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Complementarity in Training Practices

Methodological notes and empirical evidence for a local economic system in Emilia Romagna

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Methodological notes and empirical evidence for a local economic system in Emilia Romagna[•]

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Abstract

The paper develops a conceptual framework aimed at analysing the profitability to finance general training, grounding on the notion of complementarity among productive factors. First, we show that a simple application of theoretical analysis based on the lattice theory and the notion of supermodularity can provide a suitable framework to study complementarity relationships characterizing productive factors. Secondly, we discuss empirical evidence on complementarity between general and specific training with respect to firm productivity, exploiting a detailed and specifically constructed survey based dataset. Complementarity between training forms is thus tested in a discrete framework. We show that complementarity holds for most specifications, though the outcome might be dependant on other firm-related features and strategies. The multi variate analysis also shows, on the same model framework, that R&D and training expenditures are emerging as main explanatory drivers for productivity. Our results on training complementarity and productivity drivers indicates that complementarity related to training forms matters, but also that the mere training adoption is probably not sufficient: the level of training provided is positively correlated with firm productivity.

JEL: D20; C60; J24.

Keywords: General and specific training; Human capital; Super modularity, complementarity, firm productivity.

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0. Introduction

In his seminal contribution, Becker (1964) drew the crucial distinction between specific and general training and analysed its consequences. Assuming perfect competition in both the labour and the product market, perfect information and perfect mobility of productive factors, Becker showed that no employer is available to fund training of employees for the acquisition of skills/ knowledge that affect positively employees' productivity in the firm financing training, as well as in other comparable firms; namely no employer funds general training. On the contrary, employer's financing is available for specific training, namely the acquisition of knowledge/skills that affect positively employees' productivity solely in the firm providing the financial means supporting this training programme. In the case of specific training the burden of financing is sustained not only by the employer, but also by the employees benefiting from training support, who share with the employer direct training expenses and opportunity costs.

Departing from Becker's analysis, recent economic literature has shown that, if one abandons Becker's assumptions concerning perfect competition and information, the rationale for employers' funding of employees' general training can emerge. In their extensive and thorough survey Acemoglu and Pischke (1999) analyse this strategy of research. This paper adopts a marginally different strategy, as it investigates some features of production in firms. The basic idea is that the existence of complementary relationships among productive inputs can justify the employer's financing of general training. Especially, the paper emphasises the complementarity relationship, which can be established between specific and general training.

If the assumption of complementarity among general and specific training is reasonable, we do not need many other technical hypothesis, since from that assumption relevant results directly follow. Quoting Milgrom and Roberts, "Once the reasonableness of the complementarity hypothesis is verified one hardly needs to write down a fully specified mathematical model. […] certain kinds of conclusions follow directly from the complementarity structure , without further technical assumptions" (Milgrom-Roberts, 1995, p. 200). In their model, relying on complementary assumptions, the profit function is supermodular in 12 variables, and by this property they show that whatever change in one of the 12 variables will induce a systematic response in all the other 11 variables. What the theory does is just to establish "the complementarity assumptions that are sufficient to imply the stated conclusions" (Milgrom and Roberts, 1995, p. 199).

Hence, what we still need is to empirically verify how realistic is the assumption of complementarity among general and specific training.

Our aim is twofold. First, we present a methodological framework useful to empirically test complementarity among the two forms of training, keeping in mind that data about firms training practices, whether specific or general, are available and usually are discrete variables. Secondly, we consequently present empirical evidence on training forms complementarity with respect to firm productivity, exploiting detailed and specific survey based data. Complementarity between general and specific training adoption is tested in a discrete framework. As a side outcome, we also investigate what the main drivers of average firm productivity are on the basis of the same empirical model we use for assessing complementarity in training of firms. The value added of the paper relies on the integration of the two level of analysis.

The paper is organized as follows. The first section of the paper introduces the analysis of complementarity among productive factors recently developed, and analyses the consequences of complementarity in the process of skill development in firms. Particularly, this section stresses the relevance of general training in the development of specific assets and provides a preliminary discussion about problems to deal with in empirical analysis when classifying and measuring training practices. In section two, a methodological framework is presented, wherein the complementarity among general and specific training is analysed through the supermodularity of firms productivity function. Section three presents the survey based dataset, the analysis on complementarity between training forms and concludes with an assessment of productivity drivers. The last section concludes the paper by summarising results and offering insights for further research.

1. Complementarities in production

1.1 A definition

Milgrom and Roberts (1990, 1995) have developed a formal model that refines Edgeworth's approach to complementarity among productive factors. In their contributions they never define a specific unit of analysis. They refer to either characteristic features of production (Milgrom and Roberts, 1995) or to "elements of the firm's strategy" (Milgrom and Roberts, 1990, p. 513) or in a broader sense to "groups of activities" (Milgrom and Roberts, 1990, p. 514).

From a labour economics' perspective, complementarities among productive factors can be discussed with reference to four units of analysis: (a) employees' individual skills. In that case complementarity refers to both employees' knowledge and tasks carried out in productive activities; (b) division, shop floor, teams or, generically, autonomous sub-units of the productive unit; (c) organisational practices referring both to organisation of work in a broad sense (i.e.: teamwork, task and job rotation, training practices,…) and to other defining features of production (i.e.: management of inventories, degree of vertical integration, outsourcing,…); (d) capital equipment such as hardware (i.e.: lathe, computers,…), software (i.e.; computer-aided design, word processing program,…).

Complementarity among productive factors (inputs) can be observed when the level of a given productive factor affects positively marginal productivity of other productive factors. In technical terms that means that the second mixed derivative of the production function with respect to two productive inputs is always non negative.

1.2 Complementarity and skills

Complementarity among inputs entails that the return of a single skill does not only depend on the skill itself, but also on other skills and inputs. For this reason it is useful to introduce the distinction between skills acquired and skills used. The former refer to the content of education, training and, in general, to the knowledge content transmitted to the employee. Skills acquired account for the stock of knowledge and previous working experience of an employee, definable regardless of the specific productive context in which she operates. Acquisition of skills occurs through both formal (formal education, training) and informal procedures of transmission. On the other hand, skills used refer to those skills actually used by employees in their working activities and define the set of tasks to perform. Skills used cannot be specified outside a well-defined productive context and their development can occur through some kind of formal and informal training.

Skills acquired and used result from a complex process of learning in which the specification of complementary relationships between both types of skills and the other inputs play a pivotal role. From an endowment of skills acquired, one can develop a set of skills used through the establishment of complementary relationships among this bundle of skills and the other productive inputs. These relationships convert skills acquired into skills used. However, these learning mechanisms also work in the opposite direction. In other words, after a series of skills acquired has developed into skills used, the process of conversion can continue in reverse and proceed towards the acquisition of new skills and the consequent growth and sedimentation of the endowment of skills acquired.

