Some features of deindustrialisation in EU15 during the period 1999-2004: a multivariate analysis

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Abstract During the past 40 years, employment in manufacturing, as a share of total employment, has steadily fallen in the world’s most advanced economies. In this paper the causes and the different modalities of deindustrialisation process are examined closely with reference to 13 of the first EU15 countries. The aim of the analysis is to empirically explore if deindustrialisation is primarily a natural outcome associated with the development of modern societies or, on the contrary, can be defined a symptom of the failure of a country manufacturing sector. To this end, the Analysis of Principal Components (PCA), applied on a n-way matrix, is used to obtain a synthesis of the factors influencing deindustrialisation. The multivariate analysis was carried out on the Eurostat data for the period 1999-2004, at a disaggregated level of manufacturing (i.e. Nace divisions), considering simultaneously the time, the regional and the sectorial effects.

The estimates indicate that the main factors responsible of the dynamics of deindustrialisation have been efficiency and the scale of production processes in various manufacturing activities.

Keywords European Union · Industry Studies and Structural Change · Deindustrialisation · Principal Component Analysis

Riassunto Il fenomeno della deindustrializzazione, che ha connotato i sistemi economici più avanzati è stato analizzato, fin dagli anni ’70 del secolo scorso, dal punto di vista macroeconomico, ma i mutamenti che avvengono a livelli disaggregati dell’attività produttiva consentono di distinguere le modalità in cui si è manifestato questo processo. Gli economisti hanno manifestato una certa preoccupazione di fronte ai cambiamenti avvenuti nella struttura produttiva...
ritenendo che il fenomeno, attribuibile a cause diverse (perdita di competitività, crowding out ad opera del settore pubblico, aumenti della produttività del lavoro nel manifatturiero), possa determinare una perdita di benessere nei Paesi interessati. In letteratura sono state formulate altre interpretazioni che convergono nel considerate la deindustrializzazione una conseguenza naturale dello sviluppo di un’economia postindustriale che riflette differenti condizioni della domanda e dell’offerta nel lungo periodo. In generale, negli studi effettuati sono state impiegate analisi univariate a livello macro, per valutare la portata e gli effetti della deindustrializzazione nelle economie “mature” man mano di produrre una visione complessiva delle dinamiche che si sono registrate. Ma un’analisi condotta mediate singole proxy non consente una disamina congiunta di tutti gli elementi pertinenti, né può spiegare come il processo avvenga presso realtà territoriali e periodi storici differenti. Per quanto rilevato, nel presente lavoro, è stata condotta un’analisi multivariata per ottenere una descrizione del processo di deindustrializzazione valutando il fenomeno nella sua interezza e, altresì, la sua dipendenza dai fattori interni al settore manifatturiero. In una prima fase, mediante l’Analisi delle Componenti Principali (ACP), applicata a una matrice a più vie, è stata identificata la struttura latente del manifatturiero nel suo complesso, con riferimento a 13 dei primi Stati membri dell’UE, i soli di cui erano disponibili i dati completi per il periodo 1999-2004. Nello specifico, l’ACP è una tecnica esplorativa che consente di ottenere un’informazione sulla struttura interna dei dati per identificare gli aspetti più significativi (in termini di variabili latenti e punti compromesso) che influenzano l’intero fenomeno in esame. I risultati ottenuti, in termini dei principali fattori e della relativa dinamica, hanno indotto successivamente a tracciare l’evoluzione a un livello di disaggregazione che tiene conto della diversità delle attività comprese nel manifatturiero, permettendo al tempo stesso un confronto diretto tra i singoli Paesi, riguardo alle cause e alle modalità dei processi di deindustrializzazione. Per raggiungere gli obiettivi preposti, sono stati impiegati, per ognuno degli Stati membri, i dati delle 23 divisioni (a due cifre), che la classificazione NACE prevede per le attività manifatturiere, relativamente all’intervallo 1999-2004, il solo periodo per cui l’EUROSTAT fornisce l’informazione statistica completa a questo livello di disaggregazione. Dall’analisi effettuata è emerso che le variazioni registrate possono essere spiegate soprattutto da due fattori: l’efficienza e la scala delle operazioni. Nel periodo in esame si nota che la prima è aumentata mentre la seconda si è ridotta. Si può, conseguentemente, dedurre che la deindustrializzazione si accompagna in modo prevalente all’incremento nei livelli di efficienza dei processi produttivi e, in misura minore, alla diminuzione della scala a cui vengono svolti gli stessi. Il risultato riguardante il manifatturiero europeo nel suo complesso si è riproposto a tutti i livelli di disaggregazione considerati (territoriale e settoriale) rimarcando il carattere di generalità che contraddistingue la struttura latente identificata, seppure con differenze connesse alle specificità dei vari contesti a cui si si riferisce l’analisi.

