A novel factor decomposition of productivity differentials: evidence from foreign owned and domestic firms in Italy

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Abstract: Using the idea of the multidimensional generalization of the Duncans' index, the productivity per worker differentials across groups of firms can be decomposed into different components attributed to differences in: sectoral productivity, investment in human and physical capital, size and other determinants. More specifically, for decomposing group productivity differentials we propose an Oaxaca's decomposition – based approach which assumes a Reimer's weighting scheme. An application of the decomposing method aimed at evaluating productivity differences across foreign owned and domestic firms in the Italian manufacturing sector is also provided.

Keywords: Productivity, Foreign acquisitions, Oaxaca decomposition

1 Introduction

The increase of labor productivity is the driving force of improving living standards. In order to identify the sources of productivity growth, various kinds of decomposition methods are used to study the role of input reallocation induced by inter-industry and intra-industry restructuring (Bernard and Jones, 1996; Baily *et al*., 2001; Foster *et al*., 2001). Decomposition methods are also used to identify sources of productivity growth even at a deeper level, examining the role of intra-firm/intra-establishment restructuring as source of heterogeneity for productivity levels and growth rates between firms/establishments: changes in the employment structures affect the skill composition, which in turn, according to the human capital literature, should be reflected in productivity and wage growth at different levels of aggregation (Maliranta and Ilmakunnas, 2005).

The recent empirical literature on productivity measurement and economic growth shown evidence of the influence of firms heterogeneity on productivity differentials at both macro and micro economic level (Van Ark, 2004). Sources of productivity differentials are, even within the same industry, size, wage and skill gaps also connected to the differences in physical and human capital intensity, and differences related to competition and international trade.

In order to study the sources of labour productivity differentials between groups of firms we propose a decomposition approach for the productivity per worker differential into three components: one linked to differences across groups in the industrial composition, one related to differences across groups in firms' characteristics (human and physical capital endowments, and other characteristics), and one due to differences across groups in the impacts of these characteristics on productivity (the coefficients).

The proposed method combine two different decomposition approach: a number index and a regression type decomposition. Using the idea of the multidimensional generalization of the

Duncans' index (Silber 1992), and an Oaxaca's decomposition-based approach we propose a decomposition method able to separate the contribution of the different industrial distribution across groups from that of differences in other characteristics.

The general Oaxaca's decomposition approach has been modified to suite the multiplicative model implied by the productivity differential (relative aggregate productivity levels) and the productivity measure (firms' value added per worker), and in order to separate the contribution of the industrial composition from that of differences in other characteristics. The decomposition is based on the joint generalized estimation of labour productivity functions where correlation across equations may be considered. The potential determinants of value added per worker differentials are identified and the relative importance (weight) of each source of productivity differential among the groups of firms is analyzed. Our approach provides a way to measure the contribution of each well-identified source of productivity differential either in a micro or macro framework. However, the approach is of more general interest because it is applicable to any statistical comparison of the relative performance of two groups or a single group at two points in time. The presented approach is essentially descriptive and measure how much of the observed productivity gap is due to well identified sources of inequalities between the two groups of firms, basing on estimated associations between productivity and several factors.

We apply the decomposition to the analysis of labour productivity gap between foreign-owned and domestic firms in the Italian manufacturing sector.

Foreign-owned firms differ from domestic firms in many ways: foreign affiliates tend to be larger, employ a large fraction of skilled workers, have higher productivity levels, and capital and export intensity. Moreover, there is a concentration of foreign affiliates in R&D intensive, science-based, and scale-intensive industries (Oulton, 1998a, 1998b; Doms and Jensen, 1998; Bellak, 2004). Hence a large part of the differences in productivity between foreign affiliates and domestic firms may be due to a compositional effect, that is connected to the high concentration of foreign affiliates in specific industries and to the presence of a size factor. Davies and Lyons (1991) found that the productivity gap in the UK manufacturing sector is due for the 40% to the differential industry composition between foreign owned and domestic firms (the "structural effect"). Oulton (1998a; 1998b) found that the productivity gap is for the large part explained by the fact that foreign-owned firms have higher capital intensity and use more skilled labour than their domestic counterparts, both in manufacturing and service sectors in the UK. Griffith (1999) and Girma *et al.* (2001), using panel data, point out that the same factors, i.e. size, skill and capital intensity, explain great proportion of productivity differential. However, when controlling for industry and firm's characteristics and when using more appropriate data and analysis the evidence on the productivity advantage of foreign owned firms is mixed (for a review see Bellak, 2004 and Karpaty, 2007).

Our analysis differentiate from the most of the empirical literature on the productivity gap of foreign-owned firms in that a decomposition method of an aggregate measure of relative performance is used instead of a multiple regression analysis by ownership. Davies and Lyons (1991) propose an approach based on a index number decomposition for the manufacturing sector in the UK that distinguish between two components: a "structural effect" that measure the extent to which the aggregate productivity advantage is due to a better industrial distribution in the group of foreign owned firms, and a "ownership effect" that reflects the tendency for foreign-owned enterprises to be more productive than the domestic-owned counterparts. However the ownership effect that result from their decomposition "*may be due to pure efficiency and technology differential, but... it might equally be due to differential in labour skills,* *capital input, vertical integration or monopoly power in the product market*" (Davies and Lyons, 1991). Our decomposition method goes furthers and allows to disentangle the effect due to differences in the impacts of factors (characteristics' coefficients) from the effect due to differences in factors' endowments (characteristics).