This relationship between skills used and skills acquired implies that the effect on skills of specific and general training is different. As far as general training is concerned, it affects directly the endowment of skills acquired. As to skills used the story is different. As a matter of fact, the effect of general training on skills used depends on the complementary relationship with the other inputs. As mentioned in the previous paragraph, these relationships among inputs set, through the aforementioned process of conversion, the return of skills acquired. If general training favours the setting up of new complementary relationships with other productive inputs or improves the working of these relationships, this implies that the range of skills used has widened, resulting into a higher level of employees' productivity. Accordingly, if general training affects complementary relationships, positive effects can be observed on the productivity of other inputs, as well; i.e.: provision of general training may affect positively not only the productivity of the trained employed, but also the productivity of other employees.

As far as specific training is concerned, it affects the structure of the complementary relationships and, hence, the establishment and the working of links among inputs. For the same reasons as for general training, the observed effects may be positive on diverse inputs, as well as the employee trained.

1.3. Skills and asset specificity

The distinction between general and specific training has to be analysed in comparison with the notion of asset specificity. In Becker's analytical framework general training does not develop any specific asset and therefore the newly developed skills can be used in any workplace. Asset specificity stems from specific training only, giving rise to the opportunity for the employer to exploit an economic rent.

In the framework of analysis developed in this paper, things are different. Indeed, even though general training improves employees' productivity in any firm, training, favouring the establishment of new complementarity relationships, can also widen the range of skills used. The degree of asset specificity of the skills used increases, making the trainees' productivity firm specific. As a matter of fact, even though training can be general, its return, measured by increases in employee's and other factors' productivity, depends on the complementarity relationships developed within the firm and, as such, is always firm specific. As a consequence of that, the development of specific assets through training does not depend on the nature of training, but on the cobweb of complementary relationships among inputs implemented in the organisation of production. Therefore, general training can develop specific assets.

Training is not provided, if it does not promote asset specificity. The key turning-point issue is not the degree of specificity of training, but the framework of the complementarity relationships among productive inputs, stemming from the process of conversion of skills acquired into skills used. In a sense, general training, in the Becker's meaning of promotion of general assets, cannot be easily accommodated in this framework of analysis. It can be conceived as a very special case in which training is irrelevant with respect to production and does not affect productivity of inputs, at all. This can occur either because the content of training has no connections with inputs and production[1], or if, as a consequence of training, the firm does not promote the establishment and the strengthening of complementarity relationships among inputs [2].

This analysis of training, learning and skill development raises two crucial consequences. Firstly, general training affects productivity in the firm where the employee is currently employed (internal productivity) and productivity as perceived by employers in the external labour market (external productivity) in a different way . Divergence between internal and external productivity favours the setting up of internal labour markets, as they insulate the employers financing training from the underbidding of other employers. Secondly, the focus of the analysis shifts from the distinction between general and specific training to the analysis of complementary relationships among inputs. If general training can develop specific assets, this occurs through the interaction of this kind of training with other inputs. General training practices fit with other inputs and their interactions favour the process of skill development described in the previous paragraphs. Especially, as far as training practices are concerned, that means that general training has always to be analysed jointly with other training practices in order to understand its impact on the firm's productivity. It is useful to emphasize that the effect of general training is not limited to individual productivity but spreads, due to the complementarity relationship among productive inputs.

Of course, that does not mean that employers are always available to finance general training. However, the distinction between skills acquired and used provides the rationale to understand the potential arising of a positive level of employer's rent, even when general training is provided and no special assumption about the level of wages is made as in Acemoglu and Pischke's (1999) analysis.

2. Testing complementarity between general ad specific training

In the analysis set out in the previous section, it emerges that doing more of general training can raise the return to doing more of specific training, that is, complementarity among general and specific training inside a firm seems to be a reasonable hypothesis.

Following Samuelson (1974), Topkis (1995, 1998), Milgrom, Shannon (1994), Milgrom, Roberts (1990, 1995), we say that a set of variables $x \in X \subseteq R^n$ is complementary if a real-valued function $F(x)$ on R^n, has increasing differences in X. That is, if the real-valued function is an Utility function (Samuelson, 1974), we say that $F(x)$

[1] A bridge course for an electronic engineer.

[2] A course of word processing in a firm which has no computer.

has increasing differences in the components (x_i, x_j), with $i \neq j$, if the marginal utility of the component *i*, increases if there is an additional amount of component *j*.

If the real-valued function is twice differentiable on R^n, complementarity among the two components i and *j* may be expressed through the non negativity of the mixed partial derivatives, since $F(x)$ has increasing differences in (x_i, x_j) if $\partial^2 F(x)/\partial x_i \partial x_j \geq 0$.

If $F(x)$ is a real-valued function on a *sublattice* $X \subseteq R^n$, it is shown in Topkis[3] (1995), that there is equivalence between increasing differences in each pair of variables and supermodularity.

Going into details, we define a *sublattice* $(X, \geq)$ as a set X, with a partial order $\geq$, such that for any $x', x'' \in X$ the set X also contains a smallest element under the order that is larger than both x' and x'' and a largest element under the order that is smaller than both x' and x''. Let $x' \vee x''$ denote the smallest element that is larger than both x' and x'', and let $x' \wedge x''$ denote the largest element that is smaller than both x' and x''. In the *n*-dimensional Euclidean space, R^n, $x' \vee x''$ and $x' \wedge x''$, are:

$x' \vee x'' = \left(\max\{x_1', x_1''\}, ..., \max\{x_n', x_n''\}\right)$, and $x' \wedge x'' = \left(\min\{x_1', x_1''\}, ..., \min\{x_n', x_n''\}\right)$

When complementarity is expressed through the objective function, we say that a real-valued function F on a *sublattice* X is supermodular in its arguments[4], if and only if:

(1) $$F(x' \vee x'') + F(x' \wedge x'') \geq F(x') + F(x'') \qquad \forall x', x'' \in X.$$

Or, written in a different way:

(2) $$F(x'') - F(x' \wedge x'') \leq F(x' \vee x'') - F(x') \qquad \forall x', x'' \in X,$$

that is, the change in F from the minimum $x' \wedge x''$ to x'' (or x') is smaller than the change in F from x' (or x'') to the maximum $(x' \vee x'')$: having *more* of one variable *increases* the returns to having *more* of the other[5].

In our case, if general and specific training are complementary, firm's objective function must be super modular in these two variables.

