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TECHNOLOGICAL PROGRESS IN ITALIAN REGIONS: SOME COMPARISONS

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Abstract

In this paper we study technological progress in a set of representative Italian regions. The analysis is conducted using input-output data. We construct the technological frontiers and calculate new indices of technological progress (see Fredholm and Zambelli 2009 and Zambelli and Fredholm 2010). The empirical results are robust and seem to be interesting. We find, for the years 2001 and 2004 that Trentino and Sicily are the regions, among those examined, with the largest number of technologically advanced productive methods, while Veneto and Lombardy are characterized by poor relative technological performance. Given the micro data about observed productivity this result is, at first, surprising, but we provide an interpretation. In the case of the Trentino region the technological progress is actually exploited so that the region is near to full employment and the income generated is relatively high. In the case of Sicily our results show that there is a great potential for growth which is not exploited. Veneto and Lombardy seem to be cases in which the embodied technological progress is not high, this indicates, ceteris *paribus*, a low potential for future growth or, alternatively, that the development has occurred in the past. Good performance is also indicated by Emilia Romagna.

JEL CLASSIFICATION: 016; 041; P51; R11; R15.
KEYWORDS: Technological Progress; Technological Frontier; Productivity, Regional Economy,

1. Introduction

In this essay we present the computation of two new measures of technological progress applied to eight Italian regions. The method is that of combining region specific wage-profit curves so as to generate an efficient inter-regional wage-profit frontier.

We construct indices for region specific technological progress and convergence by combining the region specific wage-profit frontiers. These frontiers are computed with *total precision* (and, seemingly, for the first time). As explained in Fredholm and Zambelli (2009b) and in Zambelli and Fredholm (2010) this is now possible utilizing the new algorithm they have devised. Here we compute the values of these new indices.

2. Production Prices and the wage-profit frontier

2.1. Standard input-output Framework and Output Prices

Let **A** be a $n \times n$ square non-singular matrix of inter-industry inputs, where the $(i, j)^{\text{th}}$ entry represents the i^{th} industry's use of the j^{th} commodity in the production of the i^{th} commodity. Likewise, **L** is a $n \times 1$ vector of labour inputs and **B** is a $n \times n$ positive definite diagonal matrix of outputs, where the i^{th} diagonal entry is the gross output of the i^{th} industry. In short the above can be interpreted as input-output relations of the Leontief type.

These 'real magnitudes' can be given an accounting meaning through the use of imputation prices (also known as production prices). The following situation in which there is an accounting balance in all the sectors (when wage and profit rates are assumed to be uniform):

$$\mathbf{A}\mathbf{p}(1+r) + \mathbf{L}w = \mathbf{B}\mathbf{p} \tag{2.1}$$

is a standard representation where the costs of production implied by left-hand side is equal to the revenues implied by right hand side. The price vector **p** and the uniform profit rate r and the uniform wage rate w are imputation prices that allow the accounting equilibrium[1].

[1] These prices can be interpreted in many different ways. They can be seen as: Adam Smith's *natural prices*; Ricardo-Marx's *production prices*; somewhat analogous to Seton's *eigenprices;* long term *competitive equilibrium prices*; Walrasian *market clearing prices*; *shadow prices* and so on and so forth. In order not to attach to them any particular interpretation we have chosen to refer to them as *imputation prices* or *auxiliary prices*. Moreover there exist a cloud of possible values that the individual profit rates could take and that would guarantee a set of values for which the accounting identity would be satisfied: clearly this would imply different imputation prices. The choice of the *uniform*

System (2.1) consists of *n* linear independent equations and *n+2* variables, i.e., the system has initially two degrees of freedom. Choosing a *numéraire* $\boldsymbol{\eta}$, such that that $\boldsymbol{\eta}'\mathbf{p}=1$, the degrees of freedom reduces to one.