Parole chiave Unione Europea - Cambiamenti della struttura industriale - Deindustrializzazione - Analisi delle Componenti Principali
1 Introduction

Since the early 1970s a great amount of research has been carried out into the process of deindustrialisation occurring in many advanced economies.

In those countries the relative importance of the industrial sector has decreased due to a decline in production, employment and investments.

According to Blackaby (1978), Jones and Lee (1985), Stanners (2001) and Gallino (2003), this fact has been caused by a loss of competitiveness within the industrial sector and could negatively affect future generations. In this context, the symptoms of deindustrialisation are recognizable from the reduction in the share of the workforce employed in industry and/or in the share of added value on GDP. In many cases it is also evident from the growing value of manufactured imports in the trade balance and in the contemporary decline in manufactured exports (Singh, 1977).

Other authors (Rowthorn, Wells, 1987; Baumol et al., 1989) interpreted deindustrialisation as the natural consequence of development in a post-industrial economy, reflecting the different conditions of demand and supply arising in the long term. More specifically, according to the “stages of growth” hypothesis deindustrialisation is a long-term phenomenon explained by the progressive advantage of the tertiary sector over industrial activities, caused by the shift in domestic expenditure (Clark, 1957; Gershuny, 1978; Gemmel, 1986).

Both explanations, despite being based on different premises, employ the same instruments to deal with the subject: i.e. macro-level univariate analyses whose aim is to evaluate the effects of deindustrialisation in various economies.

The concept of deindustrialisation is, nevertheless, herete complex and an analysis carried out by means of a single proxy doesn’t allow a full investigation of all the relevant issues; nor it can explain how the process takes place.

On the contrary, in this paper a multivariate analysis is used. Specifically, a n-way PCA is applied to the data of European countries by considering simultaneously the time, the regional and the sectorial effects.

According to this method it is possible to identify the key factors that influenced the manufacturing sector dynamics in EU15, before the enlargement occurred in 2004 when other 10 countries were admitted to take part in this supranational institution.

Specifically, I considered the manufacturing sector of each EU15 country from 1999 to 2004, the only period for which a complete information is at disposal, at the chosen disaggregation level (NACE Divisions).

The empirical analysis has been performed on the data from industrial Censuses recorded by the European Statistical Institute (EUROSTAT). Consequently, only the old member states were considered over the period 1999-2004 to understand the causes and, possibly, the main effects of deindustrialisation.

The paper is organised into five parts: section 2 gives an overview of the literature on the issue and outline the productive dynamics of whole EU15, as reflected by some economic indicators; section 3 features a brief explanation of the technique known as “Principal Component
Analysis" (PCA) applied to a $n$-way matrix; in section 4 the PCA technique is applied to the European manufacturing data; finally, concluding remarks are presented in section 5.

2 An overview of the debate

2.1 Limits of the different theories on deindustrialisation

Apart from conceptual standpoints, the difficulty in accepting explanations provided by the economists, about the source and effects of deindustrialisation, depends on several factors:

a) the scope of analysis. The arising question is: Should the research address the industrial sector as a whole or just be limited to manufacturing?

b) the level of the analysis. In this regard it should be noted that the results can be different depending on the selected disaggregation level;

c) variables used in the measurement. Even the measures used for the analysis (employment, production, value added, investments) can represent a source of errors or uncertainty in the evaluation of the process, particularly if some variables are affected by the influence of inflation$^1$;

d) the business relations with other economic systems at a different development level.

Regarding a) Ferguson (1988, p.169) considered that “any of the measures taken in isolation [from the rest of the economy] (as in often done) presents but a partial view”. Thus, the analysis refers to the simultaneous consideration of the interdependence of all sectors because “the decline in the industrial sector occurs as market forces reallocate resources differently” (p.172) reflecting the changes in demand and supply conditions.

Also for the remark at point b) Ferguson (p.178) stated that “the macroeconomic viewpoint adopted by many economists analysing deindustrialisation is too crude” and many differences inside the industrial sector are neglected. Actually, the industrial sector includes different kinds of activities that are subject to a wide variety of influences and which have dissimilar performances.

This opinion is also supported by research carried out into the changing industrial composition of employment due to “the outsourcing to the service sector of activities previously undertaken by employees in the manufacturing sector” (Watts, Valadkhani 2001, p. 2), with the consequent growth in the relative importance of the tertiary sector.

$^1$ According to Rodrik (2015, p.1), “manufactures output at constant prices has held its own comparatively well in the advanced world, something that is typically overlooked since so much of the discussion on deindustrialization focuses on nominal rather than real values”.

