynamic and their relative importance changes over time (Dunning, 1993). For instance, human capital tends to matter considerably when strategic asset-seeking is an important investment motivation, but may not matter much when outright cheap labour-seeking, or efficiency-seeking (emphasising low costs *per se*) are paramount reasons underlying inward investment. Dealing specifically with this issue, Pfeffermann and Madarassy (1992) concluded that, as a result of technological progress and the concomitant shift of FDI toward more capital-, knowledge-, and skill-intensive industries, the presence of a well-educated pool of labour has become increasingly attractive for MNEs relative to low labour costs *per se*. Therefore, the relative importance of the motivations for FDI is changing, but these changes vary according to several factors, including sector-specific patterns.

The empirical application presented and discussed here takes the insights and controversy emanating from this literature, aiming to test and validate to what extent human capital is a relevant factor underlying FDI attraction, in the Portuguese case.

Hence our contribution is to use the current knowledge about the impact of human capital on FDI, and its nuances, and to apply it to an under-researched setting, using also a novel and wide-ranging dataset of companies located in Portugal.

Based on all the literature reviewed, and on our own views on the topic, we put forward the following hypothesis:

Hypothesis: *Human capital is a significant determinant of FDI attraction.*

The firms that engage in FDI are generally large in size, superior in technology, or unique in product lines (Horst, 1972; Caves, 1974; Fukao et al., 1994). Moreover, as Lin and Yeh (2005) recall, R&D has been confirmed to have a positive relationship with FDI and is often viewed as a proxy of many firm-specific advantages.

In addition, recent empirical studies (Laursen and Salter, 2004; Costa and Teixeira, 2005; Teixeira and Costa, 2006) note that relatively high performance firms tend to draw to a larger extent on universities for their innovative activities than their lower-performing counterparts.

For these reasons, it seems relevant to include the frequency of firms contacts and two interaction terms - between human capital and university contacts, and between human capital and R&D intensity - as potential controlling factors of FDI attraction.

3. Methodology

3.1. Data

The analysis is based on primary data gathered through a questionnaire survey. The firms surveyed were drawn from the Markelink 2004 list, which includes firms located in Portugal that declare and publicise R&D activities. This was the best publicly available source, in order to obtain a credible list of what we might call R&D potential performers located in Portugal. Two other reputed and comprehensive alternatives exist, notably the lists used by the Community Innovation Survey (CIS) and *Observatório para a Ciência e Ensino Superior* (OCES) survey. However, these are not publicly disclosed owing to statistical secrecy. The list of companies we use, Markelink, includes 703 companies, representing 85% of CIS III 'innovative' firms and encompassing a much higher number of firms than those considered as 'innovative' by the last OCES

survey. Hence, it is a representative list. Similarly to CIS and OCES, the Markelink list encompasses firms from all industries located within the Portuguese territory (including Azores and Madeira islands), and, differently from CIS, covers all size classes.

The questionnaire was sent in November-December 2004 to all firms listed in the Markelink 2004 list (703) plus 4 firms that we knew (through the available on-line OCES' list of Portuguese firms with the largest R&D expenditures in 2001) that performed R&D activities. By mid-December, 425 complete valid replies were received, representing an effective response rate of almost 61%. This is a surprisingly high response rate for a non-compulsory survey, typically plagued by very low response rates (Harzing, 1997). For instance, for the compulsory CIS III survey, the response rate was 45,8% in the case of Portugal (Bóia, 2003) and 41,7% for the U.K. (Stockdale, 2002). Therefore, the dataset gathered through our original survey is remarkably comprehensive and representative of the relevant population of firms.[1]

Table 1 presents the main characteristics (industry and location distribution) of respondent firms, comparing them to the population.[2]

Compared to the population of firms, the respondent sample seems to be biased towards the 'Textiles', 'Basic metals and fabric metal products' and 'Machinery' industries, and underrepresented for 'Transport and other manufacturing', 'Other services' and 'Agriculture, fishery and extractive industry'. It is interesting, however, to note that in the most knowledge-intensive industries ('Electrical' and 'Computing, R&D and firm services'), the respondent sample is quite representative of the whole population.
Regarding location distribution, Madeira and Azores appear over-represented compared to the whole population, whereas Algarve and Centro are under-represented. In the remaining NUTs, the representativeness is fair.

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[1] Using a formula for computing the size of the sample, in random samples, based on a pessimistic scenario (Vicente *et al*., 1996), a sample size of 425 observations (in a population of 697 firms) would lead, for a confidence level of95%, to a precision of approximately 0.03. Considering, N the population size, n the sample size; p the proportion of elements in the sample that possess a given characteristic; B, the precision level; Z =1,96, coefficient associated to a level of confidence of 95%. In a pessimistic scenario, i.e., in a scenario where the sample variance is maximum, p=0.5. The formula that gives the level of precision is: $n = \frac{N \cdot \hat{p}(1-\hat{p})}{N\frac{B^2}{Z^2} + \hat{p}(1-\hat{p})}$ *In our case* $425 = \frac{697 \cdot 0{,}5 \times 0{,}5}{697\frac{B^2}{1{,}96^2} \cdot 0{,}5 \times 0{,}5} \Rightarrow B \cong 0{,}03$.

[2] As the Markelink list only provides firms' name, the industry and location information was gathered by searching the Internet, Yellow Pages, Telelista and the National Register of Collective Entities.