For the interpretation of the decomposition results it is important to point out that the analysis does not allow to draw conclusions on behavioural models or on the direction of causality between productivity gap and ownership. In general, if regressions are purely descriptive, they reveal the associations that characterize the productivity inequality and the implications for policies to reduce inequality are limited. If the economic theory allows identification of casual effects, then the factors that generate the inequality are identified and conclusions about how policies would impact on inequality can be drawn. The most recent empirical literature attempts to give a behavioural and causality interpretation treating the problems of simultaneous causality and heterogeneity in the estimation of productivity functions and the endogeneity of the ownership status (among others, Conyon *et al*., 2002; Benfratello and Sembenelli, 2006; Girma *et al*, 2007, Karpaty, 2007), but this requires the availability of panel data and the use of more sophisticate econometrics models and statistical estimation techniques.

In our empirical analysis, having estimated associations between productivity and several well defined factors, the decomposition approach measures how much of the observed productivity gap is due to well identified sources of inequalities between specific groups of firms.

The approach presented here has the merit to be easily implemented and to offer readily understandable measures.

The remainder of the paper is organized as follows. Section 2 describes the proposed productivity decomposition method. In Section 3 we describe the used data set and discuss the estimated models and the results of the productivity decomposition. In the last Section we present some concluding remarks.

2 Methodology

Various productivity decomposition methods have been used, over the years, to decompose aggregate measures of productivity changes between "pure" productivity changes and employment (or market) share changes. Regardless of the actual decomposition, all these methods are derived from an indicator of aggregate productivity change, that is the difference of the aggregate productivity in two time periods, aggregate productivity being the weighted sum of some productivity measure (labour productivity or TFP) with weight equal to employment share or to industry output whether labour productivity or TFP is used.

Depending on the level of aggregation used, the various decomposition methods result in a different number of components with various interpretation, trying to identify the sources of variation in the aggregate measure of productivity (this is the classical problem of index number decomposition of the causes).

A completely different approach to decompose an inequality measure or a measure of change is the one developed by Oaxaca (1973) for studying discrimination in the labor market. In the original application, the approach was used to decompose the wage differences between males and females into an human capital and a discrimination component. The method is based on the estimation of two independent regression for each group and the difference in the (log) wages between males and females can be expressed in the sum of two components, the first given by differences in human capital characteristics between males and females and the second given by differences in the rates of returns on human capital characteristics (the coefficients of the regressions) – the discrimination components.

The result of decomposition depends on which of the two group is chosen as reference: wage discrimination can be defined in favor of or against one of the two groups implying different economic interpretations, that can be traduced into different decomposition measures using in turn one of the two groups as reference.

Various version of this basic decomposition approach have been developed, each using a different weighting scheme to obtain a specific counterfactual situation. Oaxaca and Ransom (1994) survey the different ways and propose a unified framework, and Silber and Weber (1999) compare the performances of the various decomposition algorithms, finding that no robust conclusion can generally be drawn on which algorithm works better.

We propose a decomposition method that uses elements of both approaches.

Our first task is to decompose the productivity per worker differential across groups of firms into different components attributed to differences in (observed) occupational structures by sector, and some potential sources of the productivity per worker differential. Starting from a relative index of aggregate level of per worker productivity between groups, we use a generalization of a Duncan index of dissimilarity (used in the analysis of occupational segregation by Silver, 1992) in order to isolate the component due to differences across groups in the industrial employment composition. Then, an Oaxaca's decomposition - based approach is used to measure and further decompose the productivity differences among the average per worker value added of the two groups within each sector. In this way, we obtain two more components: one related to differences across groups in the characteristics of the firms (human and physical capital endowments, and eventually other characteristics), and a second due to differences across groups in the returns of these characteristics on productivity (the coefficients).

Following the approach of Silber (1992), a multidimensional generalization of the Duncans'index, which amounts to comparing actual with expected shares, may be derived as follows.

Let N_{ij} be the number of workers in sector i belonging to the firm group j and let ln y_{ij} be the corresponding average logarithm of their per worker value added (VA).

The average ln y_{0j} for all sectors belonging to the group j may be written as:

$$\ln y_{0j} = \sum_i \left(\frac{N_{ij}}{N_{0j}} \right) \ln y_{ij} \tag{1}$$

where $N_{0j} = \sum_i N_{ij}$ is the total number of workers of group j.

The average ln y_{0h} for all sectors belonging to the group h, is defined analogously.

When there is independence of industry distribution from the variable defining firm groups, the expected number of workers in sector i belonging to group j, $E(N_{ij})$, is equal to:

$$E\left(N_{ij}\right) = \frac{N_{0j} N_{i0}}{N} \tag{2}$$

where N_{i0} and N are respectively the total number of workers in sector i and the total employment (in all sectors).