Regarding c), the process of deindustrialisation is normally measured by just a few variables: the share of manufacturing employment (Penava, Družić, 2015; Rodrik, 2016), the share of manufacturing value added in GDP (Rowthorn, Ramaswamy, 1999; Rowthorn, Coutts 2013; Grodzicki, 2014; Palma 2014) or by setting the real GDP index against the Index of Industrial Production (IPI hereafter) (Stanners, 2001).

Owing to the lack of direct measures of deindustrialisation, the dynamics underlying the phenomenon doesn’t emerge clearly. Therefore, it is impossible to draw unambiguous conclusions about its effects (particularly in the long term).

Finally, about d), it is necessary to take into account the commercial relations with other countries. In the opinion of Rowthorn and Ramaswamy (1997) deindustrialisation is also caused by external factors as foreign trade, that affects the internal structure of an economy in various ways. Specifically, international relations can impact on manufacturing employment in countries that export goods characterised by high levels of technology and import goods from “the new competitors, combining low labour costs with large productivity levels”, thus lowering “international prices for manufactured products”² (Boulhol, Fontagné 2006, p.9).

Concerning the external effects, Brady and Denniston (2006, p.297) consider the effects of globalization on deindustrialisation finding that “globalization has a curvilinear, inverted U-shaped relationship with manufacturing employment”. Their results, however, are not unequivocal because of “different varieties of capitalism, regions and historical periods” of the countries where the phenomenon occurs.

Indeed, also being typical of western economies, a “premature deindustrialization” (Palma, 2014) has recently characterized many developing countries that “are turning into service economies without having gone through a proper experience of industrialization” (Rodrik, 2016, p. 2).

It is noteworthy that the evaluation proposed by Mickievicz and Zalewska (2006, p. 159) for European eastern countries does not consider in a negative way the phenomenon because “given lower capital rehersements and possible competitive advantage of the transition economies in terms of human capital, the greatest opportunities for generating productivity increase and economic growth may be in the service sector”.

According to Penava and Družić (2015, p. 845), also now “deindustrialisation at lower levels of income in formerly socialist (developing) countries is still mainly uncharted territory.” However, the Authors conclude (p. 851) that the process of deindustrialisation in Croatia is characterised by different factors relative to developed countries because “deindustrialisation occurred just after Croatian independence” and was due to “profound structural differences” compared with western economies.

² To produce the first type of goods it is necessary to employ a small amount of skilled labour while the same value of other goods reherses a widespread use of cheap labour in capital-saving industrial processes. Such a framework of foreign trade, consequently, brings about a scaling down of employment in the manufacturing sector of the most advanced economies.
The same opinion is shared by Rodrik (2015, p.1) when asserts that “in the developing countries trade and globalization likely played a comparatively bigger role” against the presumptive causes of deindustrialisation in the advanced countries.

Lastly, the analysis by Palma (2014, p.19) proves that “countries of the former Soviet Union and Eastern Europe, […] experienced a process of de-industrialisation associated with a fall in income per capita that was associated with a reduction in manufacturing employment backwards: a case of ‘reverse’ de-industrialisation”.

2.2 A general view of the economic structure of EU15

Following the suggestion of Stanners (2001), the analysis begins with a comparison, referred to the period 1995-2005, of real GDP and IPI of 13 EU countries.

FIG.1. Dynamics of GDP and IPI in EU13 (2000=100)

In Fig. 1, two periods can be traced out: one (1995-2000) where IPI tracks GDP and the other (2000-2005) where there is a clear divergence. Precisely, in the first five years, GDP shows an average increase of 5.35% per annum while in the six last years this drops at an average yearly rate of 3.38%.

3 For this period, Eurostat data only enable a full comparison for thirteen of the EU15 Member states as information for Greece and Luxembourg is incomplete.
On the other hand, IPI in the first period grows by 2.73% per annum while in the second one the yearly average increase is only 0.43%. In other words, the industrial sector grows less than the total economy and in the last years it raises much more slowly.

The shortness of the period considered does not show an adequate picture of the dynamics that has shaped the EU’s economy; so the analysis has been extended to the interval 1986-2004 but only for IPI, the only variable supplied by Eurostat for this time span with regard to the 13 EU countries.

**FIG. 2. Evolution of GDP and IPI in EU13 (2000=100)**

![Graph showing GDP and IPI from 1986 to 2004](image)


From Fig. 2 the diversity in trends between GDP and IPI emerges more clearly.

The evolution of GDP, as a measure of global production activity, strongly depends on the service sector dynamics. The dissimilar behaviour of the two indicators reiterates a clearer verification to find new evidence of a prospective process of deindustrialisation.

For this reason, manufacturing employment was compared with total employment for the period 1995-2004. Fig. 3 shows that the two lines present a very similar evolution until 2000 but, thereafter, the discrepancy between the two trends is even more noticeable than the one detected in the previous matching.
Indeed, while total employment in EU countries continues to rise at about 1% per annum, since 2000 the number of workers employed in the manufacturing sector declines\(^4\) at an average yearly rate of 1.53%.

