Abstract

Today, engineers make efforts for post-graduate programs far more than before. The main reasons can be increasing awareness of firms about education, decreasing job opportunities for undergraduate degrees, the increasing demand for being an academician or scholarship opportunities by government. Some firms want their post-graduate student engineers to solve the firm’s problems in their master or doctoral thesis as case studies. In this regard industrial engineering is a field that adjusts almost with every sector because of its multidisciplinary nature. Thus, there are many post-graduate theses written in this area. The aim of this paper is to analyze 2,122 post-graduate theses (master & doctoral) which are carried out in the department of industrial engineering in Turkish universities. The data is obtained from the website of Council of Higher Education of Turkey. The time period is determined as 2010-2017 and only the 1,780 “permission” theses are analyzed in order to reach keywords for solution approaches and keywords analysis. Nine different indicators are used to analyze the thesis such as; university status, page numbers, language, keywords etc. As a result, this study shows how the theses are clustered according to different indicators and which topics are studied more frequently in recent years. The inference of the paper is important because the results give an insight about the road map of industrial engineering thesis completed in 56 different Turkish universities.

Keywords: Doctoral, Industrial engineering, Master, Meta-analysis, Post-graduate thesis

1 Introduction

Industrial engineering deals with figuring out how to make or do things better. Industrial engineers are concerned with reducing costs, increasing efficiency, improving the quality of products or services, ensuring worker health and safety, protecting the environment and complying with government regulations. They try to eliminate waste of time, money, materials, energy and other commodities in their multi-discipliner work fields [1]. There are 70 industrial engineering departments in Turkey however 56 of them give a graduate education. But, the more an engineer is educated, the more productive it becomes. Thus, post-graduate study is another opportunity to study a subject in more depth. People do further study for a number of reasons including; an interest in the subject, to gain a career advantage, being a necessity for entry to a particular occupation, becoming an academician, obtaining patents etc. Although it was a privilege to have a bachelor’s degree before, now it is a privilege to have a master or doctoral degree.

According to a scientific research by Erginel, Tekce, Küçük and Alper [2] the success of the post-graduate program on industrial engineering is found to be very successful with respect to the questionnaire. More than half of the attendants (51%) stated that they find these programs very effective both for their knowledge and success. Thus these findings show the necessity of industrial engineering post-graduate programs in Turkey.

But as long as the post-graduate studies focus on universal consent, they don’t contribute to the solution of the problems
of our country thus remaining the theses on the shelves. In order to prevent this, it is inevitable to carry out all kinds of researches that solve the real problems. In this regard, taking precautions for concentrating on real problems or encouraging interdisciplinary studies will also debottleneck the post-graduate research [3]. According to Das and Handfield [4], although the academic maturity of any discipline can be assessed in a variety of ways (published articles, books and etc.), dissertation research provides a useful method of evaluating conceptual and empirical contributions to the field. Jack, Stephens and Evans [5] noted that dissertation research is typically leading-edge, often breaks new ground by filling in gaps in a body of knowledge, synthesizes a wide body of previously published research, and captures trends earlier than research published in typical archival journals. The aim of this paper is to analyze the post-graduate theses in industrial engineering between 2010 and 2017 are analyzed. Turkish engineering fields. In this regard, 2,122 post-graduate theses which are carried out in the department of industrial engineering between 2010 and 2017 are analyzed. Turkish Council of Higher Education website is utilized for obtaining the data. Firstly a statistical map of Turkish post-graduate studies is shaped by using graphs; later the implications are lined up.

The remainder of this paper is organized in the following manner. A summarized literature review about the related studies is given in Section 2. In Section 3, we explain the research methodology with analyzing the data. The results for each major category are analyzed and discussed in Section 4. Finally, we present some brief conclusions of this work in Section 5.

## 2 Literature review

In the literature, there are many studies on the examination of post-graduate theses in different disciplines. These studies are very important in the sense that they provide guidance for future work by exposing the current situation and trends related to the field in which the work is done. Detailed information about the reviewed studies is given in Table 1. As can be seen from Table 1, dissertation analyses are conducted in different fields such as quality management [5]; public relations [6]; social studies education [7], [8]; human resources [9]; education sciences [10], [11]; marketing [12]-[14]. While some of the studies [5], [6] investigate only doctoral theses, some of them [14] examine only master theses.