The expected log of the per worker value added relative to group j and h, $E(\ln y_{0j})$ and $E(\ln y_{0h})$, is respectively written as:

$$\begin{aligned} E\left(\ln y_{0j}\right) &= \sum_i \left(\frac{N_{i0}}{N} \right) \ln y_{ij}, \\ E\left(\ln y_{0h}\right) &= \sum_i \left(\frac{N_{i0}}{N} \right) \ln y_{ih}. \end{aligned} \tag{3}$$

The expected gap between logs of the per worker VA relative to firms belonging to the groups j and h, $(E\Delta_{jh})$ is equal to:

$$E\Delta_{jh} = \sum_i \left(\frac{N_{i0}}{N} \right) \left(\ln y_{ij} - \ln y_{ih} \right) \tag{4}$$

Using Eq. (1) the actual gap between the logs of per worker Vas, (Δ_{jh}) can be written as[1]:

$$\Delta_{jh} = \sum_i \left[\left(\frac{N_{ij}}{N_{0j}} \right) \ln y_{ij} - \left(\frac{N_{ih}}{N_{0h}} \right) \ln y_{ih} \right] \quad (5)$$

Combining Equations (4) and (5) gives:

$$\Delta_{jh} = \sum_i \left\{ \left[\left(\frac{N_{ij}}{N_{0j}} \right) - \left(\frac{N_{i0}}{N} \right) \right] \ln y_{ij} - \left[\left(\frac{N_{ih}}{N_{0h}} \right) - \left(\frac{N_{i0}}{N} \right) \right] \ln y_{ih} \right\} + \left[\sum_i \left(\frac{N_{i0}}{N} \right) \left(\ln y_{ij} - \ln y_{ih} \right) \right] \quad (6)$$

The expression within curly brackets in (6) represents the part of the actual log of per worker VA gap which is due to differences in the employment distribution by sector. The second part of (6) is used to compute the contribution to the gap due to some specific components such as human and physical capital, which are relevant in explaining the actual per worker VA gap Δ_{jh}.

In this respect, for each group j and h, we introduce the following statistical models:

$$\ln y_{ijl} = \sum_k \beta_{ijk} x_{ijkl} + \varepsilon_{ijl} \quad (7)$$
$$\ln y_{ihl} = \sum_k \beta_{ihk} x_{ihkl} + \varepsilon_{ihl}$$

where the dependent variables are the log of per worker VA of firm l operating in sector i belonging to group j (h), β_{ijk} and β_{ihk} are the parameters of the k-th (k = 1,.., p) explanatory variables relative to sector i and groups j and h respectively. ε_{ijl} and ε_{ihl} are the corresponding error terms.

The regression analysis may be carried out fitting separate regression to each group or introducing a seemingly unrelated regressions (SUR) model as presented by Zellner (1962). The latter approach yields estimators at least asymptotically more efficient than single-equation least squares. This efficiency gain occurs when contemporaneous disturbance terms in different equations are correlated and when different sets of independent variables appear in the equations of the system.

Using coefficients estimates $\hat{\beta}_{ijk}$ and $\hat{\beta}_{ihk}$ we have:[2]

$$\ln y_{ij} = \sum_k \hat{\beta}_{ijk} \bar{x}_{ijk}$$
$$\ln y_{ih} = \sum_k \hat{\beta}_{ihk} \bar{x}_{ihk} \quad (8)$$

and we apply the Oaxaca's decomposition approach to the differential in averages log per worker value added using a Reimer's (1983) weighting scheme to approximate the counterfactual situation. A Reimer weighting scheme is invariant with respect to the treatment of groups if we reverse the role of the reference group so we can avoid the problem of having different component measures whether we use one or the other group as reference. In the case of productivity differential the choice of a specific group for defining the counterfactual situation does not lead to a particular economic interpretation of the components.

Then, it can be shown that the differential of the logs of the per worker VA of groups j and h of firms operating in sector i is given by:

$$\ln y_{ij} - \ln y_{ih} = H_i + D_i \quad (9)$$

where:

[1] This is equivalent to define the productivity differential between groups as the ratio of weighted geometric means of industrial per worker productivity with weights equal to the industry employment shares in each group.

[2] Assuming exogeneity of regressors, the conditional expectations of the error terms are zero. The average among firms of industry i in group j (h) of log per worker value added is equal to the geometric mean of firms' per worker value added of industry i in group j (h).

$$H_i = \sum_k \left(\left(\hat{\beta}_{ijk} + \hat{\beta}_{ihk} \right) / 2 \right) \left(\bar{x}_{ijk} - \bar{x}_{ihk} \right) \quad (10)$$

$$D_i = \sum_k \left(\left(\bar{x}_{ijk} + \bar{x}_{ihk} \right) / 2 \right) \left(\hat{\beta}_{ijk} - \hat{\beta}_{ihk} \right) \quad (11)$$

H_i in Eq. (9) represents that part of the differential between the means of the logs of the per worker VA of group *j* and *h* in sector *i*, which is explained by group differences in factor endowments relative to the determinants introduced into the model specification whereas D_i in Eq. (9) represents the contribution of group differences in the returns of these factors.

Combining Eq. (6), (9), (10) and (11) gives:

$$\Delta_{jh} = S + H + D \quad (12)$$

where:

$$S = \sum_i \left\{ \left[\left(\frac{N_{ij}}{N_{0j}} \right) - \left(\frac{N_{i0}}{N} \right) \right] \ln y_{ij} - \left[\left(\frac{N_{ih}}{N_{0h}} \right) - \left(\frac{N_{i0}}{N} \right) \right] \ln y_{ih} \right\} \quad (13)$$

$$H = \sum_i \left(\frac{N_{i0}}{N} \right) H_i \quad (14)$$

$$D = \sum_i \left(\frac{N_{i0}}{N} \right) D_i \quad (15)$$

S in Eq. (12) and (13) represents that part of the overall differential between groups *j* and *h* which stems from the existence of group differences in industrial employment composition. *H* in Eq. (12) and (14) and *D* in Eq. (12) and (15) give respectively the contributions of group differences in factor endowments and in the impacts of factor.