Table 1: Characteristics of the respondent firms – sector and location distribution (in %) compared to the population, 2001-2003

	Population (n=698)*	Respondent sample (n=425)
Industry		
Agriculture, fishery and extractive industry	5,6	3,8
Food, drink and tobacco	4,9	5,6
Textiles	5,1	8,7
Wood, paper and printing	3,8	3,8
Chemicals and plastics	8,2	11,8
Non-metallic minerals	3,3	4,5
Basic metals and fabric metal products	4,8	7,3
Machinery	5,9	8,7
Electrical	9,3	7,3
Transport and other manufacturing	11,6	5,6
Utilities and construction	2,0	2,8
Retail and Wholesale	8,9	7,8
Computing, R&D and firm services	18,2	16,9
Other services	8,3	5,4
Location (NUT II)		
Norte	35,2	38,4
Centro	17,0	21,9
Lisboa and Vale do Tejo	42,5	35,8
Alentejo	2,7	2,1
Algarve	1,7	0,7
Madeira and Azores	0,9	1,2

Source: Authors' calculations based on direct survey, November-December 2004.
Notes: * Concerning SIC-codes and location for the population of firms, in the Markelink list we were only able to find respectively 610 and 664 firms with valid information (recall that the original list only provides the name of the firms).

3.2. Proxies for the relevant variables

Foreign ownership

Our 'strategic' variable (foreign ownership) is a dummy variable which takes the value 1 if 50% or more of firms' equity is foreign-owned and 0 otherwise. The cut-off point of 50% was chosen owing to two main reasons: first, and without further specific information, it is the least controversial way of considering that a firm is controlled/owned by a certain type of investor, foreign or domestic; as such, it is widely used in the literature (Bellak, 2004; De Backer and Sleuwaegen, 2005), much more often than the minimum threshold of 10% of capital adopted by the more controversial OECD Statistical Benchmark Definition for Foreign Direct Investment (OECD, 1999).[3]

[3] That, actually, is currently being rethought because it is considered exactly too controversial and too low a threshold to guarantee that the foreign owner indeed controls the company.

Secondly, only 3% of the companies in the sample had a minority participation of the foreign investor. Majority ownership was overwhelmingly the main strategy when FDI occurred. Hence, we decided to consider majority ownership as the most accurate evidence of being primarily a national or a foreign-owned company. Around 15% of the sampled firms state that foreign entities owned above 50% of their capital. A substantial percentage of respondent firms are nationally owned - 82% do not present foreign capital in their equity structure.

Human capital intensity

Although skills and education are treated in countless studies as synonymous (e.g. Harris and Helfat, 1997), more accurately they are distinct (yet related) concepts. Skills can be acquired through education and (formal) training but also (and mainly) through the course of people's activities at work (i.e., learning-by-doing). Rosen (1986) points to the fact that most specific job skills are learned from performing the work activities themselves. Formal schooling complements these skills, both by providing a body of general knowledge and principles for students, as well as teaching them how to learn.

In order to capture both components of human capital we test human capital intensity by using these two alternative (though interrelated) ways of measuring it. This is reflected in the alternative model specifications presented later. Firms were asked about the number of total workers and the number of workers with an engineering degree, which tend to represent a more firm-industry *specific* human capital component, and the number of workers with 12 or more years of schooling (post-secondary school), a more *general* component of human capital (Becker, 1962).

Thus we compute two widely used ratios (proxies) for human capital intensity:

(i) the number of 'top skilled' workers over total employment, being top skills measured by the number of engineers (Wood and Ridao-Cano, 1999; Noorbakhsh *et al*., 2001); and

(ii) the number of 'top educated' workers over total employment, with top educated represented as the number of workers with twelve or more years of formal education (Bóia, 2003; Wöβmann, 2003).

The respondent sample presents high skill intensity (14,2% on average, cf. Table 2). In fact, almost half of the firms state that the number of engineers in their total employment surpasses 5% (23% said that engineers represented more than 20% of total employment). By Portuguese standards these are highly human capital-intensive firms.

Similarly to the skill intensity indicator, education intensity, measured by the percentage of employees with 12 years of schooling or more ('top educated'), also reflects the high human capital endowments of the firms covered in this study. Approximately 84% of respondents pointed out that 'top educated' workers represented more than 5% of their total workforce, with almost half of them indicating that this figure exceeded 20%. For the respondent sample the mean of the education intensity indicator is 26,3% (Table 2).

R&D intensity

The measure of R&D intensity is the ratio of firm R&D expenditure divided by firm sales. This variable is similar to that used in well-known studies such as those by Mohnen and Hoareau (2003) and Laursen and Salter (2004). It is rather peculiar that, although being listed as R&D performers, almost 20% of the respondent firms, when asked about the average amount spent in R&D activities in the three-year period 2001-2003, declared having registered in their accounts no value for this item.[4] Some of these firms recognised, however, to have performed R&D activities in the period under analysis but did not consider these expenses in their accounts. Others, being establishments and affiliates of other firms, stated that R&D was registered only in the parent companies' accounts.