For a given profit rate, it is straightforward to calculate the wage rate and the relative prices that solve system for (2.1). Solve for $\mathbf{p}$, $\mathbf{p}=\left(\mathbf{B}-\mathbf{A}(1+r)\right)^{-1}\mathbf{L}w$, premultiply with the *numéraire*, and rearrange to obtain the wage-profit frontier function and the associated prices, viz.

$$w=\left(\boldsymbol{\eta}'\left(\mathbf{B}-\mathbf{A}(1+r)\right)^{-1}\mathbf{L}\right)^{-1} \tag{2.2}$$

$$\mathbf{p}=\frac{\left(\mathbf{B}-\mathbf{A}(1+r)\right)^{-1}\mathbf{L}}{\boldsymbol{\eta}'\left(\mathbf{B}-\mathbf{A}(1+r)\right)^{-1}\mathbf{L}} \tag{2.3}$$

A very important property of the above *wage-profit* curve and of the imputation prices is that they are invariant with respect to the level of activities. Hence the *wage-profit curves* of two systems which have very different magnitudes, but have access to the same methods would have exactly the same imputation prices and the same *wage-profit curve*[2]. Furthermore the *wage-profit curve*, due to the established duality between these imputation prices and quantities, can also be interpreted as a measurement of technological progress. Bruno (1969) has demonstrated an important dual relation between the auxiliary prices and the methods of productions (and quantities, i.e., the *production possibility frontier* or the *factor price frontier*). Hence we can attempt a measurement of technological progress by comparing the prices associated with the employment of old methods with respect to the prices associated to the employment of new ones. Therefore equation 2.2 can be interpreted both as a *wage-profit curve* and a measure of technological progress: a *wage-profit* curve associated with an economic system when it dominates that of another one can be said to have a higher level of technological progress[3].

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rate of profit and of the *uniform wage rate* finds its principal justification from the fact that it allows us to work in a two dimensional space.

[2] For an explanation and elaboration on this important property see Zambelli (2004, p. 105). If $\mathbf{X}$ is a semi-positive diagonal matrix which represents the intensity of the utilization of the methods used (the activity levels), we have $w=\left(\boldsymbol{\eta}'\left(\mathbf{XB}-\mathbf{XA}(1+r)\right)^{-1}\mathbf{XL}\right)^{-1}$ and that $\mathbf{p}=\frac{\left(\mathbf{XB}-\mathbf{XA}(1+r)\right)^{-1}\mathbf{XL}}{\boldsymbol{\eta}'\left(\mathbf{XB}-\mathbf{XA}(1+r)\right)^{-1}\mathbf{XL}}$ respectively generating the same values as in eq. 2.2 and eq. 2.3.

[3] Clearly a higher potential technological progress does imply that actual output per capita would be higher. This does not imply at all that the empirically observed (value of the) output per capita is higher if associated to the higher potential technological progress. This is so because the imputation prices do not contain information about the actual activity levels, the matrix **X.** Therefore, due to a bad combination of activity levels, a region with

2.2 The Velupillai-Fredholm-Zambelli measurement for technological progress

In this paper the study of technological progress is made by using the information embedded in the set of all input-output tables included in a sample. The idea is rather simple. Given a set of production possibilities (also called production methods) there exist an outer bound *wage-profit frontier* which is the result of a combination of the production methods of the individual systems (i.e., it is the outer bound of all possible *wage-profit* curves). This concept of efficient outer frontier is well known in the literature and it has also been used as a pedagogical device, but it is almost always never computed from actual data. One of the reasons is to be attributed to the high combinatorial complexity which would require, when using a brute-force algorithm, several years to be computed.

Fredholm and Zambelli (2009) and Zambelli and Fredholm (2010) present the algorithm that shortens considerably the necessary computational time. Hence it is now possible to compute this outer frontier.

Here we will call it, for clarity and simplicity, the VFZ-*technological frontier*. As originally suggested in Velupillai and Zambelli (1993) this frontier is used as the benchmark to be used to measure technological progress.

Figure 1 shows an example of the *wage-profit* curves associated to 8 economic regions, year 2004, and the outer bound *VFZ-technological frontier*.

The VFZ - *technological frontier* has remarkable theoretically and empirically useful properties (see Fredholm and Zambelli, 2009).

The *wage profit curves* and *frontiers* are scale independent. This is a result of the *non-substitution* theorem. Hence two different productive systems, let us say the one associated with a small region and the one associated with a large region, can be compared using the same framework.

Comparison between two *wage-profit frontiers* is independent of the cardinality of their productive systems. Two systems which have different cardinality, let us say *n* and *m*, can still be compared as long as they have the same *numéraire*. The only requirement is that the *numéraire* is a transformation based on the subset of commodities which are common to both systems.

The *wage-profits curve* or the *wage-profits frontier* is dual with respect to the *production possibilities curve or frontier*: given set of profit rates the superior *production possibilities curve or frontier* is associated with the superior *wage-profit curve or frontier*.