**FIG. 3. Evolution of total and manufacturing employment in EU13 (2000=100)**


Fig. 3 shows in a more apparent way the divergence between manufacturing employment and global employment.

Given the complexity of the process of deindustrialisation, it is useful to have an empiric tool producing a global synthesis and, at the same time, an evaluation of the alterations sustained by the productive structure(s) in the EU, at an intermediate level between macro and micro, with each matching the other.

In the opinion of Ferguson and Ferguson (1994, p. 257), “[d]isaggregated data need to be considered if the changes occurring are to be better understood”.

For this reason, here a more complete analysis of the available information has been performed in order to consider the composition and the dynamics of European manufacturing structure, with the aim of identifying the causes of deindustrialisation.

\(^4\) It is worth noting that Rowthorn and Ramaswamy (1997) had already outlined that in the EU15 countries “the share of manufacturing employment stood at a comparatively high level of more than 30 percent in 1970 but then fell steeply to only 20 percent by 1994”. 
Now the purpose is to find a plausible answer to reconcile the prevailing opinions on the topic by analysing the internal dynamics of the EU industrial sector by means of a simple strategy highlighting the principal features of the productive structure of the member states. More specifically, in the event that a "weakening" of manufacturing - in terms of its sectorial composition - can cause some concern for future growth, the analysis should "also" be carried inside this sector, through a comparison of the different activities constituting it.

3 The n-way Principal Component Analysis

Without an \textit{a priori} model, the (PCA) applied to a \textit{n-way} matrix extracts from a complex set of data the main aspects of a phenomenon, due to the time, space and structure.

The principles on which this analysis is based (Bolasco, 1999) are:

\textit{Thrifthiness} in the representation (by mathematical models and graphics) of a data set reduced to few meaningful dimensions;

\textit{Fundamental strength} of analysis, as it is possible to highlight the data's latent structure also with data showing random measurement errors and in the absence of distributive links;

\textit{Immediate visibility} by means of graphic representations as these may help researchers, whose statistic knowledge is elementary, to be autonomous in interpreting - by using scatter-plotting - the results obtained from the analysis.

The starting point for the analysis is constituted by the construction of a metrical data matrix (units per attributes) from which a similarity matrix is obtained (generally a correlation or variance and covariance matrix) among variables (or among units). The purpose is to transform connections between variables into indirect relations due to the action of few sufficiently informative PCs (Principal Components or factors) reproducing a suitable synthesis of the original information.

Generally, the PCA "reduces the complexity" of reality and has the double aim of both simplifying the interpretative models and achieving a conceptual clarification that allows a data reduction.

A two-way orthogonal PCA, applied to correlation matrix \(X'X\), may be represented through the following matrix notation:

\[(1) \quad X = FA' + E\]

where:
- \(X = [x_{mi}]\) is the data matrix with \(m = 1, 2, \ldots, n\) observations and \(i = 1, 2, \ldots, p\) observed variables
- \(F = [f_{mj}]\) with \(j = 1, 2, \ldots, q\) is the matrix of latent variables normalised or PCs, with \(q \leq p\);
- \(A' = [a_{ij}] = [\tilde{r}_{ij}]\) is columnwise orthonormal, and is the correlation coefficients estimates matrix measuring the existent similarity between each variable and each PC;
- \(E = [e_{mi}]\) is the specific component matrix or error variables.

The application of this model has a double purpose:
(a) it expresses each variable as a linear function of the single principal components, each one with its own PC coefficient, plus an error component \( (e_i) \):

\[
(2) \quad x_i = \sum_{j=1}^{q} a_{ij} f_j + e_i
\]

(b) it expresses the single principal components as a linear combination of all the observed variables, each one with its own loading component \( (w_{ji}) \):

\[
(3) \quad f_j = \sum_{i=1}^{p} w_{ji} x_i
\]

where \( w_{ji} \) is the weight of each principal component.

The purpose is to minimize the sum of squared residuals:

\[
\sum_{n=1}^{n} \sum_{m=1}^{m} e_{mi}^2.
\]

In matrix algebra, this result is obtained as \( |X - AF'|^2 \), which is Pearson’s description of PCA as a technique for identifying the ordered components that can explain the maximum amount of variance in the data.

The generalization of PCA applied to a \( n \)-way matrix data set goes back to the mid 1960s and was introduced by Tucker (1966).

Within the Tucker technique it is possible to define a 4-index matrix \( [X_{mzt}] \) (where \( m = \) number of observations, \( z = \) number of objects, \( t = \) number of occasions and \( i = \) number of variables) from which to extract the matrix decomposed in PCs (Vandeginste et al., 1998; Kiers, Mechelen 2001):

\[
(4) \quad X = X' + E
\]

where \( X' = S*L \), \( E = \) error matrix representing the unexplained part of \( X \),

\( S = \) scores matrix, \( L = \) loadings matrix

Here \( X'_{(m, z, t, j)} \), with \( j = \) number of the new latent factors (PCs) and \( j \ll i \).

