

## Facility layout problem: Bibliometric and benchmarking analysis

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### ABSTRACT

Facility layout problem is related to the location of departments in a facility area, with the aim of determining the most effective configuration. Researches based on different approaches have been published in the last six decades and, to prove the effectiveness of the results obtained, several instances have been developed. This paper presents a general overview on the extant literature on facility layout problems in order to identify the main research trends and propose future research questions. Firstly, in order to give the reader an overview of the literature, a bibliometric analysis is presented. Then, a clusterization of the papers referred to the main instances reported in literature was carried out in order to create a database that can be a useful tool in the benchmarking procedure for researchers that would approach this kind of problems.

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## 1. Introduction

Facility Layout Problem (FLP) is defined as the finding of the most efficient departments arrangement on a plant area subject to different constraints in order to satisfy one or more objectives (Heragu, 1997). An effective facility layout design contributes to reduce the operating costs (Tompkins et al., 1996). Hence, the FLP still attracts the attention of many researchers in the field of production management and industrial engineering. A recent literature survey provided a general overview of the research conducted on the FLPs (Hosseini-Nasab et al., 2018) in which the main features that characterize the problem were identified and classified. In particular, the main classification is about the layout evolution from the static to the dynamic approach (Koopmans & Beckmann, 1957; Kouvelis et al., 1992). When the flow of materials between facilities does not change over time, the problem is known as the Static Facility Layout Problem (SFLP), while when material flows vary, the SFLP becomes a Dynamic Facility Layout Problem (DFLP). Another important classification regards the type of input data, such as the area of each department, the material flows between departments and the material handling costs. However, the assumption that this information is available in advance is not realistic in several conditions. For this reason, methodologies able to manage the uncertainty of these data were recently developed (Drira et al., 2013; Nematian, 2014; Kaveh et al., 2014; Neghabi et al., 2014). Moreover, it must be pointed out that the solutions referred to a single objective (i.e. material handling cost only) cannot be compared with

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those referred to the multi-object context in which other qualitative factors, such as adiacence or distance rating between departments, plant safety, and flexibility of layouts for future design changes, are also considered (Jolai et al., 2012; Aiello et al., 2013; Azevedo et al., 2017). These above-mentioned features vary from one application to the other thus making the benchmarking of the performance of each approach a tough issue (Aiello et al., 2013). Hence, to evaluate the performance of different approaches, the results have to be compared with those obtained from previous literature researches characterized by the same layout evolution, the same input data and the same objective functions. The comparison is usually made on the basis of a set of instances in which different setups of the FLP are reported. However, in many articles there is a gap in the benchmarking procedure due to the use of random data set or real cases setup. Referred to a real case study it is generally justified only when dealing with an extremely innovative problem for which there are no references in literature. The robustness of the approach proposed strongly depends on the above considerations and for this reason a database of the instances present in literature and of the papers referred to the same instances for each class of problems is here proposed. This paper reviews the research progress on the FLP in the last 60 years and focuses on the benchmarking procedure adopted in terms of instances used. We collect papers belonging to the same class of problems and we identify those referred to the same instances. This is the first time in which a bibliometric analysis is conducted on the FLP and it represents a framework of the main indicators that characterize publications in this field. The present paper is structured as follows. Section 2 describes the methodology for showing a general overview on the research trends in the last sixty years. Section 3 reports the analysis of the papers presented in the previous section in terms of instances adopted for the benchmarking procedure. Finally, the paper ends with the Conclusions in Section 4 identifying potential gaps in literature and proposing new research topics.

## 2. Data and methodology

The dataset for this study was retrieved searching “Facility layout problem” in the field *article title, abstract, keywords* of Scopus, which is one of the most widely used search engine among the scientific community. The time horizon from 1963 to 2019 was selected. Among all types of publications, we limited this study to the articles and reviews wrote in English on journals considering 5 subject areas (Engineering, Computer Science, Decision Sciences, Business Management and Accounting and Mathematics) obtaining a sample database of 922 works. Then, such database was exported and analysed through the freely available software VOSviewer, for the construction and the visualization of bibliometric maps (Van Eck and Waltman, 2010). This software is able to draw bibliometric distance-based maps, giving attention to their graphical presentation facilitating the comprehensibility.

### 2.1 Geographical landscape

Fig. 1 shows the evolution of the concentration of the papers in three different time windows (1963-1983; 1984-2004; 2005- 2019). In particular, the number of countries in which research on the FLP was conducted is almost quadrupled from 1963 to today. We have considered papers that are cited at least once and countries with a minimum number of 10 publications. Under these assumptions, in the first time window, only 4 countries meet the thresholds whereas in the second and in the third one the number of countries becomes 13 and 15 respectively. This trend confirms the importance of the FLP and the interest of many researches in this field.