| Table 1: Literature review on the studies which investigate theses. |
|---------------------------------|--------|--------|--------|--------|--------|--------|--------|
| Description                     | [5]    | [6]    | [7]    | [8]    | [9]    | [10]   | [11]   |
| Discipline                      | Quality management | Public relations | Social studies education | Human resources | Education sciences | Social studies education | Education history |
| Number of thesis                | 523    | 62     | 100    | 2216   | 229    | 612    | 61     |
| Master                          | 0      | 0      | 100    | 1953   | 0      | 550    | 53     |
| Doctoral                        | 523    | 62     | 263    | 229    | 62     | 8      |        |
| Scanned Years                   | 1981-1999 | 1965-2004 | 2000-2007 | 1983-2008 | 2003-2008 | 1990-2010 | 1987-2018 |
| Country                         | All the World | Spain | Turkey | Turkey | Turkey | Turkey | Turkey |
| Classification by               |        |        |        |        |        |        |        |
| Years                           | √      |       |        |        |        |        |        |
| Universities                   |        |        |        |        |        |        |        |
| Accessibility                  |        |        |        |        |        |        |        |
| Keywords                       |        |        |        |        |        |        |        |
| Gender                         |        |        |        |        |        |        |        |
| Advisor                        |        |        |        |        |        |        |        |
| Methods                        |        |        |        |        |        |        |        |
| References                     |        |        |        |        |        |        |        |
| Country                        |        |        |        |        |        |        |        |
| Context                        |        |        |        |        |        |        |        |
| Language                       |        |        |        |        |        |        |        |
| | Description                     | [12]   | [17]   | [18]   | [19]   | [20]   | [14]   | Proposed study |
| Discipline                      | Marketing | Geography education | Tourism | Social marketing | Mathematics | Food beverage industry | Social marketing | Industrial engineering |
| Number of thesis                | 194    | 322    | 332    | 93      | 41      | 179    | 266    | 2122   |
| Master                          | 0      | 360    | 0      | 35      | 162     | 266    | 1771   |
| Doctoral                        | 194    | 62     | 332    | 93      | 6       | 17     | 0      | 351    |
| Scanned Years                   | 1994-2012 | 2000-2012 | 2000-2009 | 1971-2013 | 2004-2013 | 1988-2013 | 1971-2015 | 2010-2017 |
| Country                         | Turkey | Turkey | Turkey | United Kingdom; Ireland | All the World | Turkey | All the World | Turkey |
| Classification by               |        |        |        |        |        |        |        |        |
| Years                           | √      |        |        |        |        |        |        |        |
| Universities                   |        |        |        |        |        |        |        |        |
| Accessibility                  |        |        |        |        |        |        |        |        |
| Keywords                       |        |        |        |        |        |        |        |        |
| Gender                         |        |        |        |        |        |        |        |        |
| Advisor                        |        |        |        |        |        |        |        |        |
| Methods                        |        |        |        |        |        |        |        |        |
| Country                        |        |        |        |        |        |        |        |        |
| Context                        |        |        |        |        |        |        |        |        |
| Language                       |        |        |        |        |        |        |        |        |
| Province                       |        |        |        |        |        |        |        |        |
| Page number                    |        |        |        |        |        |        |        |        |

[^5] Jack et al. (2001), [^6] Niles and Castillo (2006), [^7] Orczy and Ullano (2009), [^8] W bredly (2009), [^10] Kordul (2010), [^9] Sahin et al. (2011), [^11] Oggen (2012), [^12] Baker (2013), [^13] Kay (2013), [^18] AB (2013), [^15] Truong et al. (2014), [^19] Vównenez and Stipk (2014), [^22] Hud (2017), [^14] Truong and Dietrich (2018).
When we focus on the industrial engineering field, there is a limited number of studies aimed at increasing the quality of education of industrial engineering and determining trends by examining theses done on this area. Köksal and Eğitman [15] presented a quality function deployment approach to improve the quality of education at the Middle East Technical University. Li and Ying [16] focused on enhancing the skills of industrial engineering undergraduate students with graduation theses. Erginel et al. [2] examined the existing situations of working industrial engineers at industry. To the best knowledge of the authors, it is the first study which conducts a meta-analysis on post-graduate theses carried out in industrial engineering area. In this context, the research intends to draw a chronological and geographical map of the theses awarded as well as identify major trends in industrial engineering masters/PhDs. Thus, this research may be significant for different stakeholders: first, Turkish universities, which may receive this research as an indicator to understand their locations on the industrial engineering post-graduate education map; second, planners of industrial engineering education who need to have an overview of the trends and gaps in industrial engineering post-graduate education in Turkey; third, international researchers, who can use the Turkey model as a benchmark when studying post-graduate in industrial engineering area in their countries; and finally, post-graduate students who want to have a broader view of the possibilities of conducting future industrial engineering theses.

3 Methodology and database

The past few years have seen an increase in the number of tools for identifying and cataloguing scholarly material. Particularly, the advent of the internet has allowed for the blossoming of online databases, making it much easier and quicker to search for theses and dissertations from most parts of the world [14]. As a result, researchers can conduct faster, more systematic and therefore more thorough analyses than ever before.