In summary, by applying the PCA from the initial matrix, \( X_{(mtz)} \), it can be obtained a matrix of latent variables, \( F = [f_{mtz}] \), and the reconstructed pooled matrix of latent variables, \( \tilde{X}_{(mtz)} \), allowing to calculate separate average values (compromise points) (Rizzi, Vichi 1995).

As the purpose, in the present analysis, is producing complex indexes that can measure changes by latent structure of manufacturing in the EU countries, cubic matrices, \( \tilde{X}_{(mtz)} \), are pooled together to obtain the following 2-way matrices:

\[
(5) \quad \tilde{X}^{a(m)}; \tilde{X}^{b(z)}; \tilde{X}^{c(t)}; \tilde{X}^{j(\cdot)};
\]

where: \( m = \) countries, \( z = \) manufacturing divisions, \( t = \) years and \( j = \) latent variables.

4 Empirical Analysis

4.1 PC Labels and Compromise points

The 4-way matrix PCA is applied on the following variables:

V1 - Gross operating surplus/Turnover (Gross operating rate) (%)
V2 - Labour cost per employee (Unit labour cost)
Some features of deindustrialisation in EU15 during the period 1999-2004

V3 - Gross value added per employee (Labour productivity)
V4 - Investment per employee
V5 - Employees in Manufacturing/Total employees (%)
V6 - Gross investment in tangible goods/Turnover (%)
V7 - Value added at factor cost/Turnover (%)
V8 - Turnover per employee in Manufacturing

The data refer to 23 manufacturing divisions (tab. 1) in each EU13 country in the period 1999 and 2004, the only time span for which Eurostat provides a complete information at this disaggregate level.

In order to obtain the latent dimensions it was necessary to stack the original 4-way matrices in one pooled matrix. By applying the PC method to the supermatrix \( X_{ztmi} \), where \( z \) are 23 manufacturing divisions, \( m \) 13 geographical areas, \( i \) 8 variables and \( t \) 6 years, it is possible to obtain a similarity matrix \( M_{ii} \) which is, in this case, the Bravais-Pearson’s correlation coefficient matrix. From the last one, the component loadings matrix \( A_{ij} \) with \( j \ll i \) has been extracted.

Specifically, three PCs have been drawn with eigenvalues higher than 1 and explaining about 64% of the whole variance. In Table 2, the PC loading coefficients are shown.

The first component, strongly correlated with Labour cost per employee, Gross value added per employee, Investment per employee and Turnover per employee, explains 35% of total variance and represents the “efficiency” of the sector. Indeed, this factor proves to be the most important for the analysis.

Precisely, it shows how investment intensity\(^6\) is strictly correlated with the performance of labour, both in terms of productivity and remuneration.

The second component groups the Gross operating surplus/Turnover ratio and the Share of workforce employed in manufacturing; therefore it can be indicative of the “scale” of productive activity in the sector, explaining about 16% of total variance. On the basis of the loading coefficients, it is evident that the first variable is more influential on the identified component than the second one.

The third component, explaining 13% of total variance, aggregates the ratios: Gross investment in tangible goods/Turnover and Value added at factor cost/Turnover. This component can be considered a measure of the “vertical integration”\(^7\).

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5 See note no. 3

6 According to Caves and Barton (1991), gross capital expenditure has a significant positive impact on evolution of labour productivity, especially when the new equipment installed embodies R&D and innovation in supplier industries.