In spite of what was said above, overall firms in our sample present a reasonably high intensity in R&D – on average, 5% of their sales are devoted to R&D activities. Recalling that the CIS III survey for Portugal concluded that the total expenditure in R&D activities (both intramural and extramural) by firms amounted to 0,8% of their total turnover (Bóia, 2003), we may claim that indeed our sample includes highly technology and knowledge intensive firms. Around thirty firms (6,8% of the total) present truly remarkable average R&D intensities, above 20%. A few of these are firms whose business is centred on performing R&D activities.

[4] From the 425 respondent firms, 41 did not answer this question. Therefore, 384 valid responses were obtained for this specific item.

Other variables

Size

Size is proxied by the number of workers (in logarithmic form). The majority of firms (68%) employ between 10 and 250 workers. Firms with more than 250 workers represent 21% of the total. Compared to the whole population of firms (potential R&D performers and others) surveyed by 'Quadros de Pessoal' (Portugal, MSST, 2003), the sample of respondent firms is biased towards larger units.[5] In fact, in 'Quadros de Pessoal' the proportion of large firms (those employing more than 500 workers) is quite small (0,1%), whereas that of micro firms is almost 83%, an enormous figure compared to ours (11% for the latter indicator).

Age

Age is measured by the number of years in business. A large percentage of respondents are in business for a reasonable number of years. In fact, 57% of the total claimed to be in business for more than twenty years. Only 13% might be considered as startups (age below 10 years).[6] Once again, firms' age distribution highly contrasts with figures obtained from 'Quadros de Pessoal'. According to this survey, 52,2% of firms located in Portugal are in business for less than 10 years and only 1,8% are more than 50 years old (Portugal, MSST, 2003).

Export intensity

Finally, export intensity is proxied by the ratio of exports to total sales. The bulk of respondent firms are relatively inward oriented. Indeed, within the period in study (2001-2003), almost two-thirds of the sampled firms (63%) export less than 20% of their total sales. For Portugal as a whole, the average proportion of exports in total Gross Domestic Product in the period 2001-2003 amounts to 30,7% (INE, 2003). Given that a large proportion of the respondents belong to the so-called non-tradable sector (see Table 1), the low export propensity of these firms constitutes no surprise.

[5] 'Quadros de Pessoal' is a compulsory survey to all Portuguese firms with at least one employee. Its degree of coverage is thus very high (Portugal, MSST, 2003).

[6] Startup is a rather vague concept, generally meaning a new business venture in its earliest stage of development. Usually its operationalisation is made based on the age in business, ranging from 3-5 years up to 15 years. Given this wide variation, we opted for Almeida et al.'s (2003) definition, which considers startups those firms with 10 or less years in business.

Industry controls

In addition to the variables discussed above, 13 industry controls (Table 1) are included in the models estimated to control for different firms' characteristics across industries.

The next section provides more detailed descriptive statistics regarding our sample.

3.3. Descriptive Statistics and Correlation Matrix

Crossing our strategic variable (foreign ownership) with skill, education and R&D intensity might uncover some interesting patterns at the industry level. Foreign-owned (respondent) firms are relatively more concentrated in Chemicals and Plastics and Retail and Wholesale (Figure 1) where their domestic counterparts prevail in Computing, R&D and Firms' Services and Textiles.

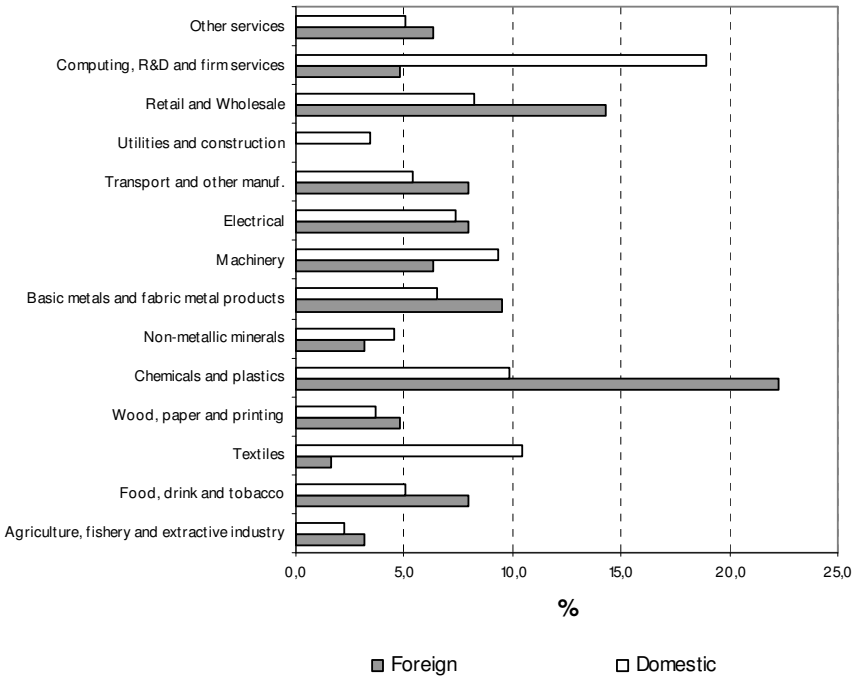

Figure 1. Distribution of firms (%) by foreign ownership and industry
Source: Unpublished data gathered from direct survey, November-December 2004

As the following figures show, skill, education, and R&D intensity's global averages hide considerable diversity at the industry level, which underlines the need to control for industry when we (econometrically) analyse the relationship between human capital related variables and FDI.