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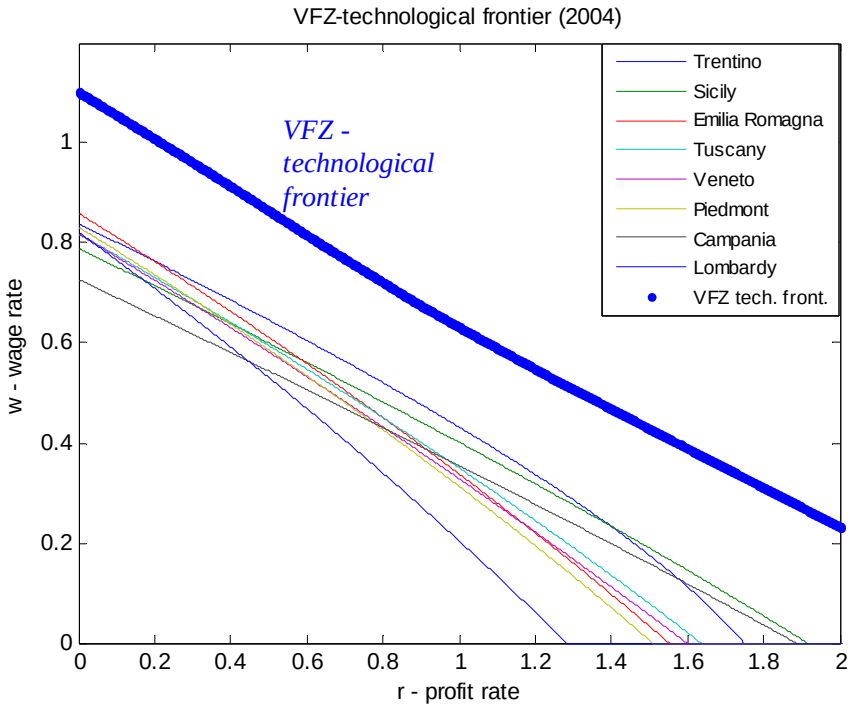
high technological progress might exhibit actual bad economic performance and vice-versa. In the ***ceteris** paribus* case in which two economic systems differ in the set of methods, but have the same activity matrix **X**, the system which has the highest dominant *wage-profit* curve exhibits the highest technological progress.

Figure 1.



Furthermore, all the possible linear combinations of two sets of methods will result in a set of *wage-profit curves* or *frontiers* which will be dominated by one of the two original wage-profit curves.

The *VFZ-technological frontier* is a piecewise function. The points on the VFZ-*technological frontier* are points in which the change from one set of methods to a new set of methods occur. But it is one and only one method which replaces another method. Moreover while the shape of the VFZ-*technological frontier* depends on the *numéraire* the value of the profit rates at the switch points are independent of it. Independent of the *numéraire* are also the production methods used for the particular piece of the piecewise VFZ-*technological frontier*.

The *VFZ-technological frontier* can be used to measure the technological progress and the relative economic performances of the different economic systems, countries. Zambelli and Fredholm (2010), based on the *VFZ-technological frontier* have constructed two different indices of performance: the VFZ-*index* and the VFZ-*ranking*.

The VFZ-*index* measures the level of development as the ratio between the system specific *wage-profit curve* and the VFZ-*technological frontier*.

The VFZ-*index* is dependent on the choice of the *numéraire*, but has the advantage of assessing the degree of economic backwardness or forwardness in terms of the globally efficient production frontier captured by the VFZ-

technological frontier. In essence it is an assessment of the actual development of the particular national system with respect to the benchmark represented by the VFZ-technological frontier. Its highest possible value is one.

The VFZ-*ranking* computes the relative performances based on the contribution of the economic systems to the formation of the efficient global VFZ-technological frontier. As Bharadwaj (1969) has shown, the switch points of the *wage-profit frontier* are independent of the *numéraire* and hence the contributions of the economic systems do not change with it. A ranking between the different systems can be made by exploiting this fact. Obviously an economic system that contribute substantially and more than others to the formation of the VFZ-*technological frontier* can be considered as being forward in technological development with respect to those not contributing at all[4].

This does not mean that we have to expect that the economic system necessarily performs better than others. Whether this technological forwardness is actually exploited so as to assure, for example, full employment level or high level of per-capita output or income is another matter which is not discussed in this paper.