This decomposition separates productivity differential between two groups of firms into three broad components: the overall *endowment component* given by *H*, the overall *impact component* given by *D*, and the *S* component which measures the contribution of the occupational composition by sector.

Although the generalization of the Duncan index is used, the dependence between the occupational composition and the groups examined may be checked on the basis of other indices, such as entropy indices or generalizations of the Gini index. However, the present study is limited to the use of the generalization of the Duncan index which also refers to the case when more than two groups are distinguished, but this does not imply that this index should be preferred.

Alternative decomposition approaches of productivity differential or changes are essentially based on index number decomposition, analysis of variance, and shift-share analysis (Davis and Lyons, 1991; Duro and Esteban, 1998, Bernardini Papalia and Bertarelli, 2009; de Boer, 2008). Each method is based on the specific measure of the effects introduced into the decomposition as well as on the choice of additive or multiplicative components and on the appropriate base/comparison group.

If compared to the other approaches, the methodology developed in this paper is of some interest since it can be easily extended to consider more than two groups or more than two dimension. Also, it does not impose any restriction on what productivity measures can be used and it allows for different (labour) productivity model specifications across groups.

3 An application to the Italian manufacturing sector

The empirical analysis presented in this Section is aimed at analyzing the productivity differential between foreign owned and domestic firms. This study is based on a dataset resulting from a survey on Italian firms in the manufacturing sector linked with balance sheets data for the same firms.

For each group of foreign and domestic firms, a different equation for labour productivity is specified. The multi-equation model specification presents the advantages: (i) of defining a different set of explanatory variables for each equation; (ii) and of considering the potential correlation across equations. Interpretation of the parameter values is not the primary concern.

3.1 Data and measures

The data comes from a sample survey on Italian manufacturing firms covering the years 2001-2003)[3].

The target population refers to manufacturing firms with more than 10 employees: firms with more than 500 employees are totally sampled whereas firms with less than 500 employees are selected on the basis of a stratified sample by size, activity sector (*Pavitt* taxonomy) and geographical area (North, Centre-South). The original sample consists of 4289 firms.

The survey information is linked with balance sheet data for the three years 2001-03, available only for 3450 firms. Our analysis focus on year 2003.

We classify a firm as "foreign" owned if there is one or more foreign subjects that own a share of the capital of the firm greater than 10%, using the definition provided by the OECD and the IMF. "Domestic" firms are then all the firms whose capital is totally hold by residents and firms with a share of foreign ownership below 10%.

We consequently excluded from the sample all firms whose ownership could not be properly identified (81 firms). Ownership information refers at the time of the interview, therefore we implicitly assume that ownership did not change in the considered period.

Productivity differentials are measured between these two groups of firms.

Firms are also grouped by sectors using the taxonomy *à la Pavitt*.[4] We use the *Pavitt* taxonomy instead of the Nace based classification mainly because the latter results in groups with a small number of firms, especially in the case of foreign ones. For the same reason, we group two Pavitt sectors so we finally work with three sectors classification comprising: (i) *Supplier dominated* - *Pavitt* sector 1; (ii) *Scale intensive* and *Science based* - *Pavitt* sectors 2 and 4; (iii) *Specialized suppliers* - *Pavitt* sector 3. However, another reason for using the *Pavitt* taxonomy is that it is a sample stratification variable so it allows to control for the sampling design. Finally, the Pavitt taxonomy is meaningful in itself because it identifies patterns of technological change that are industry-specific.

The productivity indicator is labour productivity at 2003 measured as value added per worker.

Value added at 2003 is obtained as turnover minus costs of materials and services. Value added is deflated with the corresponding two-digit implicit deflator index to ensure comparability across industries.[5]

As a proxy measure for the stock of physical capital we employ the value of fixed assets, deflated with the producer price index.[6] Missing data on value added and stock of fixed capital are imputed with the corresponding values of the year 2002 (or 2001 if the latter is not available). We measure the capital intensity as the stock of fixed capital per worker.

As indicator of human capital we use skill composition of workforce calculated as the share of managers and white collars on firm's total employment. Even in this case, missing

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[3] The survey is carried out every three years by the bank Unicredit (before Capitalia).

[4] The Pavitt taxonomy is a classification of economic sectors based on technological opportunities, innovations, R&D intensity and knowledge. It comprises four categories: *Supplier dominated* (medium-small size firms producing traditional consumer goods), *Scale intensive* (medium-high size firms which focuses on process innovation in order to exploit latent economies of scale and R&D capabilities), *Specialized suppliers* (small-size firms which focuses on product innovation and exploiting learning economies), and *Science based* (small-high size firms with high commitment to R&D).

[5] Implicit deflators for two-digit industries are calculated as the ratio of value added at current prices in 2003 and value added in 2003 at constant prices of 2000 (Istat).