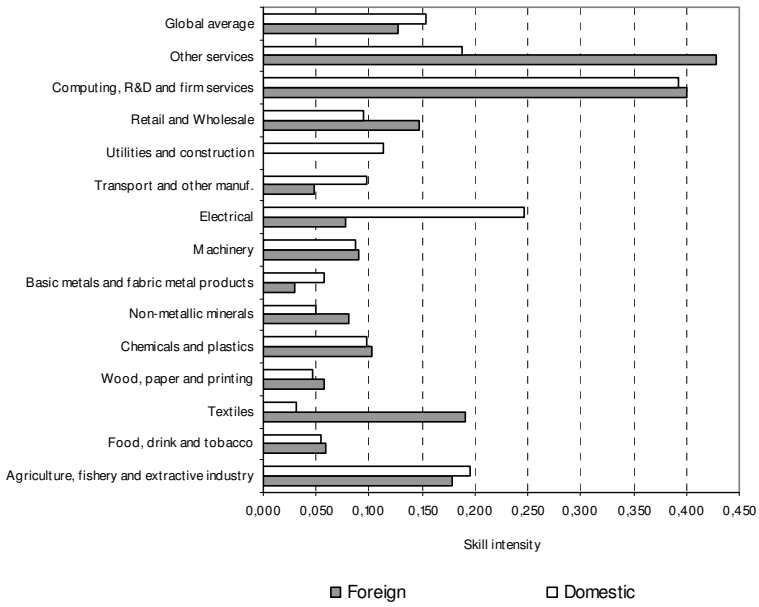

Figure 2. Skill intensity by foreign ownership and industry
Source: Unpublished data gathered from direct survey, November-December 2004

Overall, domestic firms present a slightly higher ratio of engineers in total employment than their foreign owned counterparts (15,4% versus 12,7%). Notwithstanding, in nine out of fourteen industries this ratio is higher in foreign-owned firms. The main discrepancies are founded in Other Services (foreign-owned with 42,8% versus 18,8% for domestic firms) and Textiles (foreign-owned with 19,1% versus 3% for their domestic counterparts).

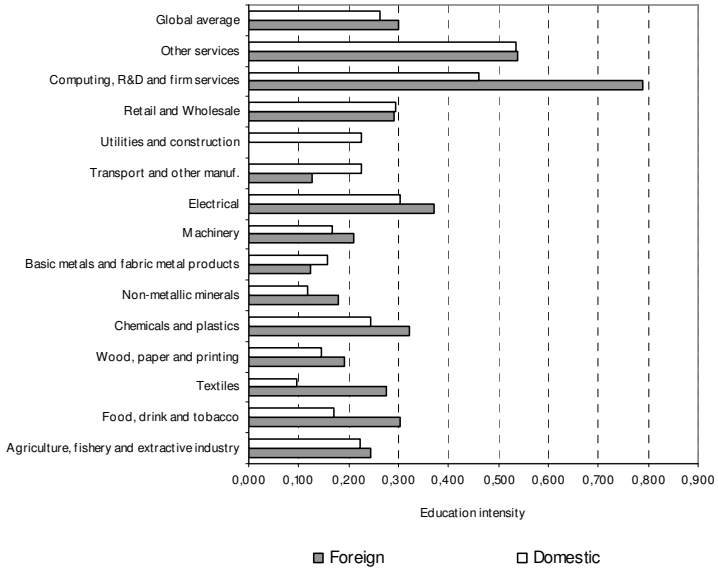

Figure 3. Education intensity by foreign ownership and industry
Source: Unpublished data gathered from direct survey, November-December 2004

Concerning education intensity (percentage of workers with 12 or more years of education in total employment), the data reveal that foreign-owned firms tend to be more endowed than domestic companies (respectively 30,1% and 26,4%). Moreover, 11 out of 10 industries present higher education intensity ratios for foreign-owned firms. The differences are more evident in Computing, R&D and Firms Services, Textiles and Food, Drink and Tobacco.

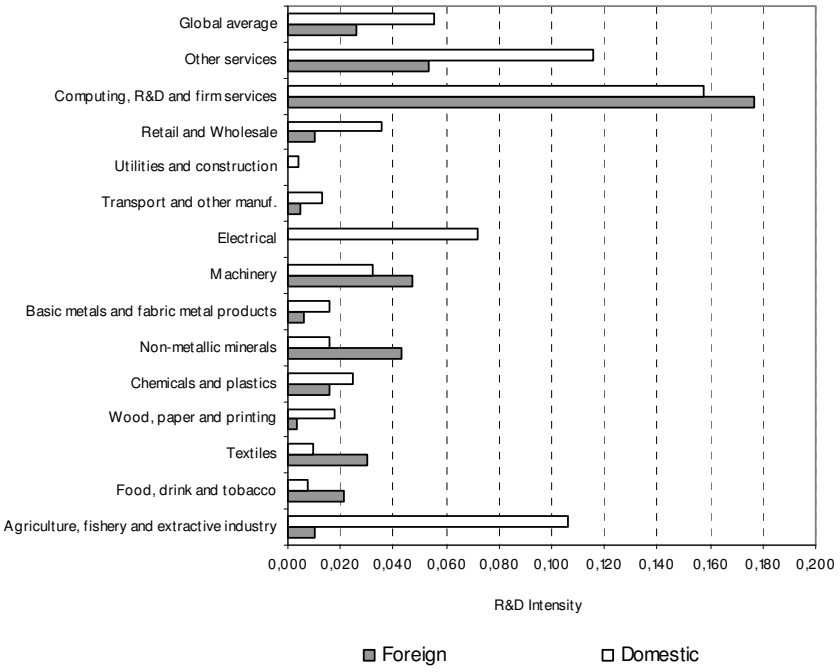

Figure 4. R&D intensity by foreign ownership and industry
Source: Unpublished data gathered from direct survey, November-December 2004