In the specific, we consider firm's average productivity function (AP_j) as the objective function, that depends on firm's decisions about general and specific training:

(3) $$AP_j = AP_j(t_g, t_s, \theta_j) \qquad \forall j.$$

The problem of firm *j* is to choose a set of policies for specific and general training, $(t_g, t_s) \in T \subseteq R^2$, which maximizes its average productivity function. θ_j represents firm's exogenous parameters. Actually, a firm operates in an environment which is characterized by exogenous parameters (such as product market) and one can be interested in how different values of the parameter θ may imply different instances of the firm's decision problem, and hence different firm's optimal choices and average productivity.

[3] Theorem 2.1, p. 376.

[4] That is its arguments are complements. Notice that "The implications of supermodularity do not depend on the usual kinds of specialized assumptions […]. For example, we do not need any divisibility or concavity assumptions, so increasing returns are easily encompassed" (Milgrom and Roberts, 1995, p. 184)

[5] From equations (1) and (2) it is evident that complementarity is symmetric: having *more* of x'' *increases* the returns to having *more* of x', as well as having *more* of x' *increases* the returns to having *more* of x''.

Complementarity between general and specific training may be analysed testing whether $AP_j(t_g, t_s, \theta_j)$ is supermodular in t_g and in t_s.

The maximization problem is the same for all the firms, but, since each firm is characterized by specific exogenous parameters (θ_j), the AP function may result supermodular in t_g and t_s for some firms, but not for others.

Our aim is to derive a set of inequalities (as those explicated in equations (1) and (2)), that can be used in empirical tests, to verify whether these inequalities are accepted by the data and, hence, whether complementarities among general and specific training is empirically confirmed, or in which specific circumstances (firm-specific exogenous parameters) complementarity holds.

Since in our case the objective function of each firm is the average productivity function, firm *j*'s AP function on the *sublattice* T is supermodular in t_g and t_s (t_g and t_s are complements) if and only if, for any $t_g, t_s \in T$:

(4) $$AP_j(t_g \vee t_s, \theta_j) + AP_j(t_g \wedge t_s, \theta_j) \geq AP_j(t_g, \theta_j) + AP_j(t_s, \theta_j),$$

or:

(5) $$AP_j(t_g, \theta_j) - AP_j(t_g \wedge t_s, \theta_j) \leq AP_j(t_g \vee t_s, \theta_j) - AP_j(t_s, \theta_j),$$

that is doing more of t_g increases the returns to doing more of t_s.

As an example we can think at two possible firm's decisions concerning general and specific training. We can consider a firm which operates in the pharmacological sector. This firm can choose to organize (or not to organize) a refresher course in general chemistry and can choose to train (or not to train) her employees in the chemical reactions of human body to the adoption of drugs. The first choice concerns general training, and the second choice concerns specific training[6]. It is obvious that in our example doing more of general training increases the returns to doing more of specific training, that is general and specific training are complements. We can consider each of the two choices about general and specific training as binary decision variables. So, if a firm chooses to organize neither the course in general chemistry nor the training in the chemical reactions of human body to the adoption of drugs, we have $t_g = 0, t_s = 0;$ in this case the element of the set T is $t_g \wedge t_s = \{00\}$. If a firm chooses to organize both the course in general chemistry and the training in the chemical reactions of human body, we have $t_g = 1, t_s = 1$, and the element of the set T is $t_g \vee t_s = \{11\}$. Including also the mixed cases, we have four elements in $T = \{\{00\}, \{01\}, \{10\}, \{11\}\}$.

From equations (4) and (5) we can assert that t_g and t_s are complements and hence that the function AP_j is supermodular, if and only if:

(6) $$AP_j(11, \theta_j) + AP_j(00, \theta_j) \geq AP_j(10, \theta_j) + AP_j(01, \theta_j),$$

or:

(7) $$AP_j(10, \theta_j) - AP_j(00, \theta_j) \leq AP_j(11, \theta_j) - AP_j(01, \theta_j),$$

[6] Where specific training may be intended in a widest meaning of sector specific, rather than firm specific. On this subject, see Acemoglu and Pischke (1999).

that is, increasing one of the two forms of training (for instance t_g) increases the average productivity in a wider way if also the other form of training increases. Actually, the increases in AP due to an increase of t_g from $\{00\}$ to $\{10\}$ are less (or at least equal) to the increases in AP due to increases of both t_g and t_s from $\{01\}$ to $\{11\}$. Summing up, complementarity among the two decision variables (t_g and t_s) exists if the AP_j function is shown to be supermodular in these two variables and this happens when either inequality (6) or inequality (7) is satisfied[7].

3. Empirical evidence

3.1 The data

The applied analysis is based on a dataset stemming from a comprehensive study concerning a Province of the Emilia Romagna Region, in Northern Italy[8]. We decided to conduct our analysis at firm level rather than industry level in order to possess detailed micro information on firm strategy and behaviour. We are aware that the choice between firm/industry focus is associated to a trade off: pros and cons are to be carefully valuated case by case.[9] We support the perspective that micro-data at firm level are necessary for the kind of theoretical and applied analyses we deal with. Surveys are therefore the only way to pursue such research direction. We exploit information, deriving from two consequential surveys on the same sample of firms, carried out in 2003 and 2005, with the aim of collecting detailed and extensive data at firm level, usually quite rare, regarding training, innovation and other high performance practices.

Surveys have been conducted on industrial and market-service firms with at least 20 employees and establishments in the Province, thus excluding agriculture and public administration. We initially identified 436 firms, which were disaggregated by sectors (metalwork, market services and other industries: textile-wearing articles, food products, chemical products, engineering and energy) and size (20-49, 50-99 and more than 99 employees, corresponding to small, medium and "large size" firms). Building on those 436 firms (the universe), a random sample of 250 firms was selected (57% of the universe).

A first wave of data was collected during 2003 by direct interviews to managers of human resources at the central offices of the firm[10]. We ended up with 243 filled questionnaires. Data concerning specific and general training activities derive from this survey, which specifically elicited information on issues like training, labour demand, workers skills, over the period 2000-2002. A second consequential survey was carried out in may 2005,

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[7] Since complementarity is symmetric, when the binary decision variables are two, the relevant inequality is one: either (6), or(7), or any other inequality deriving from one of them. For instance, in the empirical analysis below will be tested the inequality $AP_j(11,\theta_j) + AP_j(00,\theta_j) - AP_j(10,\theta_j) - AP_j(01,\theta_j) \geq 0$.

[8] The area was selected as case study given the support provided by the Province of Ferrara, the public institution that manages labour and training policies at local levels. The study is the product of a strong cooperation between the University of Ferrara and the province as public agent.

[9] See Dearden et al. (2005, p.10-11) for an assessment of pros and cons. For example, given spillovers and inter-firms effects, the coefficient on training in an industry level study should exceed that at firm level, then, there may be aggregation biases. Finally, but not least important, industry level data are usually less detailed. Those cons should be weighted to the pros of having longer time series and less difficulty of finding official data sources.