[6] We use the 2003 producer price index for intermediate goods based at 2000 (Istat).

data were imputed with values at 2002 or 2001. Capital intensity and workforce skills composition are the covariates used in the baseline regression for productivity.

We then proceed by specifying some extended models. The idea is to explore how much our discretionary choices of the functional form and the regressors affects the decomposition results.

We consider only observation with complete data (3230 firms) in order to guarantee comparability across models.

The number of foreign firms in the final sample is 229 (7.1%) with a share of total employment equal to 16.2%.

Table 1 shows the sample distribution of firms and employees by sector in domestic and foreign firms.

Table 1. Sample distribution of firms and employees by sector (domestic and foreign firms)

Sector	***Domestic***		***Foreign***		***Total***	
Firms	*n*	*%*	*n*	*%*	*n*	*%*
Supplier dominated	1621	54.0	76	33.2	1697	52.5
Scale intensive/science based	615	20.5	56	24.5	671	20.8
Specialized suppliers	765	25.5	97	42.4	862	26.7
Total	3001	100	229	100	3230	100
Employees						
Supplier dominated	129786	44.7	20448	36.5	150234	43.4
Scale intensive/science based	77196	26.6	19301	34.4	96497	27.9
Specialized suppliers	83226	28.7	16325	29.1	99551	28.7
Total	290208	100	56074	100	346282	100

The distributions of firms and employees by sector are quite different between domestic and foreign firms. In the group of domestic firms the 54% of firms belong to the *Supplier dominated* sector (sector 1) while in the foreign group the majority of firms (42%) belongs to *Specialized supplier* (sector 3). Looking at the distribution of employees, the supplier dominated sector is still the largest for domestic firms, while for foreign firms the percentage of employees in the *Specialized supplier* sector reduces to 29%. In this respect, the average size (in terms of employment) of firms in this sector is smaller than the average size of firms in sector 1 and 2, especially for foreign firms.

Table 2 reports basic statistics of some characteristics for domestic and foreign firms.

Labour productivity is greater for foreign-owned firms by 26% when considering the simple average and by 23% when considering the median. So it is confirmed as well for Italian manufacturing firms the existence of a differential in labour productivity between foreign-owned and domestic firms evidenced in the empirical literature for other countries.

Foreign firms are also larger than domestic ones either in terms of number of employees, turnover and value added (in levels).

The empirical literature has stressed that foreign-owned and domestic firms differ along other characteristics. In particular, it has been found that foreign-owned firms have an higher capital intensity and use more skilled labour. From our data we find that the share of skilled workforce on total employment is larger for foreign firms and that the stock of physical capital is larger as well but this is no longer true for capital intensity, at least when we consider the simple average. Evidently, the very large number of employees for some foreign firms reduce the ratio

capital/employment influencing the average (but not the median, which results slightly larger for foreign-owned firms).
Foreign firms are also more export-oriented than domestic firms: the share of turnover deriving from export is on average about the double for the latter than for domestics. This is a result already evidenced in the empirical literature. Moreover, foreign firms are more likely innovating products and processes, having expenses in R&D, and belonging to economic groups than domestics.
Finally we consider the firms' geographical location and the affiliation with an industrial district, as well as the weight of subcontracting on turnover, all factors that characterize specifically the Italian situation and which are likely related to productivity. As we can see, there is a prevalence of firms located in industrial districts among domestics than foreign-owned firms and the formers have also a slightly higher share of subcontracting turnover than the latter, while there are no differences regarding the geographical location.

Table 2. Sample characteristics of domestic and foreign-owned firms

Variable		***Domestic***			***Foreign***	
	Mean	*median*	*cv*	*Mean*	*median*	*Cv*
VA (000 euros)	5092.8	1975.5	3.78	15485.0	5919.0	1.91
VA per worker (000 euros)	48.6	43.0	0.64	61.3	52.7	0.62
Number of employees	96.7	44.0	3.24	244.9	109.0	1.61
R&D expenditures*	0.4	-	1.11	0.6	-	0.78
Export intensity (%)	28.9	20.0	1.03	44.4	43.0	0.71
Turnover (000 euros)	22401.8	9169.5	4.44	74584.1	23823.5	3.43
Capital stock (000 euros)	4442.4	1344.7	4.02	12140.9	3070.8	2.56
Capital-labour ratio	46.4	28.1	1.47	45.2	29.6	1.23
Industrial district*	0.5	-	1.10	0.4	-	1.19
North-Center*	0.9	-	0.42	0.9	-	0.34
Skilled workforce (%)	33	29	0.55	40	35	0.58
Intensity of subcontracting (%)	57.4	80.0	0.79	55.0	72.0	0.83
Innovation*	0.6	-	0.82	0.7	-	0.64
Business group*	0.3	-	1.66	0.7	-	0.62