To identify master and doctoral theses that focused on industrial engineering, this study made use of the national thesis center database of The Council of Higher Education which is a major source of master’s theses and doctoral dissertations in Turkey and has been utilized by previous studies [20]. To do so, a search query with the division “Industrial Engineering” and the year range “2010-2017” is used. While analyzing the solution methods and the keywords, the access type was scanned as “Authorized”. The interface of the query screen is illustrated in Figure 1.

3.1 Population and sample

This search strategy resulted in 2,122 theses which include 1,771 master and 351 doctoral theses carried out in Industrial Engineering Department of Turkish universities. It must be noted that 2,122 theses consist of theses with and without permission. Table 2 and Figure 2 show the distribution of all theses from 2010 to 2017. According to Table 2, number of master theses is five times greater than number of doctoral theses in total.

Table 2: Distribution of theses (both with and without permission) according to years.

| Year | Master | Doctoral | Total |
|------|--------|----------|-------|
| 2010 | 217    | 42       | 259   |
| 2011 | 201    | 40       | 241   |
| 2012 | 208    | 38       | 246   |
| 2013 | 251    | 33       | 284   |
| 2014 | 227    | 52       | 279   |
| 2015 | 254    | 48       | 302   |
| 2016 | 217    | 58       | 275   |
| 2017 | 196    | 40       | 236   |
| Total| 1,771  | 351      | 2,122 |
This paper was limited to post-graduate theses made between the years of 2010-2017 on the website of The Council of Higher Education. Sample of the study for solution approaches and keyword analysis was taken as theses with permission access state in the database for in order to reach keywords. Hence, 1,771 master theses and 351 doctoral theses were examined in the study. Also, 1,518 master theses and 262 doctoral theses were examined for solution approaches and keyword analysis as the sample in the study. Distribution of accessible (with permission) theses based on years is given in Table 3 and Figure 3.

Table 3: Distribution of accessible theses according to years.

| Year | Master | Doctoral | Total |
|------|--------|----------|-------|
| 2010 | 216    | 42       | 258   |
| 2011 | 198    | 39       | 237   |
| 2012 | 208    | 38       | 246   |
| 2013 | 249    | 32       | 281   |
| 2014 | 227    | 52       | 279   |
| 2015 | 191    | 22       | 213   |
| 2016 | 132    | 29       | 161   |
| 2017 | 97     | 8        | 105   |
| Total| 1,518  | 262      | 1,780 |

According to Figure 3, the number of master and doctoral theses with permission is started to decrease after 2014. Conversely, the number of theses which cannot be downloaded is increasing. The main reason is possibility of scientific publication of the authors and advisors. As we know that if a thesis is up-to-date, a paper from that thesis can be published in following years. For that reason, the authors choose to put a time limit to prevent the right of publication. Consequently, 83.88% of total theses (2,122) are chosen as the study sample for keyword analysis. The theses were added into a Microsoft Office Excel 2010 database. This data set included based on the indicators represented in Table 4. Then, results are tabulated and summarized using descriptive statistics given in following sub-sections.

4 Results

In this section, different descriptive statistics using created database file are presented. The results are organized into seven main sub-sections:

(1) Distribution of theses by universities and universities’ status,
(2) Distribution of theses by provinces,
(3) Distribution of theses by gender,
(4) Distribution of theses by language and page numbers,
(5) Distribution of theses by content,
(6) Distribution of theses by solution approaches and
(7) Distribution of theses by keywords.

4.1 Distribution of theses by universities and universities’ status

Post-graduate theses were carried out at 56 universities in total, and distribution by universities of these theses is presented in Figure 4. Three universities with highest numbers of the theses are Istanbul Technical University, Gazi University and Boğaziçi University, respectively. Sum of post-graduate theses made in these three universities constitutes 25.64% of the total.

The distribution of the number of theses according to the universities by master and doctorate is provided in...
Figure 5 and Figure 6. Three universities with highest numbers of the master theses are İstanbul Technical University, Boğaziçi University and Gazi University. Three universities with highest numbers of the doctorate theses are İstanbul Technical University, Gazi University and Yıldız Technical University, respectively.

Results obtained by examination of university status (public or private) are presented in Figure 7. 41 doctoral and 537 master theses were carried out in private universities. So, total of 578 theses were completed in private universities. 310 doctoral and 1,234 master theses, eventually total of 1,544 theses were completed in public universities.