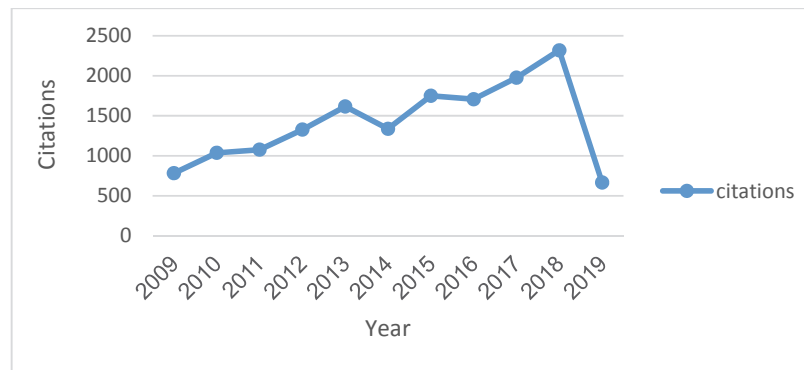
In particular in the last decade the most prolific countries are India, Iran and USA, followed by Canada, China and Italy.



Results are shown in Fig. 2, where the relatedness between items is calculated with respect to the number of documents in which they occur together. We set a threshold to 10 as the minimum number of occurrences and we limit the set to the most connected keywords. We obtain a total number of 117 keywords. However, some terms in the map result duplicated. Particularly, VOSviewer does not distinguish among singular and plural. Therefore, to overcome this problem, we removed manually four of these keywords that correspond to the ones with a lower weight. All the other settings are given by default. The distance among items was calculated on the basis of the association strength (Van Eck & Waltman, 2010), representing the ratio between the number of co-occurrences of term  $i$  and term  $j$  and the total number of occurrences of  $i$  multiplied for the total number of occurrences of  $j$ . The higher the association strength between two nodes of the network is, the shorter their distance is. The colour scale refers to the average year of publications. Therefore, Fig. 2 provides an overview of the most cited keywords over the last twenty years, enabling to infer the most debated research topics. On the basis of the map of keywords, the identified research trend shows an increasing interest in solving dynamic facility layout problems based on meta-heuristic and evolutionary approaches (Tayal & Singh, 2018; Turanoğlu & Akkaya, 2018). Moreover, the last researches involved multi-objective optimization approaches paying attention to the instances-based benchmarking procedure (Liu & Liu, 2019; Liu et al., 2018; Samanta et al., 2018; La Scalia et al., 2019).

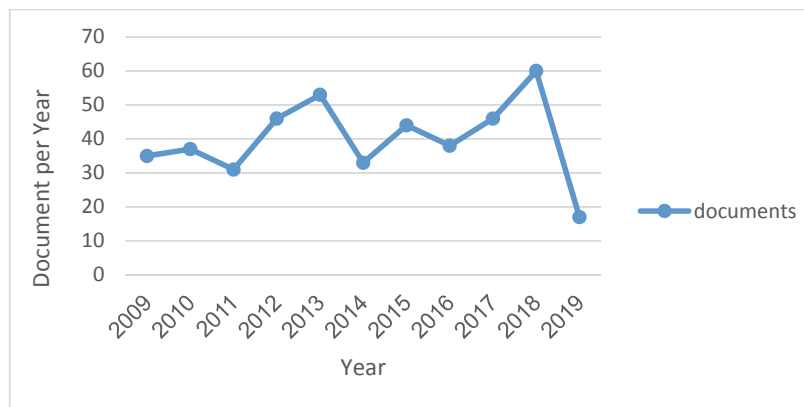
## 2.2 Citations overview

The sample of 922 publications receives in total 22,003 citations of which 15,380 in the last ten years. In this research we have used the tool available on Scopus for analysing these documents in terms of citations, authors and sources over the years. Fig. 3 refers to the last decade and shows a general increasing trend, in particular 2018 is the year with the highest number of citations.



**Fig. 3.** Citations overview in the last ten years

The same year results the most prolific with 58 papers published (Fig. 4).



**Fig. 4.** Documents by years (2009-2019)





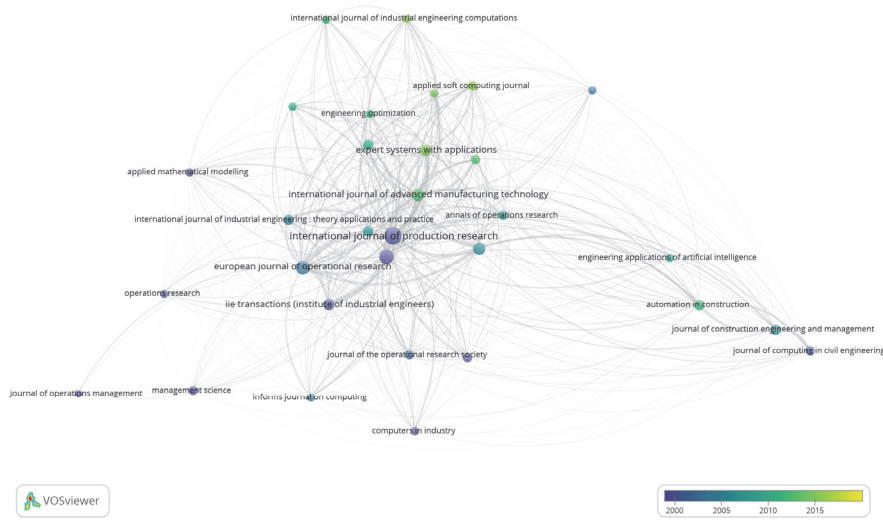


Fig. 6. Journals map

Each journal has a colour that indicates the average publication date. The more the colour tends to yellow, more recent the publications are. The font size and the dimension of the bubble in the figure represent the number of publications, whereas links represent the citations obtained in other journals.