[10] Interviewees were firm managers and human resources managers. Surveys were directly conducted at firm establishments by specialised interviewers, who administered detailed structured questionnaires of around 30 pages. Interviews thus took generally one hour or even more. A follow up of telephone interviews was then carried out in order to check data and fill gaps.

administering by telephone a shorter but focused questionnaire, which elicited information on performance trends (productivity, profit, turnover, employment) over two periods (2000-2002 and 2003-2004), high-performance practices, training efforts (coverage, expenses), R&D and technological innovation, ICT dynamics. Most of those data are elicited over 2000-2004, either as trends (i.e. adoption of some typology of innovations over the period) or as annual mean values (i.e. R&D and training expenses). We addressed the same 243 firms which joined the first survey: after dropping firms which closed down and other which refused to be interview, we ended up with 147 firms. This is the number of firms forming our integrated final dataset. The sample is highly representative of the population.

Merging the two surveys, we may in fact integrate different types of information on training, performances and innovation practices. This was the main reason of the consequential effort. Moreover, from a statistical perspective, we may use lagged information (associated to the 2003 survey) to "explain" performances over the period 2003-2004. Although this does not allow the construction of a proper panel setting[11], we mitigate the usual problem of assessing the causal direction between training and performance in cross section environments (reverse causality[12]).

3.2 General and specific training: data sources and definitions

It is worth specifying few details concerning problems on the definition and the measurement of general and specific training, since it represents a value added of the research. In fact, official sources do not exist and the need to rely on firm surveys is unavoidable. As said, the first survey conducted in 2002 was directly administered to firms and it devoted to investigating workforce features (skills, tenure, competencies), firm training investments and labour demand characteristics. We derive the variables regarding general and specific training from two specific questions devoted to elicit the degree of generality of training provided. The first question concerns the adoption of two informal forms of training, i:e: apprenticeships and task rotation. The second question concerns the nature of formal training provided by the firm. Formal training has been classified into two different categories: specific formal training and general formal training. The degree of specificity depends on trainees; the more training is focused to specific occupational groups, the higher the degree of specificity. Besides, one assumes that specificity/generality is positively/negatively affected by the nature of the training provider; an external provider is presumed to provide more general training than an internal trainer such as a senior employee or personnel in charge of the development of the employees' skills. Accordingly, training activities devoted to specific occupational groups or managed internally by the firm have been classified as specific, whereas training activities devoted to all the employees or managed by an external organization have been classifies as general training.

[11] We note that proper panel settings at firm level which concern dynamics like innovations, training and high performance practices are rare since very difficult to construct even from ad hoc surveys, given the "slow-evolving" and "trend-related" nature of most of those firm-related variables. Even national official surveys tend to have difficulties in eliciting proper panel datasets (see for example Zwick, 2002, for Germany).

[12] "Although a positive correlation is generally found, it is very difficult to interpret because the training measures are only measured at a single point in time and could be picking up many unobservable firm specific factors correlated with both training and productivity" (Dearden et al., 2005).

In the empirical analysis of training in firms problems are twofold. Firstly, the identification of the nature of training can be rather complicated. It seems that the two polar cases, "pure" general and specific training cannot be easily observed and defined. Of course, there are different degrees of generality/specificity, so that one can say that a dominant nature can be pointed out. In informal training practices such as apprenticeship or task rotation, the specific component prevails. On the other hand, in formal practices such as off-the-job training the general component can exceed the specific one. However, the dichotomies formal/informal and on-the-job/off-the-job do not overlap that between general and specific.

Secondly, a reliable and unbiased measurement of training might as well require data on single employees which can be hardly available or, when measured, can contain a high margin of error. In fact, a measurement of training practices should take account of both the percentage of employees involved in training practices and the time devoted to these practices.

The construction of a synthetic indicator of the nature and the amount of training practised in the firm would not be easily to conceive, either because the proper data could not be easily available or because it would require the introduction of arbitrary assumptions for the specification of the nature of training. Hence, it would make sense to consider the provision of training as a dummy variable, without intending to measure its intensity. Even though this procedure can appear rough exceedingly clear-cut, it is one of the first attempts in the economic literature to provide a cardinal measure of the nature of training. Conclusively, training has been classified as specific when it included one or more of the following activities: apprenticeship, job rotation and/or specific off-the-job training. On the other hand, training has been classified as general when general off-the-job training activities, i.e.: training provided by an external institution or to all the employees, were arranged (see 3.3.1 for relative shares of general/specific training adoption following our classification).

3.3. Empirical analysis

The empirical analysis has the primary aim of testing the complementarity nexus between specific and general training forms, in order to assess whether the productivity function is super modular in these two arguments. We exploit information, as said, deriving from two consequential surveys on the same sample of firms. We use original data[13] on specific and general training efforts, re-elaborated as explained above (par. 3.2).

Then, we also want to assess the significance of high performance practices, technological innovations and other drivers of productivity, thus extending the core analysis revolving around complementarity tests[14].

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[13] A trade off usually exists between the collection of specific and original data in case study surveys and the often rough measure of training collected in large longitudinal official surveys. An example is provided by the recent study by Dearden et al (2005), who exploit official survey data on training to measure the impact on productivity levels. Though the analysis is robust and brilliant, we note that (i) their measure of training rely on a question which asked workers whether they had received "any education or training over the past 4 weeks"; this is a quite rough measure. Then, (ii) they set up a dataset based at industry level, in order to use long time series of training and productivity. They observe that the only publicly available firm level panel data in the UK is a sample of 119 firms with basic training information. This confirms the absolute need, if we aim at studying firm behaviour in details, to exploit information deriving from direct survey conducted on the field, where we may set up the questionnaire frame along our research needs.

[14] We note that a simple regression analysis cannot ascertain the complementarity between the dependant variable and the drivers (i.e. Training and Innovation), as presented by some authors (Baldwin and Johnson, 1995). Complementarity is assessed focusing on the nexus characterising various drivers with respect to a defined performance index (innovation, productivity, profit). See Galia and Legros (2004a,b) and Mohnen and Roller (2005) for a detailed presentation of various complementarity tests at empirical level.

The reader may refer to tab.2 for a synthetic description of all variables used in the paper: dependant variable, training states of the world (see also above), controls and independent variables exploited in thee econometric exercise.

We use labour productivity trends for 2003-2004 as dependant variable in all regressions, in order to mitigate typical endogeneity problems encountered in cross section studies. Actually; the two surveys were motivated both by the need to integrate different information regarding the same firms and, not less important, to originate a temporal lag between dependant (productivity) and independent variables (from the two surveys).