Interchange of thesis numbers by years based on university status is presented in Figure 8. As can be seen from Figure 8, while the number of theses in private universities is increasing, conversely, it is decreasing in public universities. The main reason of this situation should be explained with the increasing number of new private universities.
4.2 Distribution of theses by provinces

Distribution of the theses by the province in which university is located is presented in Figure 9. Among 21 cities out of 81 cities, Istanbul was observed as well ahead of other cities. Following, Ankara and Izmir were observed to have the highest number of theses respectively. The ratio of the number of completed thesis in the provinces to the number of universities is represented in Table 5. Although Istanbul has 22 universities where students can write theses, Sakarya and Kocaeli have the highest ratio with only one university among other cities.

Distribution of carried out theses among the cities is also shown in Figure 10. According to Figure 10, half of all the theses are completed in Istanbul. Rest of the theses is distributed in the middle, south and west of Turkey. It means that the students who are living in north and east of Turkey and wish to conduct a thesis in industrial engineering area, they need to apply the cities which are shown in black. It must be noted that Figure 10 does not provide any insight about the relationship between geographical locations of theses and industrial zones. This figure only supports that there is a relationship between the number of theses and post-graduate programs.

Table 5: The ratio of the number of completed thesis in the provinces to the number of universities.

| Province | Number of Universities | Ratio* | Province | Number of Universities | Ratio* |
|----------|------------------------|--------|----------|------------------------|--------|
| Sakarya  | 1                      | 69.00  | Erzurum  | 1                      | 24.00  |
| Kocaeli  | 1                      | 65.00  | Konya    | 2                      | 19.50  |
| Ankara   | 8                      | 51.50  | Denizli  | 1                      | 19.00  |
| İstanbul | 22                     | 47.09  | Balıkesir| 1                      | 12.00  |
| Eskişehir| 2                      | 39.00  | Trabzon  | 1                      | 12.00  |
| KAYSERI | 4                      | 36.00  | Isparta  | 1                      | 10.00  |
| Kırıkkale| 1                      | 32.00  | Kütahya  | 1                      | 7.00   |
| Bursa    | 1                      | 30.00  | Karabük  | 1                      | 5.00   |
| İzmir    | 4                      | 28.75  | Mersin   | 1                      | 4.00   |
| Gaziantep| 1                      | 26.00  | Yalova   | 1                      | 1.00   |

*: Number of thesis/number of universities.
4.3 Distribution of theses by gender

When classified by genders of authors, male / female ratio is observed as almost equal. 1,055 theses are written by male authors, while 1,067 theses are written by female authors. Numbers is shown in Figure 11. The study reveals that master and doctoral programs in industrial engineering area are not dominated by men, who account for 49.72% of theses written compared to 50.28% of women. If we look at the Figure 11, there is no dominant side in terms of gender. The distribution of the authors by gender and years is shown in Figure 12.

![Figure 11: Gender of the authors by years.](image1)

![Figure 12: Distribution of authors by gender.](image2)

4.4 Distribution of theses by language and page numbers

Examined theses are written in three languages as in Turkish, English, and French. 1,239 theses are in Turkish, 880 theses are in English, and 3 theses are in French. The number of theses by language is presented in Table 6.

| Language | Master | Doctoral | Total |
|----------|--------|----------|-------|
| Turkish  | 1239   |          |       |
| English  | 880    |          |       |
| French   | 3      |          |       |

61.82% of doctoral theses are written in Turkish, while 38.18% are written in English. 57.71% of master theses are written in Turkish, while 42.12% are written in English, and 0.17% is written in French. The distribution of thesis types by language is also shown in Figure 13.

When the theses are classified by the page numbers, results in Figure 14 are obtained. Accordingly, most common ranges of page number of the theses were [101-150] with 825 theses, and [51-100] with 814 theses. When master and doctoral theses are examined separately, it is observed that master theses consist of averagely 111.23 pages, while doctoral theses consist of averagely 178.34 pages.

It was comprehended that the master theses examined consisted of a minimum of 35 and a maximum of 402 pages while the doctoral theses consisted of a minimum of 70 and a maximum of 470 pages. The distribution of thesis types by page numbers is represented in Figure 15.

![Figure 13: Distribution of thesis types (up: master, bottom: doctoral) by language.](image3)

![Figure 14: Classification of theses by page numbers.](image4)

![Figure 15: Distribution of thesis types (up: master, bottom: doctoral) by page numbers.](image5)

4.5 Distribution of theses by content

When the theses are examined in terms of their content (including theoretical or application), the results given in Table 7 are obtained. While 43.93% of the master’s theses are theoretical, remaining 56.07% of them are applications. In addition, while 64.39% of doctoral theses are theoretical, remaining 35.61% of them are applications. Thus it can be
implied that while master theses focus on application studies, the theoretical studies have come to the fore in the doctoral theses.