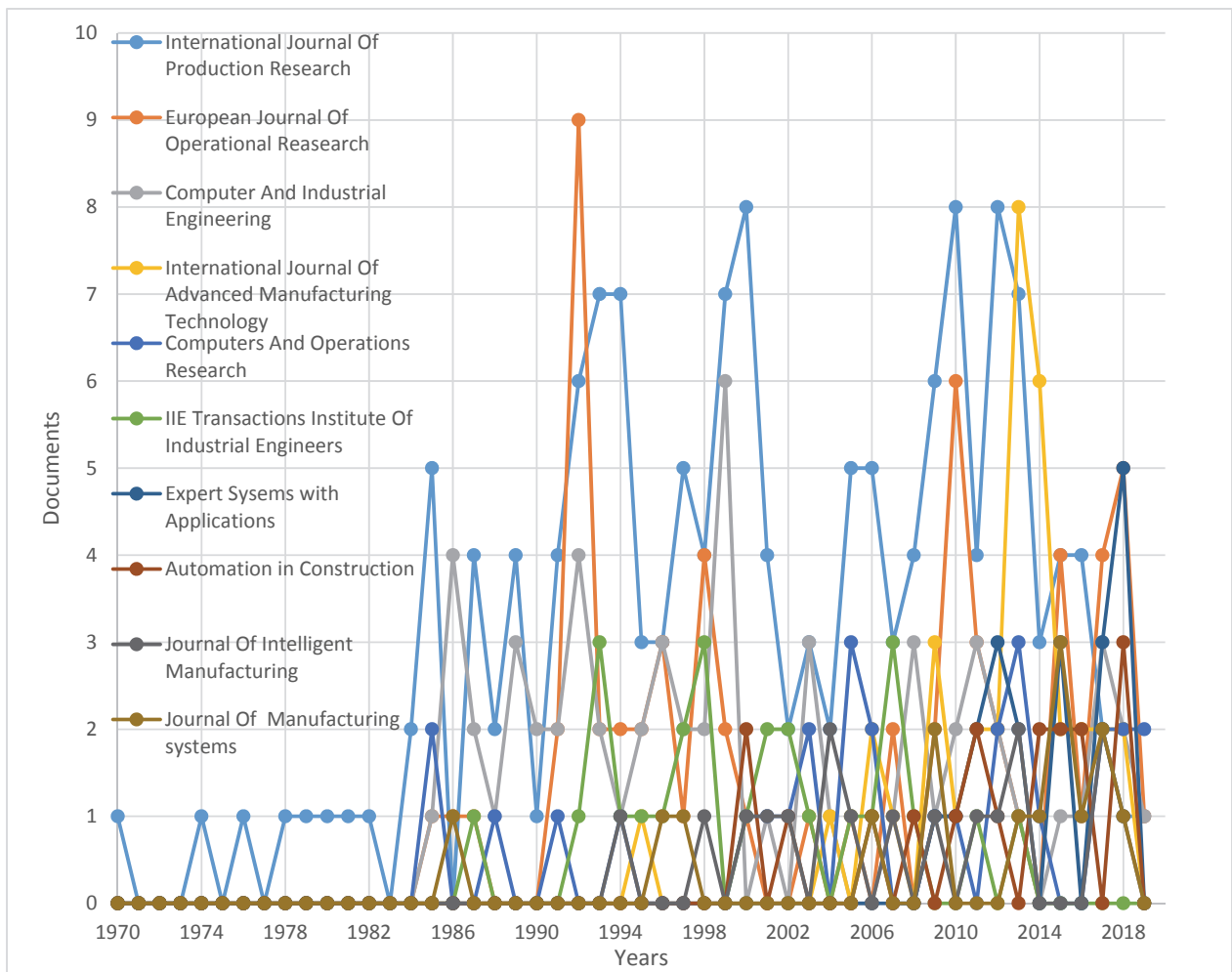
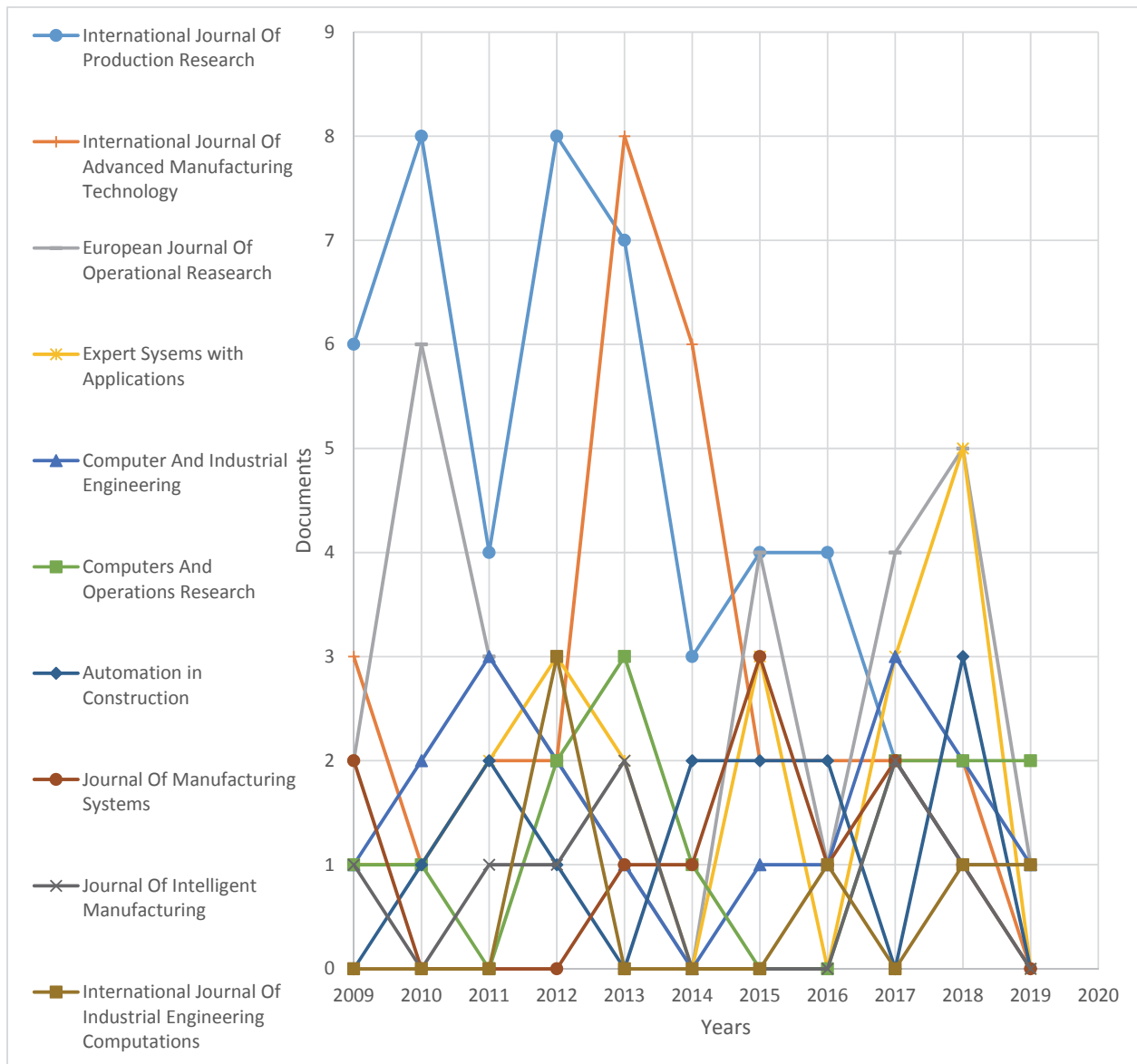