7 The vertical integration can be chosen by the industrial firms to lower the transaction costs owing to the technological interdependence among various manufacturing activities, to reduce uncertainty in the supply of...
<table>
<thead>
<tr>
<th>CODE</th>
<th>Divisions</th>
</tr>
</thead>
<tbody>
<tr>
<td>DA15</td>
<td>Manufacture of food products and beverages</td>
</tr>
<tr>
<td>DA16</td>
<td>Manufacture of tobacco products</td>
</tr>
<tr>
<td>DB17</td>
<td>Manufacture of textiles</td>
</tr>
<tr>
<td>DB18</td>
<td>Manufacture of wearing apparel; dressing; dyeing of fur</td>
</tr>
<tr>
<td>DC19</td>
<td>Tanning, dressing of leather; manufacture of luggage</td>
</tr>
<tr>
<td>DD20</td>
<td>Manufacture of wood and of products of wood and cork, except furniture;</td>
</tr>
<tr>
<td></td>
<td>manufacture of articles of straw and plaiting materials</td>
</tr>
<tr>
<td>DE21</td>
<td>Manufacture of pulp, paper and paper products</td>
</tr>
<tr>
<td>DE22</td>
<td>Publishing, printing, reproduction of recorded media</td>
</tr>
<tr>
<td>DF23</td>
<td>Manufacture of coke, refined petroleum products and nuclear fuel</td>
</tr>
<tr>
<td>DG24</td>
<td>Manufacture of chemicals and chemical products</td>
</tr>
<tr>
<td>DH25</td>
<td>Manufacture of rubber and plastic products</td>
</tr>
<tr>
<td>DJ26</td>
<td>Manufacture of other non-metallic mineral products</td>
</tr>
<tr>
<td>DJ27</td>
<td>Manufacture of basic metals</td>
</tr>
<tr>
<td>DJ28</td>
<td>Manufacture of fabricated metal products, except machinery and equipment</td>
</tr>
<tr>
<td>DK29</td>
<td>Manufacture of machinery and equipment n.e.c.</td>
</tr>
<tr>
<td>DL30</td>
<td>Manufacture of office machinery and computers</td>
</tr>
<tr>
<td>DL31</td>
<td>Manufacture of electrical machinery and apparatus n.e.c.</td>
</tr>
<tr>
<td>DL32</td>
<td>Manufacture of radio, television and communication equipment and apparatus</td>
</tr>
<tr>
<td>DL33</td>
<td>Manufacture of medical, precision and optical instruments, watches and</td>
</tr>
<tr>
<td></td>
<td>clocks</td>
</tr>
<tr>
<td>DM34</td>
<td>Manufacture of motor vehicles, trailers and semi-trailers</td>
</tr>
<tr>
<td>DM35</td>
<td>Manufacture of other transport equipment</td>
</tr>
<tr>
<td>DN36</td>
<td>Manufacture of furniture; manufacturing n.e.c.</td>
</tr>
<tr>
<td>DN37</td>
<td>Recycling</td>
</tr>
</tbody>
</table>

Source: Eurostat - Classification NACE Rev.1.1

important inputs, to avoid government price controls and taxes in different stages of production process and, not least, to eliminate the possible information asymmetry between upstream and downstream producers.

<table>
<thead>
<tr>
<th>Economic Indicators</th>
<th>Factor 1</th>
<th>Factor 2</th>
<th>Factor 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gross operating surplus/Turnover (%)</td>
<td>0.154</td>
<td><strong>0.854</strong></td>
<td>-0.201</td>
</tr>
<tr>
<td>Labour cost per employee</td>
<td><strong>0.772</strong></td>
<td>-0.216</td>
<td>0.101</td>
</tr>
<tr>
<td>Gross value added per employee</td>
<td><strong>0.889</strong></td>
<td>0.278</td>
<td>-0.049</td>
</tr>
<tr>
<td>Investment per employee</td>
<td><strong>0.767</strong></td>
<td>0.144</td>
<td>0.0003</td>
</tr>
<tr>
<td>Employees in Manufacturing/Total employees (%)</td>
<td>-0.281</td>
<td><strong>0.471</strong></td>
<td>-0.133</td>
</tr>
<tr>
<td>Gross investment in tangible goods/Turnover (%)</td>
<td>-0.017</td>
<td>0.077</td>
<td><strong>0.802</strong></td>
</tr>
<tr>
<td>Value added at factor cost/Turnover (%)</td>
<td>-0.079</td>
<td>0.365</td>
<td><strong>0.581</strong></td>
</tr>
<tr>
<td>Turnover per employee in Manufacturing</td>
<td><strong>0.856</strong></td>
<td>-0.187</td>
<td>0.022</td>
</tr>
</tbody>
</table>

Source: Elaboration from Eurostat database: Selected indicators for all Activities (NACE divisions)

FIG. 4. Trends of the factors identified by PCA inside European manufacturing in the period 1999-2004 (Fact.1=Efficiency; Fact.2=Scale; Fact.3=Vertical integration)

In Fig. 4 the first two latent variables show a clear linear tendency while the vertical integration shows a cyclical behaviour not allowing an interpretation relevant to our analysis.
In view of the less importance that vertical integration holds as third factor, the evolution of this feature of the EU manufacturing structure has not been examined closely; consequently only the dynamics observed on the first factorial plane will be expounded.

However, the results of the present analysis do have some significance allowing to sketch out the more important characteristics and the dynamics of European industrial activity, also at a disaggregate level.

**FIG.5. The dynamics of European manufacturing (1999-2004)**

Fig. 5 reproduces the compromise points (scatterplot) related to the years considered in this part of the analysis. It gives a synthetic description of the changes that characterised the manufacturing sector in the whole EU13 in that period.

In greater detail, this branch of industrial activity experienced a downsizing between 2000 and 2002 followed by a slight recovery in 2003; at the same time, it recorded an increase in efficiency levels which, in spite of a slowdown during the intermediate years (2000-2002), seemed to regain in the end of the period.