The percentage distribution of theses in terms of their content is given in Figure 16. It is seen that there are a lot of studies in the master theses in all years. In 2013, the percentages of theoretical and application theses got closed to each other and a more balanced distribution was formed in the following years. In the doctoral thesis, it was observed that theoretical studies were more prevalent until 2014, and then there was a significant increase in the studies involving the practice. However, theoretical studies maintain their superiority.

4.6 Distribution of theses by solution approaches

Solution methods are explained in Table 8. Utilized solution methods are classified as simulation, heuristic/meta heuristic methods, mathematical programming, multi-criteria decision making methods, artificial neural network, fuzzy and grey theory/modeling, statistical/data mining/time series methods, problem solving and lean techniques and others. Results of examination of theses in terms of solution methods are presented in Table 9. For theses that utilize more than one solution method, all methods are considered separately. Most frequently utilized methods were: heuristic/meta heuristic methods in 2010, multi-criteria decision making methods in 2011, multi-criteria decision making methods and mathematical programming methods in 2012, heuristic/meta heuristic methods in 2013, multi-criteria decision making methods in 2014, mathematical programming methods in 2015, mathematical programming methods again in 2016 and multi-criteria decision making methods in 2017.
Table 9 indicates that the identified solution methodologies on industrial engineering area were housed in a wide range of contexts, with multi-criteria decision making (MCDM) methods (17.99%) and mathematical programming (17.99%) being engaged in the largest number of theses. The solution techniques of heuristics/meta-heuristics provided the study context for 16.42%, followed by statistical methods (14.02%). This finding confirms that the most popular solution techniques in industrial engineering area, namely MCDM, heuristic/meta-heuristics and mathematical programming are the predominant approaches for industrial engineering related problems at both master and doctoral levels. As a result, very few theses were housed and explored the potential of other solution approaches in industrial engineering problem area such as simulation and artificial neural network. The detail list about the solution approaches is given in Table 10. Most considered 7 techniques are shown based on year under main solution approach in Table 10. According to this table, the most popular technique which is applied in both master and doctoral theses is analytic hierarchy process (AHP) under MCDM title. Among the heuristic/meta-heuristic approaches, genetic algorithm which is an evolutionary algorithm is the most preferred one. On the mathematical programming side, due to the nature of industrial engineering problem area, mixed integer models are very popular.

Table 9: Distribution of solution methods by years.

| Year | Simulation | Heuristic / Meta-heuristic | Mathematical Programming | Multi criteria decision making methods | Artificial neural network | Fuzzy and grey theory / modeling | Statistical methods / Data mining methods / Time series methods | Problem solving and lean techniques | Others |
|------|------------|---------------------------|--------------------------|---------------------------------------|--------------------------|---------------------------------|-------------------------------------------------|---------------------------------|--------|
| 2010 | 19         | 51                        | 41                       | 29                                    | 22                       | 13                              | 34                               | 17                              | 38     |
| 2011 | 12         | 41                        | 38                       | 67                                    | 16                       | 14                              | 30                               | 20                              | 30     |
| 2012 | 13         | 35                        | 47                       | 47                                    | 19                       | 14                              | 31                               | 9                               | 35     |
| 2013 | 11         | 65                        | 38                       | 39                                    | 12                       | 16                              | 47                               | 15                              | 41     |
| 2014 | 16         | 57                        | 61                       | 70                                    | 10                       | 8                               | 47                               | 4                               | 47     |
| 2015 | 8          | 23                        | 51                       | 37                                    | 37                       | 10                              | 41                               | 8                               | 33     |
| 2016 | 12         | 33                        | 44                       | 29                                    | 9                        | 13                              | 14                               | 5                               | 20     |
| 2017 | 9          | 9                         | 24                       | 26                                    | 5                        | 7                               | 10                               | 3                               | 20     |

Table 10: Applied techniques in the considered thesis.