Fig.7. Documents per year by source (1963-2019)

As instance, the International Journal of Production Research, with 155 published papers, is located in the centre of the map because of the high number of citations in the other journals present in the same map. We have refined these results using the analyser tool of scopus, comparing the 10 most prolific journals on the whole time horizon (1963-2019) with those that have most documents in the last ten years. Results are reported in the following figures (Fig. 7 and Fig. 8).



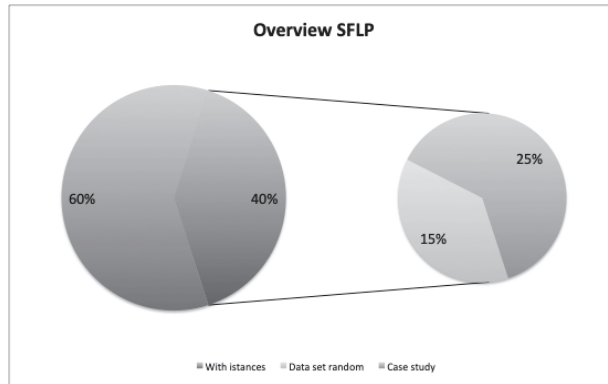
**Fig. 8.** Documents per year by source (2009-2019)

The comparison between the above figures shows that, in the last decade, the only change in the top ten of the most prolific journals on FLP is represented by the introduction of International Journal of Industrial Engineering Computations.

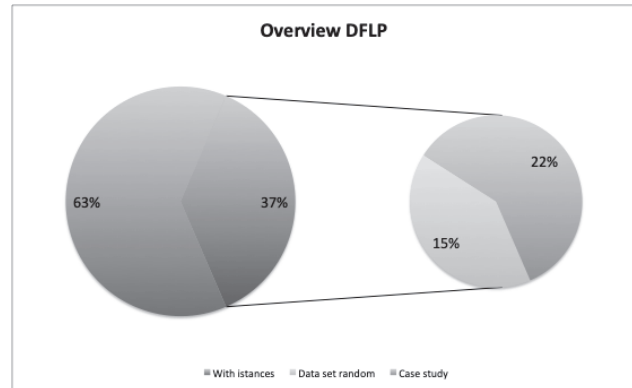
### 3. General overview of the benchmarking procedure

The benchmarking analysis applied to the facility layout problem consists in comparing the results obtained with the proposed approach with those present in literature to prove the achieved improvement.