The trend depicted in the graph appears to be consistent with the results shown by the variables previously employed in the univariate analysis (see Figg. 1, 2 and 3), but now the information is more complete with a specific reference to two factors identified by the PCA in this stage of the analysis.

In fact, the decrease in size of the manufacturing sector in the whole EU, in terms of both employees and capital invested, was counteracted by an improvement in productivity levels supported by the rationalization of productive processes.

In addition, the PCA enables to disaggregate data both in territorial terms and in NACE divisions, maintaining the possibility of comparison between the different clusters. Also, when
the compromise points are not very numerous, the same graph may be used to show all the information in one go.

Subsequently, a more detailed analysis was carried out plotting the compromise points for the 13 countries considered.


Fig. 6 shows a cohesive set constituted by Austria, Denmark, Finland and the United Kingdom. In these countries both manufacturing dimensions and performance levels are near the EU13 average in the period 1999-2004.

The nucleus formed by most of the member states shows dimension and efficiency levels a little beneath the average of EU manufacturing. Italy and Spain are not far away, presenting an alignment of dimensions to European mean value but reduced levels of efficiency.

On the contrary, the Netherlands, Belgium and Germany reveal a dimensional structure that is below the European average but efficiency levels higher than average.

The position of Ireland is rather atypical\(^8\); its position, in the upper right part of the first quadrant, implies performance levels in manufacturing that are clearly above European averages for both factors.

Both France and Portugal are at a distance from the other countries; France because of its small manufacturing structure and Portugal because of its low efficiency levels.

\(^8\) Grodzicki (2014, p. 109) verified for 1970 a similar unforeseen behaviour for this country since in that year “the least developed countries of Western Europe (except for Ireland, which is an outlier in the case of manufacturing structure) specialised in low-tech activities, while manufacturing structure of more developed economies was clearly biased in favour of more advanced industries”.

In Fig. 7 it is evident the cluster formed by the compromise points regarding the divisions of the manufacturing sector (NACE Rev.1.1 classification two-digit) for the whole EU countries.

Notably, a considerable number of the points are situated on the left side of the graph demonstrating that, in terms of efficiency, many partitions of manufacturing activities are below average levels.

Few divisions (those on the right side of the factorial plane) exceed the European average. In particular, the position of the Manufacture of chemicals and chemical products (division DG24) is indicative of an industrial activity associated with high dimensional values and good efficiency levels.

The other two divisions, the Manufactures of tobacco products (DA16) and Coke, refined petroleum products and nuclear fuel (DF23), show oddly a below-average dimensional structure but levels of efficiency that are higher than the mean. This is especially true in the latter sector, where efficiency levels are three points above the average.

This synthesis, based on divisions, rehereres a conceptual remark. In Fig. 7 a few divisions, some of which belong to the same subsection of manufacturing, show structural situations that are decidedly different and would be concealed if aggregated.

Two evident examples are subsections DA and DL whose compromise points should be situated in an intermediate position compared to the real localisation of the points of the constituent divisions (respectively, DA15 and DA16 and DI30, DL31, DL32, DL33), as shown in the graph.
4.2 Dynamic analysis of EU countries and manufacturing

divisions

In order to analyse the dynamics of manufacturing in each country, it is very useful to explore the matrix of compromise points (Fig. 8).

The representation of compromise points is a synthesis from the reproduced matrix, $\tilde{X}_{m+1}z_{ij}$, even if the raising of disaggregation on the estimates may cause some problems connected to error estimation.

Notwithstanding such a risk, it is useful to observe the evolution of manufacturing in each country during the period 1999-2004. Obviously, this information should be considered with great caution.

FIG. 8. The evolutionary paths of manufacturing in the individual EU13 Countries (1999-2004)

It should be noted that for nearly all the countries the pattern presented in Fig. 5 comes up once again, though with slightly different shapes, demonstrating that the dynamic analysis displays very similar territorial situations: a general reduction in the scale of industrial activity while the production processes turned out to be more efficient in most member states.

In other words, old “EU member states became more and more homogenous in terms of economic structure – at a high level of aggregation” (Grodzicki, 2014, p. 94).
Notwithstanding this growing homogeneity, the tracks of Ireland and Portugal are moving away from the nucleus of EU countries; France and Germany too show a similar behaviour, though to a lesser extent (see also Fig. 6).

From the above outcome, it follows that the time span does not significantly change the pattern presented in Fig. 5, namely the overall average of all countries. Therefore, the trends of the principal factors identified by PCA during the period (Fig. 4) did not show any substantial alterations in none of the manufacturing sectors of EU countries, except for Ireland, whose efficiency and scale values rose to levels much higher than the average.