It has to be stressed that the VFZ-*index* is an 'absolute' measurement of actual potential economic performance, while the VFZ-*ranking* is a 'relative' measure of the access to more advanced, and potentially more productive, industry level production methods.

The computations of these two indices require the computation of the VFZ-technological frontier. Hence, for the reason explained above, they have never been computed before (to the best of our knowledge).

[4] In order to take account also of methods that are not the most 'efficient' ones, but that are almost as efficient as the most efficient, Zambelli and Fredholm (2010) have generated a scheme in which methods can be ordered as being first, second, third, ... and last. A method would be ranked second when the method ranked first is removed from the set of methods and it is the one that would contribute to the new, and lower, VFZ-*technological frontier*. It would be ranked third when the methods ranked first and second are removed and would contribute to the new VFZ-*technological frontier* and so on.
Once these rankings have been generated they are aggregated using the Borda Counts weights. That is, the first would weighted with value 1, the second with value 1/2, the third with value 1/3 ... the N^{th} with value 1/ N^{th} (Obviously this choice is an arbitrary one). These values are used to determine the ranking of the different regions by summing all the values associated to the methods of the region. Clearly if the methods employed in a region are all superior with respect to the others**,** the highest value would be equal to the number of commodities. Hence it is appropriate to normalize this value with respect to the number of commodities, i.e industries or sectors. In this way the highest possible performance value, as in the case of VFZ-*index* would be 1, but in this case a high performance of one region would imply a much lower performance of the other regions.

3. Source and preparation of the data and the choice of numéraire

The regions examined in this study are Trentino, Sicily, Piedmont, Tuscany, Campagnia, Emilia-Romagna, Veneto, and Lombardy. From an administrative viewpoint, Trentino is an autonomous province of Italy and it is one of the two provinces which make up Italy's region of Trentino-Alto Adige. The input-output tables for the above regions are made available by the Regional Institute Economic Planning of Tuscany (Irpet), apart from the input-output table for Trentino, which is made available by the Statistical Office of the province of Trento. The data were limited only to two years: 2001 and 2004. All the input-output tables are based on the ESA 95 – NACE Rev.1 classification with 30 industries.

Given that all the data reported in the tables are in current basic prices, industry deflators have been computed and used to deflate the table. The deflated table can be regarded as proxies for the physical flows among industries for the selected regions.

Labour data are taken from the Regional accounts available on the website of the National Institute of Statistics. Labour input is measured as number of workers weighted by an index of hours worked in each sector and year. Labour data are not available at the same level of industry detail of the input-output tables; therefore there is a lack of coincidence between the sector labour input and the sectoral input-output data. Hence, some labour input data were decomposed into smaller aggregate classes so as to fit with the sector subdivision of the tables.

The 30 industries must be aggregated 'down' to 27 in order to ensure comparability.

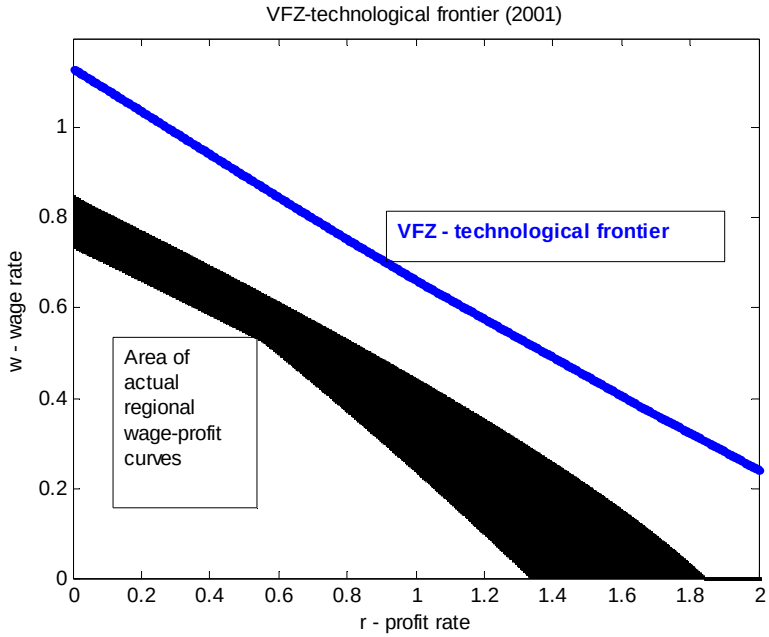
As a *numéraire*, we have used the bundle of goods formed with the average of the regional per-capita individual industry net national product relative to 2001[5]