| Technique Type                          | 2010   | 2011   | 2012   | 2013   | 2014   | 2015   | 2016   | 2017   | Total |
|-----------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|-------|
| MCDM Techniques                         |        |        |        |        |        |        |        |        |       |
| AHP                                     | 8      | 31     | 20     | 11     | 27     | 12     | 12     | 9      | 130   |
| ANP                                     | 9      | 14     | 8      | 3      | 8      | 6      | 2      | 1      | 51    |
| TOPSIS                                  | 3      | 6      | 9      | 6      | 7      | 4      | 4      | 2      | 41    |
| VIKOR                                    | 0      | 2      | 2      | 2      | 3      | 1      | 4      | 16     |       |
| PROMETHEE                               | 2      | 5      | 2      | 1      | 2      | 1      | 1      | 15     |       |
| ELECTRE                                  | 0      | 1      | 1      | 1      | 4      | 2      | 1      | 10     |       |
| MOORA                                    | 0      | 1      | 0      | 0      | 1      | 0      | 0      | 3      |       |
| Total                                   | 22     | 60     | 42     | 24     | 51     | 29     | 21     | 17     | 266   |
| Heuristic/Meta-Heuristic Techniques     |        |        |        |        |        |        |        |        |       |
| Genetic Algorithm                       | 18     | 12     | 11     | 18     | 17     | 1      | 6      | 1      | 84    |
| Simulated Annealing                     | 3      | 6      | 1      | 2      | 9      | 2      | 0      | 25     |       |
| Tabu Search                             | 3      | 7      | 4      | 6      | 1      | 2      | 0      | 1      | 24    |
| Ant Colony Optimization                 | 4      | 4      | 1      | 3      | 2      | 1      | 1      | 1      | 17    |
| Particle Swarm Optimization             | 2      | 3      | 2      | 1      | 3      | 2      | 0      | 0      | 13    |
| Local Search                            | 3      | 0      | 1      | 1      | 2      | 1      | 2      | 0      | 10    |
| Bees Algorithm                          | 0      | 0      | 2      | 4      | 2      | 0      | 1      | 0      | 10    |
| Total                                   | 34     | 32     | 22     | 35     | 36     | 9      | 12     | 3      | 183   |
| Mathematical Modeling Techniques        |        |        |        |        |        |        |        |        |       |
| Mixed Integer Programming               | 5      | 4      | 9      | 10     | 7      | 6      | 3      | 4      | 47    |
| Integer Programming                     | 3      | 3      | 4      | 4      | 7      | 1      | 6      | 2      | 30    |
| Goal Programming                        | 4      | 1      | 4      | 2      | 5      | 3      | 2      | 6      | 27    |
| Linear Programming                      | 3      | 2      | 5      | 1      | 5      | 2      | 2      | 1      | 21    |
| Stochastic Programming                  | 3      | 3      | 4      | 1      | 7      | 5      | 1      | 2      | 26    |
| Decomposition Methods                   | 1      | 1      | 0      | 1      | 2      | 5      | 5      | 0      | 15    |
| Column Generation                       | 5      | 1      | 0      | 1      | 4      | 1      | 1      | 0      | 13    |
| Total                                   | 24     | 15     | 26     | 20     | 37     | 23     | 20     | 14     | 179   |
| Other Techniques                        |        |        |        |        |        |        |        |        |       |
| Simulation                              | 19     | 12     | 13     | 11     | 16     | 8      | 12     | 9      | 100   |
| Fuzzy Theory                            | 12     | 11     | 11     | 9      | 7      | 7      | 10     | 7      | 74    |
| Artificial Neural Network               | 15     | 12     | 10     | 6      | 8      | 4      | 4      | 3      | 62    |
| Six Sigma                               | 7      | 3      | 1      | 4      | 1      | 3      | 4      | 1      | 24    |
| Quality Function Deployment             | 1      | 4      | 2      | 3      | 4      | 3      | 3      | 2      | 22    |
| Data Mining                             | 3      | 4      | 0      | 4      | 5      | 3      | 1      | 0      | 20    |
| Data Envelopment Analysis               | 3      | 3      | 1      | 7      | 2      | 3      | 1      | 0      | 20    |
| Total                                   | 60     | 49     | 38     | 44     | 43     | 31     | 35     | 22     | 322   |
4.7 Distribution of theses by keywords

In this section, 12,573 keywords are analyzed to provide insights regarding to the most frequently used keywords. Due to the huge number of keywords, they are classified according to their context. The main and sub groups of keywords which are determined according to number of usage are shown in Table 11.

Usage frequencies of main-group keywords are given in Table 12 for each year. Obtained results indicate that subjects related to production and supply chain management were the most frequently studied subjects on post-graduate theses by industrial engineers. Followed by, scheduling and information management subjects came in third and fourth places. Least frequently studied subjects were marketing/human resources/customer relationship management. This issue seems normal when the scope of industrial engineering is examined. Although there are enough keywords related to the classical research areas in industrial engineering, it is believed that there should be more studies related to the “information management and technology, decision support systems” main group because of current information age. The importance of information technology and business process redesign is critical for industrial engineers. Because the information technologies are used for analysis and modeling and industrial engineers are keen on applying these technologies to manufacturing processes. Especially the Industry 4.0 content forces to integrate all manufacturing processes with internet of things, big data utilization etc. But when the keywords are analyzed, only a few topics are determined that focus on Industry 4.0 and/or up to date technologies. There were 1 ”Big Data”, 2 “Cloud Computing” and 2 “3D Bioprinting” keywords within this context. It is expected that the post graduate thesis will focus on these topics in near future.