Note: * binary variables

3.2 SUR model specification

The basic seemingly unrelated regression model relative to the labour productivity equations is formulated as follows.
For each individual observation l there are two dependent variables (y_{jl} , j = 1,2.) each with its own regression equation:

$$\ln y_{jl} = \beta_{j1} x_{j1l} + \ldots + \beta_{jp} x_{jpl} + \varepsilon_{jl} \qquad (16)$$

where y_{jl} is the value added per worker and x_{jkl} is the k-th regressor (k=1,…p), the index l (l=1,…L) refers to firms, j refers to groups of foreign or domestic firms (j=1,2), β_{jk} are the parameters to be estimated that vary in each group (and in case across sectors), ε_{jl} are random errors.
For the stochastic component we assume that:

$$\varepsilon_{jl} \sim N(0, \sigma_{jl}) \quad (17)$$

where within each j equation ε_{jl} is identically and independently distributed with

$$Var(\varepsilon_{jl}) = \sigma_j ; Cov(\varepsilon_{jl}, \varepsilon_{jl'}) = 0$$

$$l \neq l', j = 1,2. \quad (18)$$

However, the error terms for the l-th observation can be correlated across equations:

$$Cov(\varepsilon_{jl}, \varepsilon_{j'l}) \neq 0 , \; j \neq j', l = 1,.., L. \quad (19)$$

As a result of a preliminary analysis we select four alternative model specifications (results are showed in Table 6 and Table 7 in Appendix).

The baseline model (model 1) considers only capital intensity and the share of skilled labour (all the covariates are in logarithmic terms) and are among the characteristics cited in literature that most differentiate the two groups. In the second model (model 2) we add three control variables, one capturing the effect of size, the log of turnover at 2003 and its squared term, the second is a binary indicator for location in the north and center, and the last a binary indicator for membership in an industrial district. Model 3 also considers a binary variable for the membership in a business group, the share of turnover deriving from subcontracting, and the share of turnover deriving from export (both in logarithm). Finally, model 4 includes also a binary indicator for product or process innovation and a binary indicator for expenses in R&D during 2001-2003.

As expected, parameters estimates and contribution of covariates differ across sectors as well as across groups.

As far as domestic firms are considered, we found that capital intensity and the share of skilled labour are important determinants of the labour productivity: the higher are the capital intensity and the share of skilled labour the higher is the labour productivity. The signs of coefficients on size and its square term are positive and negative respectively across all sectors, but are significant only for sector 1. Thus, size has a significant positive effect on per worker productivity, but at a decreasing rate, for supplier dominated firms but not for the others. Firms located in the North and Center have a higher labour productivity only for sector 2, while there are no significant differences for firms located in industrial districts.

Group membership has not a significant effect while the share of exporting turnover is significant (but negative) only for the *Supplier dominated* (sector 1). This results is contradictory to the conventional wisdom that a firm who is more export-intensive tends to perform better and have a higher productivity (Girma *et al*., 2004; Greenaway and Kneller, 2007). We can find at least two reasons explaining this result. The first is that the positive relationship between productivity and export intensity reflects the compound effects of others factors, as for example the size. The second is related to the industry composition inside each of the Pavitt macro-sectors: industries with higher export intensity, usually traditional ones in Italy are also those with lower labour productivity, in fact we found that the correlation between Nace two-digit industries averages of labour productivity and export intensity is equal to -0.44.

Finally it seems that innovative activity has no influence on productivity, being the coefficients of both the innovation and R&D indicators never significant. However, because productivity is measured at 2003 and innovation and R&D are measured in years 2001-03 it is possible that innovations may not yet exert any effects due to the short time elapsed.

For foreign firms, labour productivity seems to depend on the capital intensity and the share of skilled labour. No strong associations are found between labour productivity and other characteristics in this group.

3.3 Productivity Decomposition

According to the methodology introduced in Section 2, productivity differences relative to each sector between the two groups of firms are decomposed into the components attributed to differences in characteristic (*H*) and differences in the impacts of the considered characteristics (*D*).

The two components are calculated, for each sector, from the estimated models using equations (10) and (11). Results are presented in Table 3.

Firstly, we note that productivity differential between foreign and domestic firms is greatest in sector 2, obtained aggregating firms of two different sectors of the Pavitt's Taxonomy.

Considering model 1, which takes into account only capital intensity and skill workforce composition, the value added differential for each sector is due only for a minimum extent to differences in this two characteristics between foreign and domestic firms (the H_i component). Most of the differential is due to the component D_i, measured by the differences in the model's betas. This means that either there is a different impact of capital intensity and skilled workforce on labour productivity for foreign and domestic firms or the model does not explain a high quote of productivity differential.

Actually, adding firm's size and geographical location besides capital intensity and skill composition (model 2) the component H_i, due to the different values of the considered characteristics of foreign and domestic groups, captures the majority of the productivity differential at least in sector 1 and sector 3, but not in sector 2.

Table 3. Difference between the average logarithms of per worker Vas of foreign versus domestic firms by sector (SUR model, FGLS estimates)

Sector	***Hi***	***Di***	***Total difference Δlny***
Supplier dominated	0.051	0.073	0.124
Scale intensive/science based	0.026	0.315	0.341
Specialized suppliers	0.027	0.151	0.178
Supplier dominated	0.131	0.001	0.132
Scale intensive/science based	0.168	0.177	0.345
Specialized suppliers	0.107	0.040	0.147
Supplier dominated	0.089	0.060	0.149
Scale intensive/science based	0.112	0.252	0.364
Specialized suppliers	0.133	0.008	0.141
Supplier dominated	0.086	0.067	0.153
Scale intensive/science based	0.120	0.237	0.358
Specialized suppliers	0.131	0.009	0.139

When looking at model 3 and model 4, where other variables are introduced in the model specification, the measure of the component H_i due to the observed characteristics is more important in explaining the labour productivity differential only for sector 3 and sector 1 but not for sector 2 where the component D_i (due to the beta's difference) is greater than H_i that accounts for the observed characteristic.