[5] For the 27 sectors the bundle used, *numéraire*, is the following: 1.75; 0.17; 5.51; 6.15; 0.87; 2.27; 1.73; 3.51; 1.46; 1.68; 4.59; 6.49; 4.23; 4.69; 2.21; 0.97; 5.83; 11.68; 3.85; 5.39; 1.97; 2.79; 5.09; 3.01; 4.24; 2.66; 5.20. The sum of the above weights give 100.

Table 1. Income of per unit of employment. Relative positions with respect to the highest income (Emilia Romagna – 2004)[6]

Region	2001		2004	
	Income per unit of labor %	Position	Income per unit of labor %	Position
Trentino	97.8	3	96.8	2
Sicily	90.0	7	89.1	7
Piedmont	95.7	6	95.1	5
Lombardy	98.8	2	95.9	4
Veneto	97.8	4	96.4	3
Campagnia	83.1	8	82.3	8
Emilia Romagna	99.2	1	**100**	1
Tuscany	96.6	5	94.2	6

Figure 2.



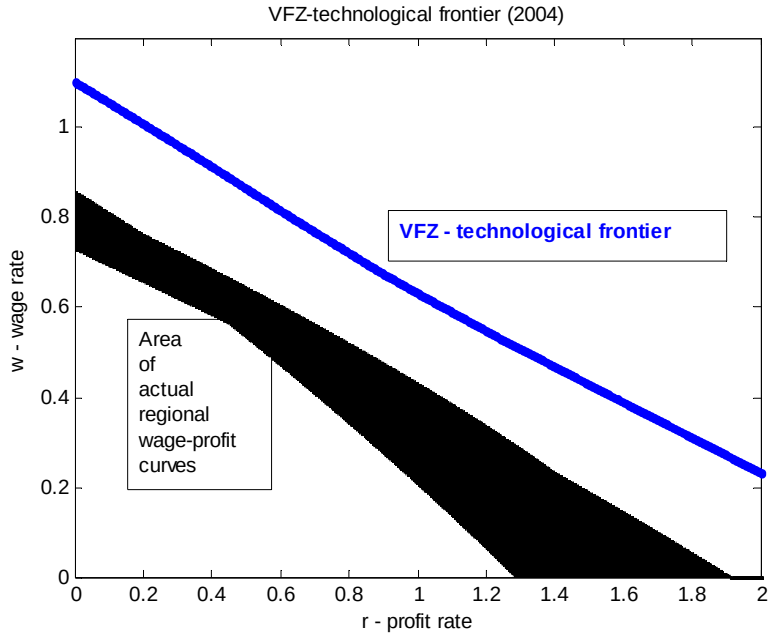
[6] The values of income per unit of employment have been computed using the imputation or production prices, that is, with prices that have been generated with the numeraire values of the previous footnote. Strictly speaking the value of income is not actual market generated income, but the average of the income estimated using the imputation prices and for a range of the share of income variable, the profit rate *r*. For the values reported in the table the profit-rate interval goes from 02 to 0.45.

4. Empirical analysis

4.1. The technological frontiers

Figures 1, 2 and 3 show the VFZ-*technological frontier* and the area of actual regional *wage-profit curves*. The distance between the VFZ-technological frontier and the actual wage-profit curves is noticeable. This indicates that there is plenty of room for possible technological improvement.

Figure 3.



Tables 1-2 report the contributions of the different regions to the 2001 and 2004 VFZ-*technological frontiers*. The first row indicates the value of the rate of profit at switch points, while the other rows indicate the number of the regions that have the dominant technique in each industry. In each column, except the first, the number of the region in industry where the switch of methods occurs is in brackets.

There are two items of particular interest in the two technological frontiers. First, the large number of dominant techniques found in Trentino. In 2001, Trentino had 10 dominant techniques out of 27 for profit rate values between 0 and 0.274. This number then gradually decreases for higher values of the rate of profit, but remains noteworthy. Secondly, a considerable number of dominant techniques have been found in Sicily and Campagnia, though these two regions were the worst in terms of aggregate productivity. Alternatively, one could also stress the low number of dominant techniques found in Emilia-Romagna and Veneto, despite the

fact that these two regions were the best in terms of aggregate productivity (see Degasperi 2010).