In this section we have analysed the paper involved in this research in order to show how many papers adopt a benchmarking procedure in their approach. Figure 9 shows that only 60% of the published papers on the SFLP make comparisons, complete or partial, on instances present in literature. Of the remaining 40%, 15% refers to a real case study and 25% to randomly generated data sets.



**Fig. 9.** General overview SFLP



**Fig. 10.** General overview DFLP

For DFLP (Fig. 10), only 63% of published articles make comparisons, complete or partial, on instances present in literature. Of the remaining 37%, 15% refers to a real case study and 22% to randomly generated data sets. To carry out benchmarking operations it is necessary to refer to the same instance. This aspect is what pushed to present the instances used in literature, subdivided in static and dynamic problems. Then for each instance a cloud of papers was built subdividing them on the basis of the type of objective function used (single or multi) and the type of data used (deterministic or stochastic). Tables 2 and 3 report the instances for the DFLP and the SFLP respectively.

**Table 2**

Instances for the DFLP

Instance	Papers single objective		Papers multi objectives	
	Deterministic	Stochastic	Deterministic	Stochastic
P6 and P12 department problem (Dunker, Radons, Westkämper, 2003; Yang & Peters, 1998)	Kulturel-Konak & Konak, 2015; Mckendall & Hakobyan, 2010; Derakhshan & Wong, 2017.		Jolai et al., 2012.	
6, 15, 30 departments problems (Conway & Venkataramanan, 1994)	Baykasoglu, & Gindy, 2001; Pillai et al., 2011; McKendall et al., 2006; Baykasoglu et al., 2006; Balakrishnan & Cheng, 2000; Erel et al., 2003; Balakrishnan et al., 2003; McKendall & Shang, 2006; Ulutas & Islier, 2009; Sahin et al., 2010; Azimi & Charmchi, 2012; Chen, 2013; Hosseini-Nasab & Emami, 2013; Saberi & Azimi, 2013; Pourvaziri & Naderi, 2014; Hosseini et al., 2014.		Bozorgi et al., 2015	Ripon et al., 2011b
6, 12, 20, 30 departments problem (Lacksonen & Enscore, 1993)	McKendall & Shang, 2006;	Kaku & Mazzola, 1997.	Bozorgi et al., 2015	
Pr1 (Rosenblatt, 1986)	Baykasoglu & Gindy, 2001; Conway & Venkataramanan, 1994; Ulutas & Islier, 2009.	Drira et al., 2013;	Azevedo et al., 2017.	
Pr2 (Conway & Venkataramanan, 1994)	Ulutas & Islier, 2009.	Drira et al., 2013;		