3.3.1 Testing complementarity between general and specific training

We specify regressions entering the four dummies associated to the potential states of the world: 00 (no training provided at all), 10 (only general training provided), 01 (only specific training provided), 11 (two forms jointly provided), where *one*, as said, means presence and *zero* the absence of the training productivity input in a specific firm. Descriptively speaking, 29% of firms do not provide any training, 48% only specific forms, as here defined; 3% provide only general training and finally 21% provide both forms. Thus, "complementary" states represent half of firms.

From a statistical perspective, each state of the world, in terms of general/specific training, is included in the productivity regression as a sort of dummy. Such dummies are like constants; the model is thus a "without constant" specification, instrumental to estimate the set of parameters for carrying out the test. We need to include all state dummies in order to recover the full estimates of coefficients and variance / covariances.

Going directly to the definition, we may recall from the theoretical section that complementarity hold if and only if [b1+b2-b3-b4≥0]. Empirically speaking, b1 and b2 are the estimated parameter linked to "complementarities states" (i.e. (00), (11)), while b3 and b4 are associated to other states ((10), (01)). The reasoning revolving around couples of input drivers (bivariate analysis) leads to a statistical framework where the complementarity's hypothesis is the one expressed above. A *one sided t test* is thus applicable and sufficient for the present investigation in order to assess the degree of complementarity[15]. The null hypothesis is the complementarity state under a non strict inequality (≥0)[16]; we thus test complementarity in a non strict framework. Only if a negative value is observed below the defined threshold (e.g. 5%, 1%) we may conclude and reject the null at the specified significance level.

We here sum up main results (see tab.1). First, considering regressions including the four states and control variables only (base specification), we note that complementarity holds across various specifications; the outcome is not sensitive to the number and type of controls introduced (the t ratio of the one sided test range across different specifications with controls only between 0,37 and 0,56).

[15] We note that one-tailed tests make it easier to reject the null hypothesis when the alternative is true. A large sample, two-sided, 0.05 level t test needs a t statistic less than -1.96 to reject the null hypothesis of no difference in means. A one-sided test rejects the hypothesis for values of t less than -1.645. Therefore, a one-sided test is more likely to reject the null hypothesis when the difference is in the expected direction.

[16] More specifically, in this case we have three possible outcomes: if the null is not rejected the hypothesis of complementarity holds in the ≥0 form, which is consistent with the theory. A value higher than 1.645 on the positive sign will lead to a strict complementarity assessment (b1+b2-b3-b4 >0), while a negative value lower than the defined threshold (e.g. 1,645, or a 5% tail, within the one tail framework) will lead to a rejection of the null.

Secondly, adding other covariates to the base regression, this result is robustly confirmed[17]. The inclusion of other explanatory variables (high performance practise, R&D, organisational innovation index, technological innovation actors, ICT factors) does not lead to a rejection of the null in any case. It is worth noting that, when we include the dummy variable "adoption of technological innovation", the t test raises to barely 0,90. Complementarity holds since the null hypothesis [b1+b2-b3-b4≥0] is not rejected by data across specifications[18]. The assessment of the hypothesis for different specifications is aimed at verifying the dependence of the result on relevant potentially omitted factors. In fact, the test statistics varies in association with the inclusion of other covariates, though in our case this variation does not lead to a rejection of the null.

Finally, we attempted to disaggregate the sample of firms by size and other critical variables in order to assess whether sub-sample analyses lead to different results. We find some different results, some counter intuitive.

When splitting the sample by size, we observe that complementarity holds, even in a stricter sense, for smaller firms (t=2,62), while the null is rejected for medium-large firms (t=-1,98).

Splitting by sectors, we find strict complementarity for market services (t=4,01) and a rejection of the complementarity hypothesis for metalwork/manufacturing firms (t=-3.34). Turning attention to innovation dynamics, the analysis by R&D confirms the hypothesis for both samples: but firms with positive R&D would pass a strict complementarity test (t=2,11). As a final attempt, various splitting of the sample by the number of organisational practices show that, for firms adopting more than two high performance practices (just in time, teamworking, TQM, quality circle) the null is rejected (t=-3,79). Using the number of organisational practices linked to human resource management (i.e. job rotation, worker evaluation, etc..), various splits of the dataset tend to confirm the null, though the t ratio of the test is higher for firms associated to fewer practices.

The econometric analysis on sub-sample may be nevertheless less robust, since relies on fewer observations. Differently from the addition of covariates, the sub sample analysis leads to a more significant variation in test statistics for the complementarity hypothesis. Some results might appear as counterintuitive.

Summing up, data shows that complementarity holds, though non strictly, in the overall sample, while strict complementarity but also substitutability cases emerge when the sample of firms is split by primary innovative and fir structural variables. Thus, further research is encouraged along this line.

3.3.2 The drivers of productivity

Extending the reasoning to the analysis of explanatory variables than general and specific training, we analyse the significance of other potential productivity drivers, taken from the realms of techno-organizational practices,

[17] For example, Dearden et al (2005), in their analysis of firm level data, note that the training coefficients may be affected (reduced) by the addition of other variables, even sector dummies. Thus, robustness of results in base specifications must be always validated by the addition of potentially covariates, even in a model which is instrumental to the complementary test.

[18] This paper focuses on a bivariate analysis circumscribed to general and specific training, taking other firm innovative strategies and firm features as given (the θ_j exogenous parameter described in the theoretical section). See Galia and Legris (2004a) for an analysis on complementarity using four organisational drivers, including a (rough) proxy of training. We note that, compared to our analysis, they exploit a pure cross section dataset and include rough measures of training and other firm practices. We focus on training practices only in order to ground empirical evidence on original firm based information associated to training, whose value added is commented in par. 3.2.

other training efforts, firm innovative strategies, etc..[19]. We investigate their effects maintaining a model specification with the four state dummies at the place of a usual constant terms, in order to implement the econometric exercise on the frame used for testing complementarity. Since we have shown that complementarity, in its non strict sense, holds independently of other explanatory variables included, the econometric exercise analyse drivers holding fixed the (latent) outcome regarding complementarity between general and specific training. Results are nevertheless and obviously not affected by this specification choice regarding the constant term.

The picture we observe is the following[20]. As far as structural factors used as main controls are concerned, a clear size effect emerges. Size is a crucial and confirmed explanatory factor. Then, productivity is also correlated to metalwork manufacturing firms, although statistically less significant across specifications, and not to market service firms, also confirming an expected result (though the sign of the correlation is positive).