A comparison between the two tables shows that there were only minor changes from 2001 to 2004. Practically, this means that if a region had the dominant technique in an industry in 2001, it had the dominant technique in the same industry in 2004.

We now observe the values of the profit rate at every point of change. What emerges is that the switch points are uniformly distributed along the spectrum of possible profit rates.

A comprehensive examination of the VFZ-technological frontier highlights two important aspects.

The first concerns the number of switch points and their distribution on the frontier. The switch points are less than those found in Fredholm and Zambelli (2009), both in the contemporary and inter-temporal frontiers. As the two authors note, the number of points increase with the number of available techniques and this explain the low number of switch points in this study.

The second aspect is that no region at a single point in time dominates the entire technological frontier. Hence, all regions could potentially gain through greater integration.

Tables 4 and 5 present the VFZ-*ranking numéraire*-free values for 2001 and 2004. The values are parametrized for the number of sectors. Consequently if a region dominates the entire technological frontier the absolute value would be 1.

Trentino is the region with the highest value both in 2001 and 2004 followed by Sicilia and Emilia Romagna.

There are no relevant differences between the two years examined. Campagnia moves up from the sixth to the fourth position of the ranking, while Lombardia and Tuscany loose one position.

Table 2. Contemporary frontier – 2001 (The switch points are in brackets).

Industry / Rate of Profit	0,274	0,343	0,498	0,635	0,702	0,830	1,019	1,065	1,259	1,390	1,521	1,664	1,983	2,182	2,425	2,460	2,568	2,574
Agriculture and Fishing	4	4	4	4	4	4	4	4	4	4	4	4	4	(8)	8	8	8	8
Extraction of minerals	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Mfr. of Food, Beverages and Tobacco	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Mfr. of Textiles, Wearing Apparel, Leather	1	1	(2)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Mfr. of Wood and Wood Products	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Mfr. of Paper Products, Printing and Publishing	1	(2)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Mfr. of Refined Petroleum	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Mfr. of Chemicals and Man-Made Fibers Etc.	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Mfr. of Rubber and Plastic Products	8	8	8	8	8	8	8	8	8	8	8	(6)	6	6	6	6	6	6
Mfr. of Other Non Metallic Mineral Products	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Mfr. And Processing of Basic Metals	8	8	8	8	8	(2)	2	2	2	2	2	2	2	2	2	2	2	2
Mfr. of Machinery and Equipment n.e.c.	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Mfr. of Electrical and Optical Equipment	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Mfr. of Transport Equipment	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Mfr. of Furniture, Mfr. n.e.c	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Electricity, Gas and Water Supply	4	4	4	4	4	4	4	4	4	4	(3)	3	3	3	3	3	3	3
Construction	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Wholesale and Retail Trade	4	4	4	4	4	4	(3)	3	3	3	3	3	(1)	1	1	1	1	1
Hotels and Restaurants	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Transport, Post and Telecommunications	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Financial Intermediation, Insurance	2	2	2	2	(1)	1	1	1	1	1	1	1	1	1	1	1	1	1
Computer, Research and Development, Consultancy	1	1	1	1	1	1	1	1	(6)	6	6	6	6	6	6	6	6	6
Public Administration	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Education	8	8	8	8	8	8	8	8	8	8	8	8	8	8	(7)	(2)	2	(6)
Health Care Activities Etc.	6	6	6	6	6	6	6	6	6	(1)	1	1	1	1	1	1	1	1
Other Service Activities	1	1	1	1	1	1	1	(2)	2	2	2	2	2	2	2	2	2	2
Renting of Machinery	1	1	1	(5)	5	5	5	5	5	5	5	5	5	5	5	5	(3)	3

Trentino=1; Sicily=2; Piedmont=3; Lombardy= 4; Veneto=5; Campagnia=6; Emilia Romagna =7; Toscana=8.

Table 3. Contemporary frontier – 2004 (The switch points are in brackets).