**Table 3**  
Instances for the SFLP

Instance	Papers single objective		Papers multi objectives	
	Deterministic	Stochastic	Deterministic	Stochastic
AB20 (Armour & Buffa, 1963)	Bozer et al., 1994; Tate & Smith, 1995; Banerjee et al., 1997; Wang et al., 2005; Konak et al., 2006; Liu & Meller, 2007; Anjos & Vannelli, 2006; Enea et al., 2005; Scholz et al., 2009; Wong & Komarudin, 2010; Komarudin & Wong, 2010; Jankovits et al., 2011; Kulturel-Konak & Konak, 2011a; Kulturel-Konak & Konak, 2011b; Bozer & Wang, 2012; Ulutas & Kultural-Konak, 2012; Mazinani et al., 2013; Kulturel-Konak & Konak, 2013; Kulturel-Konak & Konak, 2015; Fernando Goncalves & Resende, 2015; Ahmadi & Akbari Jokar, 2016; Liu & Liu, 2019; La Scalia et al., 2019.		Ripon et al., 2013; Aiello et al., 2013.	
AML instances (Amaral & Letchford, 2011)	Kothari & Ghosh, 2013a; Kothari & Ghosh, 2014; Palubeckis, 2015; Guan & Lin, 2016; Rubio-Sanchez et al., 2016; Palubeckis, 2017.			
AKV instances (Anjos, Kennings, Vannelli, 2005)	Ozcelik, 2013; Kothari & Ghosh, 2013a; Kothari & Ghosh, 2014; Palubeckis, 2015; Guan & Lin, 2016; Rubio-Sanchez et al., 2016; Samarghandi & Eshghi, 2010; Kothari & Ghosh, 2013b; Palubeckis, 2017.			
AV instances (Anjos & Vannelli, 2008)	Amaral, 2009; Samarghandi et al., 2010; Hungerländer & Rendl, 2011; Hungerländer, 2014.			
BA12 (Bazarraa, 1975)	Kulturel-Konak, 2012; Scholz et al., 2009; Wong & Komarudin, 2010; Komarudin & Wong, 2010; Jankovits et al., 2011; Kulturel-Konak & Konak, 2011a; Kulturel-Konak & Konak, 2011b; Bozer & Wang, 2012; Ulutas & Kultural-Konak, 2012; Mazinani et al., 2013; Kulturel-Konak & Konak, 2013; Fernando Goncalves & Resende, 2015; Hassan et al., 1986; van Camp et al., 1991; Kamoun & Yano, 1996; Gau & Meller, 1999; Castillo et al., 2005; Liu & Liu, 2019; Allahyari & Azab, 2018.		Ripon et al., 2013; Logendrana & Kriausakula, 2006; Ripon et al., 2011a.	
BA13 (Bazarraa, 1975)	Kulturel-Konak, 2012; Kulturel-Konak & Konak, 2011a; Liu & Meller, 2007; Kulturel-Konak & Konak, 2013; Hassan et al., 1986; van Camp et al., 1991; Kamoun & Yano, 1996; Castillo et al., 2005.			
BA14 (Bazarraa, 1975)	Tate & Smith, 1995; Banerjee et al., 1997; Liu & Meller, 2007; Kulturel-Konak, 2012; Scholz et al., 2009; Wong & Komarudin, 2010; Komarudin & Wong, 2010; Jankovits et al., 2011; Kulturel-Konak & Konak, 2011a; Kulturel-Konak & Konak, 2011b; Ulutas & Kultural-Konak, 2012; Konak et al., 2006; Mazinani et al., 2013; Kulturel-Konak & Konak, 2013; Fernando Goncalves & Resende, 2015; Ahmadi & Akbari Jokar, 2016; Gau & Meller, 1999; Allahyari & Azab, 2018; Liu & Liu, 2019.		Ripon et al., 2013; Ripon et al., 2011a.	
Clearance requirement instances (Heragu & Kusiak, 1991)	Amaral & Letchford, 2011; Samarghandi & Eshghi, 2010; Amaral, 2009; Anjos & Vannelli, 2008; Hungerländer & Rendl, 2013.	Nematian, 2014;		
D6 (Das, 1993)	Hungerländer & Rendl, 2013.			
D8 (Das, 1993)	Klausnitzer & Lasch, 2019;			Liu et al., 2018.
D10 (Das, 1993)	Klausnitzer & Lasch, 2019;			Liu et al., 2018.
D12 (Das, 1993)	Klausnitzer & Lasch, 2019;			Liu et al., 2018.
Du62 (Dunker, Westkämper, 2003)	Scholz et al., 2009; Komarudin & Wong, 2010; Kulturel-Konak & Konak, 2011a; Kulturel-Konak & Konak, 2011b; Ulutas & Kultural-Konak, 2012; Fernando Goncalves & Resende, 2015; McKendall & Hakobyan, 2010; Leno et al., 2018; Liu & Liu, 2019.		Ripon et al., 2013; Ripon et al., 2011a; Liu et al., 2018.	
FO7 e FO8 department problem (Meller, Narayanan, Vance, 1999)	Wong & Komarudin, 2010; Sherali et al., 2003; Castillo & Westerlund, 2005.			Saraswat et al., 2015.