At a first sight surprisingly, R&D efforts are much lower in foreign-owned than in domestic firms. On average, domestic firms spent 5,5% of their turnover in R&D activities, whereas their foreign-owned counterparts spent 2,6%. It is important to recall here that some foreign-owned firms do perform R&D activities however these are not included in their own accounts, being instead centralised at their parent firms' headquarters. Contrary to human capital related ratios, the number of industries where R&D intensity of foreign-owned firms surpasses that of domestic firms is reduced (5), despite that, for the highest R&D-intensive industry (Computing, R&D and Firms Services), the ratio is higher for the first type of companies (17,7% against 15,8%).

The correlation matrix (Table 2) shows that, without controlling for other variables (notably, industry), skill and education intensities are negatively (and significantly)

linearly related to size, age and export intensity, and positively (and significantly) linearly related to R&D intensity. Thus, smaller, younger, export-led and technology-intensive firms tend to be more strongly associated with high levels of human capital intensity. In contrast, ownership structure fails to be linearly and in a *univariate* way statistically related to human capital variables.

4. Model Specification

The aim is to assess whether human capital (proxied by both top skill intensity and education intensity) is a relevant variable to explain the likelihood of a firm being foreign-owned. In other words, the work undertaken is intended to evaluate the empirical relevance of human capital in determining FDI attractiveness.

The nature of data observed relative to the dependent variable [Foreign owned? (1) Yes; (0) No] dictates the choice of the estimation model. Conventional estimation techniques (e.g., multiple regression analysis) in the context of a discrete dependent variable are not a valid option. First, the assumptions needed for hypothesis testing in conventional regression analysis are necessarily violated – it is unreasonable to assume, for instance, that the distribution of errors is normal. Secondly, in multiple regression analysis predicted values cannot be interpreted as probabilities – they are not constrained to fall in the interval between 0 and 1. The approach used, therefore, will be to analyse each situation in the general framework of probabilistic models.

Prob (event j occurs) = Prob (Y=j) = F[relevant effects: parameters].

In the model of foreign likelihood, during a given period, the firm's equity either is (majority) owned by foreign entities (*Y=1*) or not (*Y=0*). Moreover, it is believed (*cf.* Section 3) that a set of factors, such as human capital, R&D efforts, size, and industry, among other variables, gathered in a vector *X*, explain the outcome, so that

$$\Pr ob(Y = 1) = F(X, \beta)$$
$$\Pr ob(Y = 0) = 1 - F(X, \beta)$$

The set of parameters β reflect the impact of changes in *X* on the likelihood of foreign ownership. For instance, among the factors of interest to this study is the marginal effect of human capital intensity (in particular the top skilled or top educated intensity), on the probability of the firm being majority foreign-owned (proxy for FDI attractiveness).

Table 2: Descriptive statistics and correlation matrix

	Mean	SD	Min	Max	1	2	3	4	5	6	7	8	9
(1) Skill intensity	0,142	0,200	0	1,00	1	0,134*	-0,032	-0,399*	-0,310*	0,368*	-0,232*	0,188*	0,005
(2) Education intensity	0,263	0,253	0	1,00		1,000	0,058	-0,371*	-0,238*	0,212*	-0,308*	0,109*	-0,023
(3) Foreign owned	0,153	0,361	0	1,00			1,000	0,194*	0,052	-0,097***	0,095**	0,327*	0,685*
(4) Firm size (log)	4,305	1,479	0	8,79				1,000	0,341*	-0,307*	0,369*	-0,018	0,128**
(5) Firm age (log)	3,125	0,789	0	5,19					1,000	-0,211*	0,065	-0,097***	0,090***
(6) R&D intensity	0,051	0,126	0	1,00						1,000	-0,175*	0,177*	-0,047
(7) Export intensity	0,265	0,341	0	1,00							1,000	-0,017	0,068
(8) Foreign*R&D	0,004	0,029	0	0,50								1,000	0,273*
(9) Foreign*Contacts with Universities	0,090	0,309	0	2,30									1,000

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

The problem at this point is to devise a suitable model for the right-hand side of the equation. The requirement is for a model that will produce predictions consistent with the underlying theory. For a given vector of regressors, one would expect that

$$\lim_{\beta'X \to +\infty} \Pr ob(Y = 1) = 1$$
$$\lim_{\beta'X \to -\infty} \Pr ob(Y = 1) = 0$$

Partly because of its mathematical convenience, the logistic distribution, $\Pr ob(Y = 1) = \frac{1}{1 + e^{-\beta'X}}$, has been used in many applications (Greene, 1993). Rearranged in terms of the log odds,[7] this expression is the so-called *logit* model.[8]

The probability model is a regression of the following kind:

$$E(Y \setminus X) = 0\left[1 - F(\beta'X)\right] + 1\left[F(\beta'X)\right] = F(\beta'X)$$

Whatever distribution is used, it is important to note that parameters of the model, like those of any non-linear regression model, are not necessarily the marginal effects.