Industry / Rate of Profit	0,098	0,543	0,589	0,628	0,632	0,681	0,879	0,892	1,020	1,221	1,243	1,414	1,535	1,710	2,066	2,076	2,162	2,569
Agriculture and Fishing	4	4	4	4	4	4	4	4	4	4	4	4	4	4	(8)	8	8	8
Extraction of minerals	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Mfr. of Food, Beverages and Tobacco	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8
Mfr. of Textiles, Wearing Apparel, Leather	1	1	1	1	(2)	2	2	2	2	2	2	2	2	2	2	2	2	2
Mfr. of Wood and Wood Products	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7	7
Mfr. of Paper Products, Printing and Publishing	7	7	(2)	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Mfr. of Refined Petroleum	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Mfr. of Chemicals and Man-Made Fibers Etc.	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Mfr. of Rubber and Plastic Products	8	8	8	(6)	6	6	6	6	6	6	6	6	6	6	6	6	6	6
Mfr. of Other Non Metallic Mineral Products	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3	(6)
Mfr. And Processing of Basic Metals	8	8	8	8	8	8	(2)	2	2	2	2	2	2	2	2	2	2	2
Mfr. of Machinery and Equipment n.e.c.	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Mfr. of Electrical and Optical Equipment	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Mfr. of Transport Equipment	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Mfr. of Furniture, Mfr. n.e.c	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Electricity, Gas and Water Supply	5	(4)	4	4	4	4	4	4	4	4	4	4	(6)	6	6	6	6	6
Construction	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Wholesale and Retail Trade	4	4	4	4	4	4	4	4	(3)	(2)	2	(1)	1	1	1	1	1	1
Hotels and Restaurants	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Transport, Post and Telecommunications	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Financial Intermediation, Insurance	2	2	2	2	2	(1)	1	1	1	1	1	1	1	1	1	1	1	1
Computer, Research and Development, Consultancy	2	2	2	2	2	2	2	2	2	2	2	2	2	(6)	6	6	6	6
Public Administration	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4	4
Education	8	8	8	8	8	8	8	8	8	8	8	8	8	8	8	(6)	6	6
Health Care Activities Etc.	6	6	6	6	6	6	6	6	6	6	(1)	1	1	1	1	1	1	1
Other Service Activities	1	1	1	1	1	1	1	(2)	2	2	2	2	2	2	2	2	2	2
Renting of Machinery	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	(3)	3

Trentino=1; Sicily=2; Piedmont=3; Lombardy= 4; Veneto=5; Campagnia=6; Emilia Romagna =7; Toscana=8.

Table 4. VFZ-*ranking:* index of relative economic performance – 2001

Position	Region	Value
1	Trentino	0.4958
2	Sicily	0.3898
3	Emilia – Romagna	0.3499
4	Tuscany	0.3233
5	Lombardy	0.3151
6	Campagnia	0.3127
7	Piedmont	0.2721
8	Veneto	0.2591

Table 5. VFZ-*ranking*: index of relative economic performance – 2004

Position	Region	Value
1	Trentino	0.4818
2	Sicily	0.4073
3	Emilia – Romagna	0.3561
4	Campagnia	0.3367
5	Tuscany	0.3107
6	Lombardy	0.3034
7	Piedmont	0.2671
8	Veneto	0.2548

Tables 6 and 7 contain the values of VFZ-*index*. It is a measurement of the distance the VFZ-technological frontier and the actual regional wage-profit curves.

5. Conclusion

This paper makes an attempt to measure technological progress from the information embedded in regional input-output tables. We select information from 8 Italian regions, 2001 and 2004.

The measurements of productivity presented here are also standard elaborations based on a particular notion of imputation prices. Using these

prices we have computed a measurement of productivity which is based on the notion of net national product. Table 1 reports these computations which are straight forward calculations and do not measure technological progress,

Table 6. VFZ-*index* - 2001

Position	Region	Value
1	Trentino	0.6332
2	Sicily	0.5776
3	Tuscany	0.5626
4	Emilia Romagna	0.5527
5	Veneto	0.5465
6	Piedmont	0.5351
7	Campagnia	0.5211
8	Lombardy	0.4890

Table 7. VFZ-*index* - 2004

Position	Region	Value
1	Trentino	0.6153
2	Sicily	0.5842
3	Emilia Romagna	0.5551
4	Tuscany	0.5484
5	Piedmont	0.5333
6	Veneto	0.5281
7	Campagnia	0.5259
8	Lombardy	0.4636

but productivity. For the years 2001 and 2004 we see that Emilia Romagna has had the highest generation of net income per unit of employment and that Sicily and Campagnia are respectively penultimate and last. While the Trentino has moved up from 3rd position to 2^{nd,} and the Veneto from 4th to 3rd, Piedmont from 6th to 5th, Lombardy has dropped from 2nd to 4th, Tuscany from 5th to 6th .