FO9 department problem (Meller, Narayanan, Vance, 1999)	Sherali et al, 2003; Castillo & Westerlund, 2005.		Saraswat et al., 2015.
O7 e O8 department problem (Meller, Narayanan, Vance, 1999)	Sherali et al, 2003; Castillo & Westerlund, 2005; Liu & Meller, 2007; Scholz et al., 2009; Komarudin & Wong, 2010; Bozer & Wang, 2012; Fernando Goncalves & Resende, 2015; Castillo et al., 2005; Liu & Liu, 2019; Klausnitzer & Lasch, 2019.	Ripon et al., 2013; Ripon et al., 2011a;	Saraswat et al., 2015.
O9 department problem (Bozer & Meller 1997)	Sherali et al, 2003; Castillo & Westerlund, 2005; Liu & Meller, 2007; Scholz et al., 2009; Komarudin & Wong, 2010; Bozer & Wang, 2012; Fernando Goncalves & Resende, 2015; Castillo et al., 2005; Konak et al., 2006; Wong & Komarudin, 2010; Jankovits et al., 2011; Ahmadi & Akbari Jokar, 2016; Liu & Liu, 2019; Klausnitzer & Lasch, 2019.	Ripon et al., 2013; Ripon et al., 2011a;	Saraswat et al., 2015.
FO10, FO11, O10 (Meller, Chen, Sherali, 2007)	Jankovits et al., 2011; Amaral & Letchford, 2011; Klausnitzer & Lasch, 2019.		
F10 (Montreuil et al., 2004)	Kulturel-Konak & Konak, 2011a; Kulturel-Konak & Konak, 2011b; Kulturel-Konak & Konak, 2013; Kulturel-Konak & Konak, 2015; Kulturel-Konak, 2012.		
Fortenberry instances (Fortenberry & Cox, 1985)	Suresh & Sahu, 1993; Singh & Singh, 2010; Matai et al, 2013; Matai, 2015; Harmonosky & Tothoroa, 1992.		
Imam & Mir, 1989	Derakhshan & Wong, 2017.		
HOT (Mir & Imam, 2001)	Allahyari & Azab, 2018; Derakhshan & Wong, 2017.		
LW5 (Love & Wong, 1976)	Solimannpur et al., 2005; Rubio-Sanchez et al., 2016; Samarghandi & Eshghi, 2010; Datta et al., 2011; Samarghandi et al., 2010; Heragu & Kusiak, 1991; Heragu & Kusiak, 1991; Heragu & Alfa, 1992; Kumar et al., 1995; Amaral, 2006; Amaral, 2008; Teo, & Ponnambalam, 2008; Ou-Yang & Utamima, 2013.	Nemantian, 2014;	
LW11 (Love & Wong, 1976)	Solimannpur et al., 2005; Rubio-Sanchez et al., 2016; Datta et al., 2011; Samarghandi et al., 2010; Heragu & Kusiak, 1991; Heragu & Alfa, 1992; Kumar et al., 1995; Amaral, 2006; Amaral, 2008; Teo, & Ponnambalam, 2008; Ou-Yang & Utamima, 2013.	Nemantian, 2014;	
M11, M15, M25 department problem (Meller, 1992)	Konak et al., 2006; Wong & Komarudin, 2010; Kulturel-Konak & Konak, 2011a; Kulturel-Konak & Konak, 2011b; Kulturel-Konak & Konak, 2013; Gau & Meller, 1999; Klausnitzer & Lasch, 2019.		
OAP instances (Burkard et al., 1991)	Amaral & Letchford, 2011; Hungerlander, 2014; Heragu & Alfa, 1992; Ramkumar et al., 2009a; Rankumar et al., 2009b; Singh & Sharma, 2008; Matai et al., 2013.	Matai et al., 2013.	
Simple Nugent instances (Nugent, Vollmann, Ruml, 1968)	Khalil, 1973; Scriabin & Vergin, 1985; Solimanpur et al., 2005; Samarghandi & Eshghi, 2010; Samarghandi et al., 2010; Heragu & Kusiak, 1988; Kumar et al., 1995; Singh & Sharma, 2008; Neghabat, 1974; Wilhelm & Ward, 1987; Tsuchiya, 1996; Feng & Che, 2018.	Matai et al., 2013.	
QAP Nugent instances (Nugent, Vollmann, Ruml, 1968)	Khalil, 1973; Scriabin & Vergin, 1985; Solimanpur et al., 2005; Samarghandi et al., 2010; Heragu & Kusiak, 1988; Kumar et al., 1995; Neghabat, 1974; Wilhelm & Ward, 1987; Tsuchiya, 1996; Heragu & Alfa, 1992; Goetschalckx, 1992; Ramkumar et al., 2009a; Ramkumar et al., 2009b; Konak et al., 2006; Wong & Komarudin, 2010; Kulturel-Konak & Konak, 2011a; Kulturel-Konak & Konak, 2011b; Kulturel-Konak & Konak, 2013; Mazzinani et al., 2013; Hungerlander, 2014; Matai et al., 2013; Palubeckis, 2012; Ingole & Singh, 2016; Feng & Che, 2018.	Matai, 2015.	
P4 e P15 (Amaral, 2006)	Samarghandi & Eshghi, 2010; Samarghandi et al., 2010; Amaral, 2008; Ou-Yang & Utamima, 2013; Ning & Li, 2017.		
P20 e P30 department problem (Heragu, Kusiak, 1991)	Heragu & Alfa, 1992; Kumar et al., 1995; Teo, & Ponnambalam, 2008; Ou-Yang & Utamima, 2013; Amaral & Letchford, 2011; Solimanpur et al., 2005; Guan & Lin, 2016; Anjos & Yen., 2009; Datta et al., 2011; Anjos & Vanelli, 2008; Amaral, 2009; Ning & Li, 2017.		
S8 e S8H (Simmons, 1969)	Love & Wong, 1976; Heragu & Kusiak, 1991; Heragu & Alfa, 1992; Kumar et al., 1995; Amaral, 2006; Amaral, 2008; Ou-Yang & Utamima, 2013; Amaral & Letchford, 2011; Anjos et al., 2005; Samarghandi & Eshghi, 2010; Anjos &	Nemantian, 2014;	