5 Conclusion

The post-graduate studies are important from two points of views. The first one is about personal development, the programs gives education at higher levels thus helping the students develop their necessary skills for their work. Secondly, the educated workforce can result in economic development. The nations can make use of this educated workforce themselves or when the educated workforce becomes well-known, it can attract international investment. In this regard, motivation of this study is to figure out the dispersion of industrial engineers post-graduate theses to analyze the general situation and trends.

As a summary, in this study 2,122 post-graduate theses are analyzed which are carried out in the department of industrial engineering in Turkish universities. Nine different indicators are used for the analysis. To not to repeat ourselves all the findings of the paper is not written in conclusion and can be found in related sections of the study. But it is noted that heuristic/meta-heuristic and multi-criteria decision making methods are used in recent years more frequently in the theses. Also production and supply chain management related topics are determined as the most recent studied topics.

Table 11: Classification of analyzed keywords.

| Main-group | Sub-group |
|------------|-----------|
| Information management and technology / Decision support system | Decision Support System, ERP, Electronic Data Interchange, Mobile, E-Commerce, Information Management, Geographic Information System, RFID, Information Technology, Wireless Quality, ISO/TSE, Statistical Quality Control |
| Production Scheduling Risk | Stock, Assembly Line Balancing, Assembly, Demand, Production Planning, Production, Inventory, Machine Scheduling Risk |
| Marketing / Human Resources / Customer Relationship Performance Management | Marketing, Human Resources, Customer Relationship Management Performance |
| Supply Chain Management / Logistics | Logistics, Supply, Supplier, Supply Chain, Transport, Vehicle Routing, Travelling Salesman Problem, Facility, Site Selection Cost, Pricing, Finance, Accounting, Investment |
| Occupational Health and Safety / Ergonomic / Work study / Time Study | Occupational Health, Occupational Safety, Ergonomic, Safety, Job Evaluation, Work study, Time study |

Table 12: Classification of analyzed keywords.

| Information management and technology, Decision support system | Risk Management | Marketing, Human Resources, Customer Relationship Management Performance | Supply Chain Management Cost | Occupational Health and Safety, Ergonomic, Work study, Time study |
|-------------------|---------------|--------------------------|-------------------|-------------------------------|
| Quality Production Scheduling | 2010 | 16 | 11 | 35 | 27 | 6 | 3 | 10 | 57 | 15 | 3 |
| | 2011 | 15 | 9 | 45 | 20 | 3 | 4 | 13 | 42 | 8 | 3 |
| | 2012 | 19 | 7 | 47 | 24 | 12 | 4 | 10 | 40 | 18 | 4 |
| | 2013 | 24 | 7 | 46 | 27 | 8 | 3 | 14 | 54 | 14 | 8 |
| | 2014 | 15 | 9 | 44 | 29 | 21 | 2 | 9 | 59 | 20 | 2 |
| | 2015 | 5 | 2 | 39 | 17 | 10 | 1 | 7 | 47 | 9 | 15 |
| | 2016 | 9 | 11 | 32 | 11 | 10 | 1 | 8 | 38 | 12 | 3 |
| | 2017 | 8 | 8 | 15 | 12 | 2 | 4 | 2 | 28 | 5 | 1 |
Since the analysis results are differing according to the universities, the developing universities can benefit from the role model ones. In this regard, especially the keyword analysis can help the researchers to find themselves a promising topic. Also analysis from other countries would be very helpful to understand how the topics are changing according to the countries. For the future studies, a statistical analysis should be conducted to investigate the relationship between geographical distributions of the theses and the potential jobs or population of provinces and the number of theses.

6 References

[1] Miller A, Bures M. “New approach to industrial engineering education with the help of interactive tools”. Procedia-Social and Behavioral Sciences, 174(12), 3413-3419, 2015.

[2] Erginel N, Telce M, Küçük G, Alper A. “An academic view of industrial engineering job in Turkey”. Industrial Engineering Journal, 27(1), 25-38, 2015.

[3] İbis E. “The problems of graduate education”. Journal of Higher Education, 4(3), 117-123, 2014.

[4] Das A, Handfield RB. “Just-in-time and logistics in global sourcing: an empirical study”. International Journal of Physical Distribution & Logistics Management, 27(3/4), 244-259, 1997.

[5] Jack EP, Stephens PR, Evans JR. “An integrative summary of doctoral dissertation research in quality management”. Production and Operations Management, 10(4), 363-382, 2001.