In general,

$$\frac{\partial E(Y \setminus X)}{\partial X} = \frac{dF(\beta'X)}{d(\beta'X)}\beta = f(\beta'X)\beta$$

where *f(.)* is the density function that corresponds to the cumulative distribution, *F(.)*.

For the logistic distribution,

$$\frac{d\Lambda(\beta'X)}{d(\beta'X)} = \frac{e^{\beta'X}}{(1 + e^{\beta'X})^2} = \Lambda(\beta'X)\left[1 - \Lambda(\beta'X)\right]$$

Thus, in the *logit* model,

$$\frac{\partial E\left[Y \setminus X\right]}{\partial X} = \Lambda(\beta'X)\left[1 - \Lambda(\beta'X)\right]\beta .$$

[7] The odds of an event occurring are defined as the ratio of the probability that it will occur to the probability that it will not.

[8] If instead a normal distribution function is assumed, one would have the *probit* model. The logistic distribution is similar to the normal except in the tails, which are considerably heavier. There are practical reasons for favoring one or the other in some cases for mathematical convenience, but it is difficult to justify the choice of one distribution over another on theoretical grounds. Notwithstanding, in most applications, this seems not to make much difference (Greene, 1993).

It is obvious that these values will vary with the values of *X*. In interpreting the estimated model, it will be useful to calculate this value at, say, the means of the regressors and, where necessary, other pertinent values.

In the logistic regression, the parameters of the model are estimated using the maximum-likelihood method (ML). That is, the coefficients that make observed results most 'likely', given the assumptions made about the error distribution, are selected.

The empirical assessment of the FDI attractiveness argument is based on the estimation of the following general logistic regression:

$$P(Foreign) = \frac{1}{1+e^{-Z}}$$

$$Z = \beta_0 + \beta_1 HC + \beta_2 RD + \beta_3 Size + \beta_4 Age + \beta_5 Export + \beta_6 University + \\ + \beta_7 (HC * RD) + + \beta_8 (HC * Univ) + \underbrace{\beta_9 SIC1 + ... + \beta_{22} SIC13}_{\text{Industry dummies}} + \varepsilon_i$$

Definitions of the variables' proxies were provided in Section 3.2. In order to have a more straightforward interpretation of the logistic coefficients, it is convenient to consider a rearrangement of the equation for the logistic model, in which the logistic model is rewritten in terms of the odds of an event occurring.

Writing the logistic model in terms of the odds, one obtains the *logit* model

$$\log\left(\frac{\Pr ob(Foreign)}{\Pr ob(Domestic)}\right) = \beta_0 + \beta_1 HC + \beta_2 RD + \beta_3 Size + \beta_4 Age + \beta_5 Export + \beta_6 University + \\ + \beta_7 (HC * RD) + + \beta_8 (HC * Univ) + \underbrace{\beta_9 SIC1 + ... + \beta_{22} SIC13}_{\text{Industry dummies}} + \varepsilon_i$$

The logistic coefficient can be interpreted as the change in the log odds associated with a one-unit change in the independent variable.

$$\left(\frac{\Pr ob(Foreign)}{\Pr ob(Domestic)}\right) = e^{\left[\begin{array}{l}\beta_0+\beta_1 HC+\beta_2 RD+\beta_3 Size+\beta_4 Age+\beta_5 Export+\beta_6 University+ \\ +\beta_7 (HC*RD)++\beta_8 (HC*Univ)+\beta_9 SIC1+...+\beta_{22} SIC13+\varepsilon_i\end{array}\right]}$$

Then *e* raised to the power β_i is the factor by which the odds change when the i^{th} independent variable increases by one unit. If β_i is positive, this factor will be greater than 1, which means that the odds are increased; if β_i is negative, the factor will be less than one, which means that the odds are decreased. When β_i is 0, the factor equals 1, which leaves the odds unchanged.

5. Results

In the case data corroborates our hypothesis, "*Human capital positively influences FDI attraction*", the estimate of β_1 should emerge as positive and significant for the conventional levels of statistical significance (that is, 1%, 5% or 10%). The estimates of the βs are given in Table 3 below.

It is important to stress that goodness-of-fit measures, namely the percentage of correctly predicted cases and the Hosmer and Lemeshow (1988) (H&L) measure,[9] indicate that all the estimated models present a reasonable fit. H&L's goodness-of-fit statistic tests the hypothesis that the observed data are significantly different from the predicted values from the model. So, in effect, one wants a non-significant value for this test as this would indicate that the model does not differ significantly from the observed data. Thus, a non-significant value for the H&L test is indicative of a model that is predicting real world data fairly well.

Controlling for firms' structural (that is size, age and industry), strategic (R&D and export intensities) and linkages (density of university contacts) related variables, human capital emerges here as a (statistically) important determinant of FDI attractiveness in Portugal. Our model's estimates give credit to Zhang and Markusen's (1999) model (mentioned in Section 2), where the availability of skilled labour in the host country is a direct requirement of MNEs and affects the volume of FDI inflows.