Focusing on main productivity drivers, expenditures per employee in R&D and in formal training by firms emerge both significant factors, impacting on productivity with the expected positive sign. This is in line with other evidence on Sweden and France: R&D and training exert significant effects on productivity which may be partially country specific; nevertheless, no evidence is found in favour of positive interactions between these two forms of capital (Ballot et al., 2001)[21]. Instead, when using dummies as proxies of the mere *presence* of R&D and formal training, the correlation with productivity is not statistically significant. The interpretation is that, for our firms, the *intensity* of R&D and training expenses matter more than the mere existence of such investments. Further, the training coverage variable, when included separately, is associated to a positive significant coefficient. This shows that intensity, in terms of expenses and coverage efforts by firms, matters more than presence of training, captured by dummy variables. This is true for both dummies capturing *the adoption* of formal and informal training activities (elicited in the 2003 survey) and for the dummy linked to positive *expenses* in formal training (2005 survey).

This result is not extensively comparable to other studies, given the high heterogeneity in the literature concerning the proxies authors use, both for training and other dependant and independent variables, descending from the survey based data of most studies. Nevertheless, our outcomes are very similar to those obtained by Zwick (2002) who analyses a recent dataset (1997-2000), focusing on the effect of various training indexes (in 1997) on productivity levels in 1998 and 1999. He finds that training intensity (training coverage) has a positive and significant effect on productivity. Formal internal and external training exerts also a positive but overall lower in significance effect. Then, training on the job presents a negative effect, and other training-

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[19] Tab. 3 presents the correlation matrix for main relevant independent variables potentially impacting on productivity. It shows that innovative dynamics are generally correlated to each other, and that R&D, networking and technological innovation are particularly correlated, as expected. Explanatory factors which are highly correlated are consequently included separately in regressions.

[20] Since we posses an extended vector of potential drivers, we test their significance incrementally adding set of drivers (realm of technology, realm of ICT, realm of organisational innovation) to the base specification, instead of adopting a "general from particular" selection procedure.

[21] Other correlated evidence is provided by Cassidy et al (2005), who find that the relationship between R&D / training and productivity is significant for national firms but not for multinational (located in Ireland, the case study), which may tend to undertake most investments in home countries.

organisational practices (seminars, talks, quality circles) do not arise as significant direct drivers. The picture is mixed in evidence but points to stronger effects concerning intensity of training.

We are aware that endogeneity may affect data when using R&D and formal training per employee, elicited as annual trend values over 2002-2004, as covariates for explaining productivity. We thus estimate regressions for R&D and training expenses in order to recover predicted values/residuals and consequently carry out regression based tests for endogeneity[22].

We use our index related to organisational innovations, high-performance practices and workforce features (i.e. tenure, stock of short term employees, skill level) as instruments for training, in addition to basic structural controls, while we exploit the networking index, the ICT composite[23] index and the high-performance practice index as instruments for R&D. It is worth noting that the former (first stage) regression, specifying training expenses as dependant variable, shows that size, international market turnover share, workforce skill level and the two indexes of high performance practices and organisational innovations are all firm specific elements which are positively and significantly correlated with training. This is a result not central in our paper but that adds evidence on the drivers of training, in terms of expenditures per employee[24].

The regression for R&D instead shows in addition the potential role of networking as driver of R&D intensity in firms (this is scope for further applied research). On those grounds, endogeneity is tested by a t test on the coefficient of such obtained fitted values in the second stage heteroskedastic robust regression: for training, the t test shows that the null hypothesis of exogeneity is not rejected by data (we observe a very low t ratio for the predicted value coefficient). As far as R&D is concerned, the same outcome emerges[25].

To conclude the analysis on drivers, we add further possible omitted explanatory factors of productivity, following the aforementioned incremental procedure.

We observe that other significant factors impacting on productivity trends are (i) the dummy capturing whether firms have adopted technological innovations over 2000-2005 and (ii) the index of networking activities in the realm of innovation activities[26]. Given the correlation with R&D, in those cases we omit the R&D covariate. Also, and interestingly, (iii) the dummies associated to the outsourcing of accessory and core activities show respectively a positive and a negative, plausible, sign of the coefficients.

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[22] See Wooldridge (2002, pp. 90-92) for a comprehensive discussion on "two-stage least squares" and for a clear presentation of regression based form (omitted variable approaches) of the Hausman endogeneity test (p.118). He notes that the first stage regression producing the fitted values must contain both all instruments for x and *all* exogenous variables then included in the second stage regression, along with x and its predicted values or eventually first stage residuals. Otherwise, inconsistent estimators of relevant coefficients may arise. See also Wooldridge (1999, pp.506-7) and Kennedy (2003, pp.197-8).

[23] The choice over the set of instruments is driven by the low correlation between ICT, organisational innovation, high-performance practices and workforce characteristics with respect to productivity. Most of those elements are instead related to training and R&D. In our case, thus, ICT and organisational innovations seem not to directly affect firm performances, but indirectly, through a correlation with other drivers.

[24] This result is usually confirmed in the empirical literature focusing on training. See the good survey in Zwick (2002) and the results found by Guidetti and Mazzanti (2005, 2006), who study training drivers at firm level in local production systems.

[25] Exogenity is not rejected both using predicted and residuals in the second stage regression. Then, it is confirmed for both productivity and overall performance 2003-2004 levels (including also profitability, turnover, and investments).

[26] Networking is defined with respect to cooperation activities regarding other firms (clients, suppliers, competitors) and institutions (university). The index varies between 0 and 1 and captures the intensity of networking activities by firms.

In a multi-variate setting, instead, ICT dynamics, high performance practices, like TQM, QC, JIT, and organisational innovations do not *directly* exert significant impact on 2003-2004 productivity trend[27]. A similar result, associated to mixed evidence concerning the direct relationship between ICT and productivity, while a strong evidence in support of positive correlation between ICT and training, R&D, organizational innovation and workers involvement practices, is presented by Matteucci et al. (2005) for data on Germany, Italy and UK. We stress that R&D and training expenditures are determinant for providing a good fit to the overall regression, emerging as main explanatory drivers. Those seem to be the most crucial variables, adding robustness to the productivity regression. Their high statistical significance is not undermined by the inclusion of the other relevant drivers, which on the other hand (marginally) increases the explanatory power of regressions (see tab.4 for a summary of main regression outcomes).

4. Concluding remarks

From a methodological perspective this paper has brought attention on two interrelated topics concerning the economics of training in firms. First of all, it introduces the notion of complementarity in the analysis of training practices managed in firms. In this framework of analysis training is not analysed per se, but it is studied as a component of a complex system such as a firm. This paper emphasises complementarity between general and specific training, but these are only two of the many elements interacting and matching in the firm. Training practices do not occur in vacuum but have to fit into a complex nexus of inputs, intended in the broad meaning. The application of the notion of complementarity provides the rationale for employer's funding of general training.