[6] Xifra J, Castillo A. “Forty years of doctoral public relations research in Spain: a quantitative study of dissertation contribution to theory development”. Public Relations Review, 32, 302-308, 2006.

[7] Oruç Ş, Ulusoy K. “Social studies education and dissertations in this field”. Journal of Selçuk University Ahmet Keleşdoğan Education Faculty, 26, 121-13, 2008.

[8] Şahin M, Yıldız DG, Duman R. “An evaluation of the theses on social studies education in Turkey”. Journal of Social Studies Education Research, 2(2), 96-121, 2011.

[9] Benlirgray S. “The theme analysis of the postgraduate theses written on human resource management in Turkey: 1983-2008 period”. Eskisehir Osmangazi University Journal of Economics and Administrative Sciences, 4(1), 167-197, 2009.

[10] Karadağ E. “Research models used in doctoral dissertations in the area of education sciences in Turkey: Quality of research and analytical errors”. Educational Administration: Theory and Practice, 16(1), 49-71, 2010.

[11] Uygun S. “Analysis of graduate theses on history of education”. Journal of Erciyes University Social Science Institute, 33(2), 263-282, 2012.

[12] Balar NO. “Categorical evaluation of PhD thesis in the marketing field (1994-2012)”. Öneri, 10(40), 1-13, 2013.

[13] Truong VD, Garry T, Hall CM. “Social marketing as the subject of doctoral dissertations”. Social Marketing Quarterly, 20(4), 199-218, 2014.

[14] Truong VD, Dietrich T. “Master’s thesis research in social marketing (1971-2015)”. Journal of Social Marketing, 8(1), 58-98, 2018.

[15] Köksal G, Eğıtm cm A. “Planning and design of industrial engineering education quality”. Computers & Industrial Engineering, 35(3-4), 639-642, 1998.

[16] Li Y, Ying B. A project-oriented model of graduation thesis in the industrial engineering undergraduate program. Editors: Zhang L, Zhang C. Engineering Education and Management, 317-322, Berlin, Heidelberg, Springer, 2012.

[17] Kaya M, Kaya MF. “Tendencies in geography education: A meta-analysis study on graduate theses up to 2012”. Journal of Marmara Geography, 27, 282-313, 2013.

[18] Alfı F. GMH. “A survey of doctoral theses accepted by universities in the United Kingdom and Ireland for studies related to tourism (2000-2009)”. Journal of Hospitality & Tourism Education, 25(1), 29-30, 2013.

[19] Yenilmez K, Sölpük N. “The examination of theses to relate with mathematics curriculum (2004-2013)”. Journal of Research in Education and Teaching, 3(2), 33-42, 2014.

[20] Aydın B. “Bibliometrics analysis of thesis about food beverage industry registered in thesis center of council of higher education”. Journal of Multidisciplinary Academic Tourism, 2(1), 23-38, 2017.

[21] Dengiz B. “Benzetim Ders Notları”. Başkent Üniversitesi Endüstri Mühendisliği Bölümü, Ankara, 2018.

[22] Desale S, Rasool A, Andhale S, Rane P. “Heuristic and meta-heuristic algorithms and their relevance to the real world: a survey”. International Journal of Recent Trends in Engineering & Research, 351(5), 2349-7084, 2015.

[23] Liberti L, Calieri S, Tarissan F. Reformulations in mathematical programming: A computational approach. Editors: Abraham A, Hassanian AE, Siarry P, Englebretcht A. In Foundations of Computational Intelligence Vol 3, 153-234, Berlin, Springer, 2009.

[24] Karaatlı M, Ömürbek N, Budak İ, Dağ O. “Çok kriterli karar verme yöntemleri ile yaşanabilir ilerilen sırnaması”. Selçuk University Journal of Institute of Social Sciences, 33, 215-228, 2015.

[25] Karahan M. “Turizm talebinin yapay sinir ağları yöntemiyle tahmin edilmesi”. Süleyman Demirel Üniversitesi, İktisadi ve İdari Bilimler Fakültesi Dergisi, 2012), 195-209, 2015.

[26] Wermo N. “Fuzzy classification of online customers. 1st ed. Heidelberg, Springer, 2015.

[27] Akdeniz, F. “İstatistikte yeni eğilimler ve gelişmeler”. Sosyal Bilimler Araştırmaları Dergisi, 4(4), 1-11, 2015.

[28] Özkan, V. “Veri Madenciliği Yöntemleri”. İstanbul, Türkiye, Papatya Yayınları, 2008.

[29] Yarar A. Susurluğuz Hayrızsık Akış Verilerinin Modellemesi. Doktora Tezi, Selçuk Üniversitesi, Konya, Türkiye, 2010.