S9 e S9H (Simmons, 1969)	Vannelli, 2008; Hungerländer & Anjos, 2015; Hungerländer & Rendl, 2013; Ning & Li, 2017.	Nemantian, 2014;
S10 e S11 (Simmons, 1969)	Teo, & Ponnambalam, 2008; Love & Wong, 1976; Heragu & Kusiak, 1991; Heragu & Alfa, 1992; Kumar et al., 1995; Amaral, 2006; Amaral, 2008; Ou-Yang & Utamima, 2013; Amaral & Letchford, 2011; Anjos et al., 2005; Samarghandi & Eshghi, 2010; Anjos & Vannelli, 2008; Hungerländer & Anjos, 2015; Hungerländer & Rendl, 2013; Samarghandi et al., 2010; Amaral, 2013.	Nemantian, 2014;
SC30 e SC35 (Liu & Meller, 2007)	Teo, & Ponnambalam, 2008; Love & Wong, 1976; Heragu & Kusiak, 1991; Heragu & Alfa, 1992; Kumar et al., 1995; Amaral, 2006; Amaral, 2008; Ou-Yang & Utamima, 2013; Amaral & Letchford, 2011; Anjos et al., 2005; Samarghandi & Eshghi, 2010; Anjos & Vannelli, 2008; Hungerländer & Anjos, 2015; Hungerländer & Rendl, 2013; Amaral, 2013; Solimanpur et al., 2005; Guan & Lin, 2016; Amaral, 2009.	Ripon et al., 2013; Ripon et al., 2011a.
Sko instances (Anjos & Yen, 2009)	Wong & Komarudin, 2010; Komarudin & Wong, 2010; Kulturel-Konak & Konak, 2011a; Kulturel-Konak & Konak, 2011b; Bozer & Wang, 2012; Kulturel-Konak & Konak, 2013; Kulturel-Konak & Konak, 2015; Fernando Goncalves & Resende, 2015; Kulturel-Konak, 2012.	Logendrana & Kriausakula, 2006.
TAM 20 e TAM 30 (Tam, 1992)	Amaral & Letchford, 2011; Kothari & Ghosh, 2013a; Kothari & Ghosh, 2014; Palubeckis, 2015; Guan & Lin, 2016; Rubio-Sanchez et al., 2016; Kothari & Ghosh, 2013b; Hungerländer & Rendl, 2011; Hungerländer 2014; Kahlia & Datta, 2018; Ning & Li, 2017; Palubeckis, 2017.	
TI instances (Tam, Li, 1991)	Kulturel-Konak, 2012; Kulturel-Konak & Konak, 2011a; Kulturel-Konak & Konak, 2011b; Ulutas & Kulturel-Konak, 2012; Kulturel-Konak & Konak, 2013; Fernando Goncalves & Resende, 2015; Gau & Meller, 1999; Meller & Bozer, 1996; Liu & Sun, 2012.	
VC10 (Van Camp, Carter, Vannelli, 1991)	Scholz et al., 2009; Fernando Goncalves & Resende, 2015; Kado, 1995.	Logendrana & Kriausakula, 2006; Garcés-Perez et al., 1996; Schnecke & Vomberger, 1997.
8, 12, 15 e 20 department problem (Chen & Sha, 1999)	Tate & Smith, 1995; Banerjee et al., 1997; Liu & Meller, 2007; Wong & Komarudin, 2010; Komarudin & Wong, 2010; Jankovits et al., 2011; Konak et al., 2006; Kulturel-Konak & Konak, 2011a; Kulturel-Konak & Konak, 2011b; Bozer & Wang, 2012; Ulutas & Kulturel-Konak, 2012; Mazinani et al., 2013; Fernando Goncalves & Resende, 2015; Ahmadi & Akbari Jokar, 2016; Scholz et al., 2009; Kamoun & Yano, 1996; Gau & Meller, 1999; Castillo et al., 2005; Liu & Liu, 2019.	Ripon et al., 2013; Logendrana & Kriausakula, 2006; Ripon et al., 2011a;
6, 12 department problem (Walgama & Gibson, 1993)	Das, 1993; Rajasekharan et al., 1998; Hu et al., 2007; Jerin Leno et al., 2016.	Singh & Singh, 2010; Matai et al., 2013; Matai, 2015; Sahin, 2011.
7 department problem (Wu & Appleton, 2002), 20 department problem (Aiello, Enea, Galante, 2002)	Hu et al., 2007; Jerin Leno et al., 2016; Leno et al., 2018.	
6 department problem (Rosenblatt, 1979)	Matsuzaki et al., 1999; Bernardi & Anjos, 2012; Ahmadi & Akbari Jokar, 2016.	Harmonsky & Totheroa, 1992; Matai et al., 2013; Matai, 2015; Azevedo et al., 2017.
8 department problem (Dutta & Sahu, 1982)	Xie & Sahmidis, 2008; Hungerländer, 2014.	Suresh & Sahu, 1993; Harmonsky & Totheroa, 1992; Matai et al., 2013; Matai, 2015.
15 department problem (Bozer, Meller, Erlebacher, 1994)		
Y (Yu & Sarker, 2003), and O instances (Obata, 1979)		

#### 4. Conclusions

This paper explores the extant literature on the “Facility Layout Problem” to identify the main research trends over the last decades. Moreover, the analysis of the keywords allows to visualize the past research trends, and could even support researchers in the identification of potential gaps in literature. In particular, the distance among nodes in the map could show unexplored connections among research topics, whereas the bubble size could indicate a still little debated topic. As instance, future research could involve multi objective approaches, as well as the use of evolutionary methods to solve the FLP. The aim of the following research is also to offer a valid tool for identifying all the papers related to a specific instance in order to optimize the benchmarking procedure. In particular, 922 articles were analysed in order to present a broad and complete revision of the theme and 128 of them were clustered according to the benchmarking procedure adopted. Revising this collection of publications distributed between 1963 and 2019, 49 clouds of papers belonging to the same instance were collected, divided for type of objective function and input data assumed. This collection shows how many and which publications have used instances for the benchmarking analysis, that is essential to test the methodological rigour of a given approach compared to others. The results reveal that in literature only a small number of authors compare their method with a significant number of instances. This evidence therefore suggests that the benchmarking method adopted until now cannot be considered sufficiently robust and has to be improved. Moreover, further developments could include the comparison of the results obtained through other databases (such as web of science), to provide an overarching analysis of the extant literature.

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