The odds of foreign ownership come substantially and significantly higher for larger values of the skills and education ratios – all other factors remaining constant, 1% increase in the top skill [education] ratio increases the odds of foreign ownership by between 10 ($e^{2.365}$) up to 58 ($e^{2.4.068}$) [7 ($e^{1.963}$) up to 15 ($e^{2.746}$)] fold. Such evidence is also in line with Dunning's (1998) contention that the skill and education level of the workforce can influence both the volume and the activities that MNEs undertake in a country. Another pertinent aspect to take into account is that inward investment to industrialised countries is increasingly aimed at seeking complementary created assets (Narula, 1996).

[9] Hosmer and Lemeshow's (1988) (H&L) measure might be considered an analogue to the R^2 value in linear regression; it is the proportional reduction in the absolute value of the log-likelihood measure and as such it is a measure of how much the goodness-of-fit improves as a result of the inclusion of the predictor variables. It can vary between 0 (indicating that the predictors are useless for predicting the outcome variable) and 1 (indicating that the model predicts the outcome variable perfectly).

Table 3: ML estimation for explaining the FDI attractiveness - dependent variable: foreign ownership of R&D performers located in Portugal, 2001–2003

	Human capital proxied by top skill intensity			Human capital proxied by education intensity		
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
HC	2,365**	3,632***	4,068***	1,963*	2,226*	2,746*
Size (log)	0,528*	0,545*	0,550*	0,554*	0,569*	0,567*
Age (log)	-0,119	-0,117	-0,117	-0,142	-0,141	-0,138
R&D intensity	-1,089	-0,557	-0,486	-0,593	-0,186	-0,005
Export intensity	0,693	0,724	0,726	0,815	0,846	0,844
University Contacts	-0,077	-0,079	0,000	0,057	0,059	0,340
HC*R&D		-0,130	-0,138		-0,044	-0,049
HC*University contacts			-0,595			-1,008
Constant	-3,676*	-3,763*	-3,823*	-4,314*	-4,355*	-4,605*
N						
Foreign	58	58	58	58	58	58
Domestic	318	318	318	317	317	317
% correct	85,1	85,4	85,4	86,1	86,1	86,1
Hosmer and Lemeshow Test	12,433 (0,133)	6,374 (0,605)	6,776 (0,561)	12,711 (0,122)	7,728 (0,461)	10,874 (0,209)
Nagelkerke R^2	0,225	0,227	0,228	0,236	0,238	0,241

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

In this vein, the presence of human capital plays an increasingly important role as countries move along their development path. Such argumentation fits well the data and estimates obtained in the present exercise.

Excluding size, all the remaining variables, in particular, R&D intensity, export intensity and university linkages failed to emerge as relevant FDI attractors – in all estimated models, the coefficients are statistically not significant. The non-significance of R&D efforts is in large part explained by the fact that we are investigating (potential) R&D performers. Thus, for this restricted type of firms, it is less surprisingly that small differences exist between domestic and foreign owned firms.

6. Conclusions and Policy Implications

This paper tried to test whether human capital is, for the Portuguese case, an important FDI determinant. The answer is yes. Using brand new evidence gathered through a purposefully-designed and representative large-scale survey of R&D-performing firms located in Portugal (with a usable sample of 475 firms, 61% response rate to the comprehensive survey undertaken), our main result is that human capital is an important (statistically significant) FDI attractor, for the Portuguese case. This is in line with the findings of various studies reviewed above (both in Section 2, and in restated in the discussion of results immediately above). This key finding provides unequivocal support for hypothesis previously formulated. Human capital, therefore, does matter as a pulling factor for the set up of MNC subsidiaries in Portugal.

Our *logit* model clearly indicates, with no margin for doubts, that the odds of foreign ownership are considerably higher for larger values of both the skills and education intensity ratios. It is also shown that all other variables (export intensity, R&D intensity, and university linkages) are not significantly associated to foreign ownership. In turn, size turns out to be significant: larger firms are more likely to be foreign-owned (which tends to be a stylised fact regarding MNEs).

Important policy implications emerge from the results of this study, at two main levels: (i) concerning policies intended to stimulate human capital formation; (ii) as regards FDI-focused policies.

Our key finding highlights the importance of human capital as a FDI determinant. Hence, our main policy conclusion is that human capital formation should be emphasised in Portugal, if FDI attraction is then considered a valid policy objective. Given current Portuguese circumstances (sluggish economic growth, lagging behind in technological development and in terms of entrepreneurial dynamic, needing to increase exports), it seems fair to consider FDI attraction (and maintenance of extant foreign-owned operations) a worthwhile pursuit (if consistent with domestic needs and available resources, and within a systems view encompassing other policy objectives).

Our results lend thus support to initiatives aiming at stimulating human capital formation both through formal education, and through skill upgrading. There are multiple ways of doing so. One area to act upon, given the rather unfavourable indicators of educational attainment in Portugal (OECD, 2005), would be the promotion of education in its general component, i.e. horizontally. This would imply acting on pre-secondary levels of education, as well on secondary and tertiary levels. It would mean generalising access to education to the Portuguese population, counteracting drop-out from secondary school, for instance, as well as adapting courses and channelling them to areas that are specifically needed by (current and prospective) employers. A measure that could be implemented would be to adapt the supply of secondary and tertiary (and also technical) courses to the strategy delineated (e.g. Ireland increased dramatically the number of courses offered to engineers, particularly in electronics, in line with its fine-tuned industrial targeting; Costa Rica attracted Intel, and undertook a commitment to changing secondary education curricula to emphasise electronics and English; and many other examples exist, in countries like Malaysia, Singapore and Thailand). This is not to say, of course, that 'success recipes' should be acritically imported and emulated, but that lessons can be learnt, and the content and focus of courses should evolve to reflect new realities and needs.