Campagnia has a productivity measure which is almost 20% less and Sicily is around 10% below the productivity level of Emilia Romagna. For

these two regions these numbers are a matter of concern especially when one considers the low level of employment of these two regions.

We think that one has to distinguish between the actual labor productivity and the level of technological backwardness and forwardness Labor productivity can be the result of a complex set of causes that may have little to do with actual technological progress, but can be determined by policy, a particular choice of activity levels, and the particular infrastructure. Clearly, in the case of heterogeneous production the economic efficiency of the individual methods of productions do depend on the structure and on the interdependence with the other sectors.

Here we propose the VFZ-*technological frontier* (see Fredholm and Zambelli. 2009, Zambelli and Fredholm. 2010) as a benchmark against which to measure actual and potential technological forwardness or backwardness of an economic region. Using this concept we have defined (following Zambelli and Fredholm, 2010) two indicators of technological progress, the VFZ-*ranking* and the VFZ-*index*. These measures are independent of the activity levels and are independent of scale.

Using the information of the VFZ-*ranking* we are able to give a measure of relative performance in terms of regional technological progress. This indicator expresses the degree in which a method of production, relative to a specific region, is leading with respect to the other regions. Tables 4 and 5 give these rankings. A 'winner' seems to be the Trentino. The second position of Sicily seems, at first, to be surprising. In terms of the labour productivity of Table 1, Sicily was performing very poorly, but here it is performing well. Our result indicates that Sicily has high potentials for growth and hence the low productivity performance is not to be attributed to technological backwardness, but to other factors. Also the case of Campagnia is a similar one. Campagnia is the lowest in terms of actual productivity, but 4^{th} in terms of the forwardness of some of the sectors. Equally surprising is the performance of the Veneto and Lombardy regions. Our results indicate that these regions have sectoral aggregated production methods that are not advanced. Contrary with respect to Sicily and Campagnia these two regions have high actual productivity. This indicates that, ceteris paribus, these two regions have lower potential for growth with respect to that of other regions. The situation of both the Trentino and Emilia Romagna seem to be particularly favourable. Their good performances and

their position in terms of the VFZ-rankings indicate that there potentials have, up to a degree, been exploited and that their sectors can constitute an engine for further development.

While the VFZ-ranking is a measurement of relative performance the VFZ-*index* does measure the distance in terms of the technological progress between the actual regional positions and the potential captured by the VFZ-*technological frontier*. Please note that our measure is independent of the production level, the actual employment levels and the actual market prices, but it depends almost exclusively on the specific regional methods of production that are used to generate a 'global' measure. This is in a way the strength of our approach. This allows us to compare economies with different scales and is independent of contingent short run market factors. When comparing the results of the VFZ-*index* we have some surprising results. From Tables 6 and 7 we see that all the regions are very far from the potential expressed by the VFZ-*technological frontier*. The maximum value would be 1 and all the regions are a little above 50%. This is also clear from Figures 2 and 3. The details of the measure indicate leadership of the Trentino and second position for Sicily and indicate a problematic state of Veneto, Campagnia and Lombardy.

Clearly the results presented here have to be interpreted and compared with the results and data of other studies. We leave this task to those that might be better qualified to do so. What we want to stress is that the tools we have presented (the VFZ-*technological frontier*, the VFZ-*ranking* and the VFZ-i*ndex*) may be used to shed light on the actual forwardness and/or backwardness of a region. In particular our results indicate (see Table 1) that on one hand Emilia Romagna, Lombardy, Trentino and Veneto have an actual structure of production that allows a relative high production per worker, but on the other hand (see Tables 3 to 7) the reading of our indices indicate that the Trentino, Sicily Emilia Romagna and Tuscany have the highest embodied technological progress.

When we intersect the two sets of observations it turns out that it is only Emilia Romagna and the Trentino that have both the characteristics of exhibiting a high level of actual productivity per worker and have at the same time a high level of embodied technological progress.

Whether the results presented here allow us to claim that we observe an Emilia Romagna/Trentino model which is superior with respect to the

Veneto/Lombardy model is quite another matter. Further studies on this issue would have to be made.

Surely our data indicates interesting directions for research and require further interpretations.

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