Secondly, this work constitutes one more step towards the analysis of complementarity between general and specific training inside a firm, in the sense of providing a methodological support to the empirical analysis.

Complementarity between the two forms of training has been analysed through the super modularity of the productivity function. Adopting the principles of the *lattice theory*, the relevant inequalities which insure the super modularity of the productivity function and, hence, the complementarity among the variable choices concerning general and specific training, have been derived.

As far as the empirical evidence is concerned, we exploit a specific two-waves survey based dataset providing detailed information on training dynamics, firm performances and other innovative strategies, and find that complementarity holds between general and specific training. We explicitly addressed general and specific training constructing empirical proxies which represent a value added of the paper, given the literature seldom present data availability specifically on the two forms. More specifically, data shows that complementarity holds, though non strictly, in the overall sample, while strict complementarity but also substitutability cases emerge when the sample of firms is split by primary innovative and fir structural variables. Thus, further research is encouraged along this line.

[27] As far as high performance practices are concerned, we could test whether the introduction of TQM, QC, JIT, and team working *before* 2000 had an impact on 2003-2004 productivity, allowing (at least) four years lag causal response between the driver stimulus and the effect on performances. Using dummy variables for adoption before 2000, for each practice, we then do not observe any statistical significance. Firms adopting such practice before 2000 were on average very few, with a 16% maximum for TQM.

Nevertheless, a direct effect of such variables (adoption of general and specific training) on productivity is not clearly emerging from our data. This may be related to the lower, mainly not significant, impact that we observe for training and other drivers, when proxied by dummies (adoption/presence of general/specific training, of formal/informal training). Thus, it seems that it is not the presence/adoption of training practices to have impact on productivity performance, but the intensity of training (and also R&D), both in terms of expenses per employee and coverage.

Our results on training complementarity and training intensity provide and indication for firm strategies and policy action. Complementarity in investments matters, but the mere adoption is probably not sufficient: the level of training provided is positively correlated with firm productivity. As far as complementarity of general and specific training is concerned, further research is needed towards the analysis on the extent to which this complementarity is influenced by firm related features such as size, sector, and other tecno-organisational strategies.

References

Acemoglu D. Pischke J-S. (1999), Beyond Becker: training in imperfect labour markets, *The Economic Journal*, vol. 109, February, pp. 112-142.

Amir R. (2005), Super modularity and complementarity in economics: An elementary survey, *Southern Economic Journal*, vol. 71, n. 3, pp. 636-660

Baldwin J. Johnson J., (1995), Human capital development and innovation: the case of training in small and medium sized firms, *mimeo*.

Ballot G. Fakhfakh F. Taymaz E. (2001), Firm's Human capital, R&D and Performance: a study on French and Swedish Firms, *Labour Economics*, vol.8, pp.443-62.

Becker G. (1964), *Human Capital: A Theoretical Analysis with Special Reference to Education*, New York, Columbia University Press.

Becker B. Huselid M. (1998), High performance work systems and firm performance: a synthesis of research and managerial implications, Research in Personnel and Human Resource management, vol.16, pp.53-101.

Cassidy M. Gorg H. Strobl E. (2005), Knowledge, accumulation, and productivity: evidence from plant level data for Ireland, *Scottish Journal of Political Economy*, vol.52, n.3, pp.344-358.

Dearden L. Reed H. Van Reenen J. (2005), The impact of training on productivity and wages: evidence from British panel data, WP n.16, IFS, London.

Galia F. Legros D., (2004a), Testing for complementarities between team, incentives, training and knowledge management: evidence from France, ERMES, Paris, mimeo.

- (2004b), Complementarities between obstacles to innovation: evidence from France, *Research Policy*, vol.33, pp.1185-99.

Guidetti G. Mazzanti M. (2006), Firm training activities and complementarities in production: conceptual insights and empirical evidence, *Journal of Socio-Economics,* forthcoming.

- (2005), The driving Forces of Firm training activities, *Reflets et perspectives de la vie economique,* De Boeck University Press, n.2, pp.47-62.

Kennedy P. (2003), *A Guide to econometrics*, Routledge, Fifth edition.

Kessler A. Lulfesmann C., (2002), The theory of human capital revisited: on the interaction of general and specific investments, CESifo working paper n.776, CESifo, Munich.

Matteucci N. O'Mahony M. Robinson C. Zwick T. (2005), Productivity, workplace performance and ICT: industry and firm level evidence for Europe and the US, *Scottish Journal of Political Economy*, vol.52, n.3, pp.359-385.

Milgrom P. Roberts J. (1995), Complementarities and fit Strategy, structure, and organizational change in manufacturing, *Journal of Accounting and Economics*, n. 19, pp. 179-208.

- (1990), The economics of modern manufacturing: technology, strategy and organization, *The American Economic Review*, vol. 80, n. 3 (June), pp. 511-528

Milgrom P. Shannon C. (1994), Monotone comparative statics, *Econometrica*, vol. 62, n. 1, pp. 157-180

Mohnen P. Roller P.M. (2005), Complementarities in innovation policy, *European Economic Review*, n. 49, pp. 1431-1450

Samuelson P. (1974), Complementarity, *Journal of Economic Literature*, n.12, pp. 1255-1289.

Topkis D. M. (1998), *Super modularity and Complementarity*, Princeton University Press, Princeton, NJ

Wooldridge J. (2002), *Econometrics Analysis of Cross Section and Panel Data*, Cambridge, Massachusetts, The MIT press.

- (1999), *Introductory econometrics: a modern approach*, Thomson learning.

Zwick T. (2002), Continuous training and firm productivity in Germany, Discussion paper n. 50, ZEW, Mannheim.