Table 4 presents results of the decomposing procedure for productivity differential between domestic and foreign firms into the components *H*, *D* and *S* at the aggregate level. *H* and *D* are calculated using (14) and (15). The component *S* is calculated using equation (13) and accounts for the different sectoral workforce composition between foreign and domestic firms.

There is a labour productivity differential (in logs) of 0.22 between foreign and domestic firms. Focusing on the two components *H* and *D* we can see that their contribution differ significantly across models with different specification. The component *H* accounts only for the 17% of the total differential in model 1: differences in capital intensity and in skilled workforce between foreign-owned and domestic firms cannot by themselves explain the productivity differential between the two groups. Considering structural variables like the firms' size and the geographical location improves the fitting of the model for productivity (model 2), lowering the measure of the component *D* to the 28% of the total and rising the weight of the component due to differences in observed characteristics (*H*) to the 62% of the total.

When we use the specification of model 3 and 4, that consider not only structural characteristics but also variables associated with specific behaviours and choices, the *D* component rises again to the 43% of the total productivity gap, almost the same weigh of the foreign-owned and domestic productivity differential explained by the differences in the considered characteristics.

This can be understood looking at the estimates of the two models for foreign-owned and domestic firms (tables in Appendix): not only the parameter's estimates are different for the two groups but also the significance of the coefficient estimates is different across the two groups, implying different functions describing the performance of foreign and domestic firms. With reference to the *S* component, our results indicate that the workforce distribution by sector accounts only for the 10% of the total gap and is less important than differences either in firms' characteristics and in factors' impact in explaining productivity differentials between foreign and domestic firms.

Table 4. Difference between the average logarithms of per worker Vas of foreign versus domestic firms (SUR model, FGLS estimates)

Δlny	*S* Differences in occupational composition		*H* Differences in firms' characteristics		*D* Differences in Value Added	
		%		%		%
0.222	0.022	9.84	0.037	16.81	0.163	73.35
0.218	0.022	10.04	0.134	61.78	0.061	28.18
0.228	0.022	9.57	0.108	47.38	0.098	43.05
0.228	0.022	9.58	0.108	47.52	0.098	42.89

4 Concluding remarks

In this paper we propose an approach to decompose productivity differentials among groups of firms. The idea is to decompose the productivity gap among groups of firms into three different components that can be interpreted as the part of the gap that is explained by group differences in: (i) average observable characteristics of the firms, (ii) the impact of these characteristics, and (iii) workforce composition by sector. The methodology developed in this paper does not impose any restrictions on the choice of the productivity measures and on the specification of the productivity model of each group of firms. This particular decomposition is interesting because it quantifies the extent to which the aggregate productivity advantage is due to different industrial distribution (the structural effect) and to different characteristics (inputs endowment and other factors), and how much it reflects a tendency of foreign-owned firms to be more productive than their domestic-owned firms counterparts within each industry. It is applicable to any statistical comparison of the relative performance of two groups or alternatively of a single group at two points in time even when the analysis is focused on productivity differences along more than two groups or more than two dimension.

The proposed approach is used to explain differences in productivity between foreign owned and domestic firms in the Italian manufacturing sector. Our results, based on data from a survey carried out by Capitalia for the years 2001-2003, show that productivity differential between foreign-owned and domestic firms cannot be principally attributed to the different characteristics of the firms in the two groups, because a large part (ranging from 28% to 43%) of the productivity differential is due to the different impacts of the factors considered, that is to say different performances of firms in the two groups. The explained component accounts the more for the 62% of the overall productivity differential but its weigh falls to the 47% when characteristics other than input factors are considered. This is particularly true for sector 2 where the productivity differential is only for a small part due to differences in the endowment of the firms in the two groups. The different sectoral workforce composition, instead, accounts only for the 10% of the total differential.

In this respect, our results attempt to provide the first set of evidences on the role of well-defined determinants in analyzing the productivity differences from foreign and domestic ownership firms in Italy, even at a sectoral level, and offer a new analysis's perspective.

This method should be of interest also in the decomposition of price and poverty indices by population subgroups as well as in the growth model analysis aimed at decomposing the total output into factor contributions and a residual term that is the total factor productivity.

Our framework can be extended in a number of ways. One is to explain changes in productivity gaps over time. Another extension would be to explore other applications where selectivity issues concerning (i) the potential unit sample selection problem and/or (ii) the group assignment selection problem, are emerged. The sample selection correction term can then be used to adjust the group mean difference in the outcome variable by modeling the probability that the unit appears in the sample. Analogously, the group assignment problem can be dealt with by modeling the probability for the unit of being in one group rather than the other, and then by using the selection correction terms to adjust the difference in group means. These issues represent directions for future research and empirical investigation.