What is more, the dynamics of the various manufacturing divisions in EU (Fig. 9), reveals that their trajectories are intertwined, localizing along the dimensional axis rather than on the efficiency one except, once again, for divisions DA16, DF23 and DG24 (see Fig. 7).

For an in-depth examination, results regarding the divisions have been grouped in three macro-sectors according to the well-known Pavitt taxonomy, established on the basis of a descriptive analysis of the innovation process in different industrial activities (Figs. 10-12).
Fig. 10 shows the evolution of the divisions belonging to the category “Supplier dominated”, characterized by small and medium-sized companies operating in traditional manufacturing activities and buying their technology from external sources.

The relevant trajectories are all situated on the left side of the plane thus demonstrating, for the entire period, lower efficiency levels than those for the whole EU manufacturing. Only the manufacture of tobacco products (division DA16) shows higher and ever-increasing efficiency values.

Fig. 11 shows the evolutionary paths of divisions belonging to the macro-sector, “Scale intensive”. In this group, we generally find large companies producing standardized bulky products (such as steel, glass, etc.). Their technology is generally developed in-house but may also be purchased from suppliers.

The trajectories depicted in the graph show a greater dynamics in terms of efficiency, in comparison to the preceding ones. Besides, the values of these divisions are near the European mean while a few (i.e. DE21, DL32 and DN37) manifest higher efficiency levels. One aspect of
Fig 12 shows the evolution of the divisions belonging to the “Science based” and “Specialised suppliers” macro-sectors, considered together. These sectors are generally composed of small firms. During the period under examination, downsizing of the partitions became increasingly evident as did the low mobility of the efficiency values. The only exception is the division DF23 (Manufacture of coke, refined petroleum products and nuclear fuel), whose efficiency level shows an upward trend.

5 Concluding remarks
FIG.12. The dynamics of divisions belonging to “Science-based” and “Specialised suppliers” macro-sectors (1999-2004)

The paper focuses on the deindustrialisation process, occurred in 13 of the first European member states, during the period 1999-2004. Data of 23 divisions (two-digit NACE classification) of manufacturing have been used. The statistical analysis has been carried out by the 4-way Principal Component Analysis (PCA) that, simultaneously, takes into account both the territorial and temporal dimensions of the phenomenon; further, it allows to compare data at a fitting level of disaggregation. According to the latent structure revealed by the analysis, it is easier to understand the real dynamics of deindustrialisation and its territorial and sectorial aspects.

The analysis shows a very heavy process of deindustrialisation in EU13 countries that is strongly corroborated by the similarities of the manufacturing production processes at a fine disaggregated level.
Indeed, regardless of the industrial structure of each country, or the size of the respective economic systems, nearly all the first member states have experienced a process of deindustrialisation, both in terms of whole manufacturing and its constituent industries. This outcome underlines the high degree of cohesiveness that was typical of the European industrial sector during 1999-2004.

Specifically, the multivariate approach has highlighted the synthesis dimensions (PCs) mainly responsible for the manufacturing evolution in EU13.

In particular, the main changes recorded can be summarized as follows:

1) deindustrialisation can be explained fairly well by using just two parameters (factors): i) the efficiency of productive processes and ii) their dimensions;

2) the efficiency parameters are positive and produce the largest variance between the countries;

3) manufacturing activities are considered downsized when the percentage of the total workforce employed in manufacturing decreases and, secondly, a reduction occurs in the ratio of the Gross operating rate, (i.e. the share of capital remuneration on sales). Therefore, deindustrialisation not only concerns the employment but also the level of capitalization of the industrial system, an aspect that, until now, has not been deeply explored;

4) on a territorial level, European countries (but for a few exceptions) are not very differentiated about manufacturing structures. Moreover, considering their respective dynamics, the initial positions are not significantly far away from European mean;

5) as far as efficiency is concerned, the analysis carried out at a disaggregate level shows only three divisions whose levels are well above the European averages: chemicals, tobacco products and coke, petroleum products and nuclear fuel. It should be noted that last division, in particular, breaks away from the average global situation.

In a specific effort to understand modifications in the behaviour of each division, three clusters derived from the well-known Pavitt taxonomy were studied separately. From the trajectories describing the different trends, it is evident that divisions belonging to the macro-sector “Scale intensive” show, in general, a greater dynamism in the direction of a widespread reduction in the overall dimension of productive processes even if they continue to improve in terms of efficiency.

Within the other two groupings (“Supplier dominated”, on the one hand, and “Science based” and “Specialised suppliers”, on the other hand), the evolutionary process has caused a certain downsizing for the most divisions during the period, but no significant changes in efficiency levels.

In summary, using \( J \)-way PCA allows to monitoring different aspects of deindustrialisation, even if a remarkable portion of the variance may be ascribed to other causes which, from the available data, are unidentifiable.

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