Tab. 1- Complementarity tests on general and specific training

Controls	*Other variables included*	*One sided T test* *(t ratio for the test* b1+b2-b3-b4≥0 regarding training state dummies)
Size dummies, sector dummies	/	0,37601 (non strict complementarity holds)
Size dummies, sector dummies, firm market shares (international market and subcontracting)	/	0,5693 (non strict complementarity holds)
Size dummies, sector dummies, firm market shares (international market and subcontracting)	R&D expenditure per employee	-0.03 (non strict complementarity holds)
Size dummies, sector dummies, firm market shares (international market and subcontracting)	Innotech	0,8988 (non strict complementarity holds)
Size dummies, sector dummies, firm market shares (international market and subcontracting)	Training coverage	1,004 (non strict complementarity holds)
Size dummies, sector dummies, firm market shares (international market and subcontracting)	Training expenditure per employee	0,5354 (non strict complementarity holds)
Size dummies, sector dummies, firm market shares (international market and subcontracting)	R&D expenditure per employee, Training expenditure per employee,	0,4573 (non strict complementarity holds)
Size dummies, sector dummies, firm market shares (international market and subcontracting)	R&D expenditure per employee, Training expenditure per employee, ICT index variables, organizational innovation index (including TQM, JIT, QC, Teamworking)	0,4229 (non strict complementarity holds)
	Sub-sample analyses (only controls used)	
Variable investigated	Sub-samples	*One sided T test*
sectors	Market services	*4,01* (strict complementarity holds)
	Manufacturing	*-3,34* (null rejected)
Size	(small firms, less than 50 employees)	2,62 (strict complementarity)
	(medium-large firms, more than 50 employees)	-1,98 (null rejected)
R&D	R&D >0	2,11 (strict complementarity holds)
	R&D =0	0,3641 (non strict complementarity holds)
Indexes of labour related ten innovation practices	Lower than median (0,3)	2,98 (strict complementarity)
	Higher than median	0,41 (non strict complementarity holds)
Organizational practices adopted (TQM, JIT, QC, TW)	0 practices	2,58 (strict complementarity holds)
	One practices	0,04 (non strict complementarity holds)
	two practices	-3,79 (null rejected)

Tests are carried out on coefficients deriving from regressions using as dependant variable the firm productivity trend in 2003-2004; N=147, OLS corrected for heteroskedasticity is used as estimation tool.

Table 2- Descriptive statistics of variables: dependent and independent variables, training states "of the world", instruments

Variable	Typology and value range	Acronym	Mean value	Minimum and maximum values	Period of observation
Dependent variable					
Averagelabour productivity 2003-2004	Continuous index (0-1)	PROD	0,58	0,1	2003-2004
Independent variables					
Controls					
Sectors: Services, manufacturing/metalwork, benchmark base: other industry	2 dummies	SERV, MANUF	0,42; 0,30		Elicited in 2005 survey
Share of revenue on international markets	Continuous index (0-1)	NAT-REV	0,14	0,1	Elicited in 2005 survey
Share of revenue from acting as subcontractor	Continuous index (0-1)	SUBCONTR	0,67	0,1	Elicited in 2005 survey
Firm size	2 dummies (50-99 employees, >100 employees) or alternatively number of employees	Size1, Size2, Size	110 employees	20; 2207 employees	2004 employment level
State dummies					
Adoption of general training practices Adoption of specific training practices	Four dummies are generated (states of the world: (11, 00, 01, 10) from which coefficients complementarity tests are implemented (01 only specific, 10 only formal)		Shares: (00): 29% (01): 47% (10): 3% (11): 21%	0,1	2000-2002
Innovation and training variables					
R&D expenditures per employee	Continuous	R&D-EXP	479€	0, 10000€	2000-2004
R&D positive expenditures	Dummy	R&D	0,41	0,1	2000-2004
Networking index (summarising cooperative behaviour with private and public agents within and outside the local area)	Continuous index (0-1)	NETW	0,18	0; 0,66	2000-2004
Index of technological output innovations (radical and incremental, process and product)	Continuous index (0-1)	INNOTECH	0,55	0,1	2000-2004
Formal training coverage (share of employees involved)	Continuous index (0-1)	COVER	0,39	0,1	2002-2004
Formal training expenditures per employee	Continuous	TRAIN-EXP	160€	0, 1458€	2002-2004
Presence of any formal training expenditures using internal firm sources (excluding public funding)	Dummy	TRAIN	0,63	0,1	2002-2004
Formal and informal training adoption	Dummies	FORM, INFORM	0,55 (informal); 0,53 (formal)	0.1	2000-2002
Techno-organizational (instrumental) variables					
High performance practices (TQM, Just in time, Quality circle, Team working) index	Continuous index (0-1)	HPP	0,38	0,1	2000-2004
Labour related innovation index (on ten HRM practices; i.e. task rotation, formal evaluation)	Continuous index (0-1)	LAB-INNO	0,32	0,1	2000-2004
ICT index of adopted ICT-related innovations	Continuous index (0-1)	ICT	0,28	0; 0,76	2000-2004
Outsourcing indexes: core activities, ancillary activities	Dummies	OUT-CORE, OUTANC	0,18; 0,34	0,1	2000-2004
Consultation with trade unions regarding innovation adoptions	Dummy	INDREL	0,26	0,1	2000-2004

Table shows the all set of variables used in econometric exercises. Acronyms are shown for all variables entering final specifications in tab.4 and for instruments used for endogeneity- related tests (see also par. 3.3.2).

Tab. 3 correlation matrix for main independent variables

		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*
1	Index of Organizational practices adopted	1.00										
2	OUTACC	0.15	1.00									
3	OUTCORE	0.20	-0.04	1.00								
4	Index-labour-practices	0.46	0.17	0.05	1.00							
5	coverage	0.34	0.20	-0.05	0.37	1.00						
6	Training expenditures >0 (binary index)	0.45	0.30	0.09	0.43	0.42	1.00					
7	Training expenditure per employee	0.27	0.01	0.07	0.34	0.28	0.50	1.00				
8	networking-index	0.40	0.23	0.01	0.42	0.30	0.34	0.18	1.00			
9	R&D>0 (binary index)	0.20	0.20	0.17	0.22	0.12	0.36	0.13	0.42	1.00		
10	R&D expenditure per employee	0.01	-0.10	0.11	0.18	-0.07	0.12	0.09	0.27	0.43	1.00	
11	INNOTECH	0.30	0.14	0.10	0.33	0.18	0.31	0.15	0.40	0.48	0.23	1.00

Tab. 4- Productivity Regressions

SIZE1	2,669***	1,960*	2,076**	2,546**
SIZE2	2,330**	2,970***	2,799***	2,515**
SERV	0,783	0,679	0,708	0,909
MANUF	1,483	1,626	1,847*	1,708*
R&D-EXP	2,416**	…	…	2,508**
TRAIN-EXP	3,261***	3,255***	3,247***	…
INNOTECH	…	2,081**	…	…
NETW	…	…	2,031**	…
COVER	…	…	…	3,539***
F test (prob)	3,34 (0,0006)	3,28 (0,0008)	3,23 (0,0009)	4,04 (0,0001)
Adj-R^2	0,138	0,135	0,132	0,172
N	147	147	147	147

Notes: Dependant variable is productivity trend 2003-2004; (PROD); OLS corrected for heteroskedasticity is used as estimation tool; the four states of the world regarding general and specific training adoption are use in place of the constant term (not shown)).We recall coefficients should not to be interpreted as elasticities; the table shows t ratios and emphasises statistical significance of coefficients at 10%, 5% and 1% (*, **, ***) levels. Besides size and sector dummies, only significant controls are presented in this table. The variable SIZE when included in place of size dummies is significant at ***: overall fit is unaffected.