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Appendix

TABLE 5. Definition of the variables used in model specifications

Name	***Description***	***Type***
Lnva	Log of value added per worker at 2003 (euros' 000)	Continuous
Lncapin	Log of capital stock on employment at 2003 (euros' 000)	Continuous
Lnskill	Log of white collars and managers on employment at 2003	Continuous
Lnturnover	Log of turnover at 2003 (euros' 000)	Continuous
Lnturnsq	Square of log of turnover	Continuous
North	Location in the North or the Center	Binary
District	Location in an industrial district	Binay
Group	Affiliation with a business group	Binary
Lnsub	Log of subcontract sales on total turnover (%)	Continuous
Lnexport	Log of export sales on total turnover (%)	Continuous
Innov	Product or process innovation in 2001-03	Binary
R&D	Expenses in R&D in 2001-03	Binary

TABLE 6. SUR model, FGLS estimates - Domestic firms

Variables	*Sector*	*model 1*	*model 2*	*model 3*	*model 4*
Constant	*Supplier dominated*	2.131***	-3.779	-4.429*	-4.699*
	Scale intensive/science based	2.554***	-2.389	-2.969	-4.441
	Specialized suppliers	2.754***	0.724	0.738	0.874
Lncapin	*Supplier dominated*	0.126***	0.087**	0.066*	0.070*
	Scale intensive/science based	0.150**	0.153***	0.126**	0.137**
	Specialized suppliers	0.112**	0.081*	0.074	0.073
Lnskill	*Supplier dominated*	0.360***	0.372***	0.383***	0.391***
	Scale intensive/science based	0.216	0.248*	0.293*	0.376**
	Specialized suppliers	0.213*	0.205*	0.215*	0.216*
Lnturnover	*Supplier dominated*		1.261**	1.402**	1.456*
	Scale intensive/science based		0.866	0.886	1.127
	Specialized suppliers		0.370	0.371	0.347
Lnturnsq	*Supplier dominated*		-0.064*	-0.070**	-0.073*
	Scale intensive/science based		-0.040	-0.036	-0.048
	Specialized suppliers		-0.015	-0.015	-0.014
North	*Supplier dominated*		-0.170*	-0.114	-0.109
	Scale intensive/science based		0.339	0.299*	0.285*
	Specialized suppliers		0.065	0.056	0.029
District	*Supplier dominated*		0.108	0.125	0.126
	Scale intensive/science based		0.018	-0.022	-0.006
	Specialized suppliers		0.003	0.016	0.020
Group	*Supplier dominated*			-0.009	0.008
	Scale intensive/science based			-0.133	-0.112
	Specialized suppliers			0.076	0.057
Lnsub	*Supplier dominated*			-0.005	0.000
	Scale intensive/science based			0.054	0.069*
	Specialized suppliers			0.009	0.013
Lnexport	*Supplier dominated*			-0.074**	-0.069**
	Scale intensive/science based			-0.024	-0.018
	Specialized suppliers			-0.012	-0.016
Innov	*Supplier dominated*				-0.044
	Scale intensive/science based				-0.177
	Specialized suppliers				-0.054
R&D	*Supplier dominated*				-0.074
	Scale intensive/science based				0.002
	Specialized suppliers				0.064

*Note: * p<0.05, ** p<0.01, *** p<0.001*

TABLE 7. SUR model, FGLS estimates - Foreign firms

Variables	*Sector*	*model 1*	*model 2*	*model 3*	*model 4*
Constant	*Supplier dominated*	2.212***	-2.572	-2.689	-2.488
	Scale intensive/science based	4.242***	3.770	4.295	3.116
	Specialized suppliers	2.461***	1.954	2.793	2.785
Lncapin	*Supplier dominated*	0.230***	0.213***	0.216***	0.213***
	Scale intensive/science based	-0.048	-0.092*	-0.077	-0.070
	Specialized suppliers	0.116**	0.083*	0.098*	0.077
Lnskill	*Supplier dominated*	0.254**	0.246**	0.242**	0.247**
	Scale intensive/science based	0.018	0.096	0.121	0.144
	Specialized suppliers	0.333***	0.326***	0.337***	0.319***
Lnturnover	*Supplier dominated*		0.840	0.882	0.842
	Scale intensive/science based		-0.069	-0.137	0.098
	Specialized suppliers		0.035	-0.105	-0.093
Lnturnsq	*Supplier dominated*		-0.035	-0.036	-0.034
	Scale intensive/science based		0.010	0.013	0.003
	Specialized suppliers		0.004	0.009	0.009
North	*Supplier dominated*		-0.059	-0.019	-0.019
	Scale intensive/science based		-0.233	-0.103	-0.153
	Specialized suppliers		-0.200	-0.153	-0.103
District	*Supplier dominated*		0.040	0.016	0.043
	Scale intensive/science based		0.274*	0.258	0.327*
	Specialized suppliers		0.097	0.100	0.123
Group	*Supplier dominated*			-0.070	-0.030
	Scale intensive/science based			-0.264	-0.240
	Specialized suppliers			0.189	0.138
LnSub	*Supplier dominated*			-0.005	-0.006
	Scale intensive/science based			-0.040	-0.041
	Specialized suppliers			-0.004	-0.011
Lnexport	*Supplier dominated*			-0.035	-0.024
	Scale intensive/science based			-0.032	-0.027
	Specialized suppliers			-0.057	-0.041
Innov	*Supplier dominated*				-0.059
	Scale intensive/science based				-0.266
	Specialized suppliers				-0.246*
R&D	*Supplier dominated*				-0.082
	Scale intensive/science based				-0.090
	Specialized suppliers				0.150

*Note: * p<0.05, ** p<0.01, *** p<0.001*