In terms of public investment in education and training, it is urgent that a better allocation of resources is achieved, as Portugal per capita spending on education (the 'input' measure) is relatively high, but the output indicators are simply not in tune with the high spending – so, investing better, and not necessarily more, is a priority. This would imply a selection of what should be publicly provided, or more emphasised, and what could be provided (in terms of training, education) by private stakeholders. The

role of the private sector in the process is very important. Private entities can act in various fronts, especially in providing on-the-job and external training to their employees, training new workers to undertake new tasks, providing opportunities for continuing education, and even collaborating with Government's initiatives (there are fruitful examples regarding the set-up of postgraduate courses).

Regarding the role of MNEs in this process, UNCTAD (2000: 17) notes very clearly that these firms "(…) use the technologies that are appropriate to local education levels and train mainly to create efficient operators of such technologies (…) the upgrading of the general skill level and provision of high-level specialised training is something that host countries have to do for themselves. Indeed, such upgrading itself can be used to attract higher-quality inward FDI and to induce existing investors to move into more complex activities." This seems to suggest that the public sector should probably focus on providing general skills and act especially at basic and secondary education levels, targeting better education at the tertiary level as well, as suggested above.

We argue that an interesting development would be to focus more on the training of engineers and on technical courses, which is cheaper and more efficient than trying to provide general university education at all levels, including in those areas for which there is already saturation in the labour market. However, and also as stated above, the Portuguese government should continue promoting the involvement of the most resourceful and technology-based firms, international or domestic, in particular training and educational initiatives. This is not to say that the majority of firms would be prone to embark on projects of this kind, but would be already a major contribution if some industry leaders do, giving their spillover potential, and ability to generate demonstration effects that would trickle down to competitors and other stakeholders.

Other relevant measures would be to promote the establishment and development of specialised research labs and university centres (encouraging also public-private partnerships); building industry clusters (proactive planning of infrastructure and business parks). This would imply the full implementation of a systems view of industrial development, and economic development in a more general way. That systems view, with full implementation associated, for Portugal is still a mirage, or a dream. That ought to be pursued, and as soon as possible.

The policy complementarity between these general policies and FDI-related policies ought to be recognised. In this vein, as Saggi (2000) refers, without adequate human capital, spillovers from FDI may simply be unfeasible. This calls on for human capital formation policies to be complemented by other policy measures, including those aiming to attract high quality and high value-added and knowledge-intensive MNEs.

Nowadays, most countries, developed and developing alike, adopt proactive FDI-related policies (Te Velde, 2001; Young, 2004; Tavares and Young, 2005), including a variety of measures both in terms of FDI attraction, and as regards FDI upgrading. Given this proactivity (that started in the 1980s and intensified in the 1990s, the playing field for FDI changed considerably. The current situation can only be qualified as a tough race for new subsidiaries and projects (Oxelheim and Ghauri (2004), meaning that it is increasingly more difficult to be successful in the midst of this increasing competition, and that the stakes are higher for ever more discerning, and especially better implemented, policy measures.

Our results (and especially those of a former paper companion to this one [Tavares and Teixeira, 2005]) show that majority foreign-owned projects tend to be associated to high human capital intensities. This lends support for proactive FDI-attraction measures, for the Portuguese case. At the same time, this positive association between human capital intensity and FDI bears good perspectives for the sustainability (i.e. survival) of FDI projects (*vis-à-vis* their domestic counterparts).

However, this does not mean an indiscriminate warm welcome to all types of FDI projects. In our view, it should imply a selective and targeted approach, focused on the promotion of high value-added activities – only feasible if appropriate human capital endowments exist, i.e. investments chased need to be compatible with the endogenous resources and capabilities that the country can realistically offer. Fiscal and financial incentives should be 'tied' to the quality of the investment, measured by transparent criteria, as such incentives have important opportunity costs (Tavares, 2001). This would also help to weed out purely opportunistic, rent-seeking and incentive-snatching investors, and would give a more serious sign that the country is really committed to changing its model of development, and its way of acting. Hence, a balanced, and more

systemic approach is needed, encompassing a more coordinated implementation of measures, and, above all, a focus on the quality of operations.

A distinct area in which host country policy should act would be in helping to overcome information asymmetry – e.g. in Portugal there are skills/human capital available and abundant for certain sectors, but if firms (especially MNEs, that are less informed about the country's resources) do not know, opportunities are missed.

Last but by no means the least, all these policies will fall if institutions are not capable of implementing them. Portugal needs badly institutional development, and policy independence and consistency. A paramount hindrance to a credible image of the country *vis-à-vis* foreign investors is the remarkable institutional and policy instability that is obvious to the eye of any investor. FDI-related policies have to be implemented by a stable, independent, uncontroversial, and credible institution, that has the legitimacy and the ability to decide on most of the issues that interest an investor (foreign or national). But it needs much more than that; it needs that other institutions, and government departments are operational, efficient, and de-bureaucratised; it needs proper rule of law and an improved judicial system, and, in short, better institutional quality and stability, especially meaning less volatility according to political swings.

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