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BAHÇEŞEHİR UNIVERSITY

INDUSTRY 4.0: READINESS OF TURKEY

Capstone Project

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ISTANBUL, 2019

T.C.

BAHÇEŞEHİR UNIVERSITY

FACULTY OF ENGINEERING

DEPARTMENT OF INDUSTRIAL ENGINEERING

INDUSTRY 4.0: Readiness of Turkey

Advisor: Dr. Sabri Tankut Atan

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10/05/2019

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Committee Member	Signature
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Academic Honesty Pledge

In keeping with Bahçeşehir University Student Code of Conduct, we pledge that this work is our own and that we have not received inappropriate assistance in its preparation.

We further declare that all resources in print or on the web are explicitly cited.

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Abdulmalek Battikh	10/05/2019	

ABSTRACT

INDUSTRY 4.0: READINESS OF TURKEY

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Faculty of Engineering

Department of Industrial Engineering

Advisor: Doç. Dr. Sabri Tankut Atan

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Even though renowned point of view expresses that Turkey will not be ready for industry 4.0 revolution for at least another century, a country's success on digital transformation progress may not be visible to the ones who aren't informed with factors of the more profound level. Industry 4.0 can be shortly defined integration of digital technologies to different industries to achieve automation and productivity. In order to consider the readiness of something, factors that are beneficial and that acts as obstacles must be determined. In the case of industry 4.0, since it is an excessively broad concept, economical factors such as unemployment, barriers of technology such as insufficient amount of data or experts that can utilize the technology, energy requirements for operating and expand of its use in the society can be taken into the account. While factors are investigated; in order to define the objectives and required levels of these factors are researched, import and export data of 150 countries are extracted and placed into R for world trade network analysis. By calculating the centrality measures for each country and researching correlation ratios between export & import - GDP and export & import - Technology Scores, even more assisting information about a country's state on its digital transformation can be possessed. Later, data related factors is placed into matrix along with 10 countries which are determined by world trade network's analysis previously. Using the information acquired from world trade network & centrality measures and statuses of each country in the mentioned factors, Readiness of Turkey for industry 4.0 revolution is realized to be lacking on investment values, energy requirements and knowledge of society, on the other hand, Turkey seemed to have an advantage on its human capital with its young population and engineer graduates. To sum up, Turkey may not be as feasible as other countries for digitalization but with accurate actions taken to educate its human capital, there is no objective reason to state Turkey isn't ready for industry 4.0 revolution.

Keywords: Industry 4.0, Digital Transformation, Network Analysis, Spearman Correlation.

ÖZET

INDUSTRY 4.0: READINESS OF TURKEY

Ufuk Altan

Barış Vardar

Abdulmalek Battikh

Mühendislik Fakültesi

Endüstri Mühendisliği Bölümü

Proje Danışmanı: Doç. Dr. Sabri Tankut Atan

MAY, 2019, 60 sayfa

Ortak kabul edilen düşünceler Türkiye'nin Endüstri 4,0'ı en az bir yüz yıl sonra sahiplenebileceğini ifade etse de, bir ülkenin dijital transformasyon da ki süreci konuyla ilgili daha detaylı bilgiye sahip olmayanlara pek de görünür olmayabilir. Endüstri 4.0, dijitalleşme teknolojilerinin üretim ve ulaşım sistemlerine entegrasyonuyla, otomasyonu ve üretkenliği sağlamak olarak tanımlanabilir. Hazır olmak kavramı sorgulandığında, hazır olmak istenen kavrama faydalı veya engel olabilecek faktörler belirlenmelidir. Endüstri 4.0 çok geniş bir konu olmasıyla birlikte işsizlik gibi ekonomik faktörlere, veri eksikliği veya uzmanlar gibi teknoloji bariyerlerine, enerji gereksinimlerine ve bu yeni sistemin toplum içerisinde yayılması faktörler içerisinde gösterilir. Faktörler incelendiği sırada, bu faktörlerde ne seviyede olunması gerektiğiyle ilgili veriler araştırılmış, 150 farklı ülkeye ait ihracat ve ithalat verileri bulunup R üzerinde network analizi yapılmıştır. Ülkelere ait merkezilik ölçüleri hesaplanmış, ihracat & ithalat - GSYİH ve ihracat & ithalat - Teknoloji Skorları arasındaki korelasyon oranları hesaplanmıştır. Bu sayede bir ülkenin dijitalleşmedeki durumuyla ilgili yardımcı olabilecek bilgiler edinilmiştir. Daha sonra, network analizi aracılığıyla bulunan 10 ülkenin çeşitli faktörlerdeki verileri araştırılıp, faktörler matrisine yerleştirilmiştir. Faktörler matrisi ve ticaret verilerinden çıkan merkezilik ölçüleriyle, Türkiye'nin Endüstri 4.0 ile ilgili yaptığı yatırımların, enerji gereksinimdeki durumunun ve toplumun konuya aşinalığının yetersiz olduğu göze çarpmıştır. Diğer bir tarafta, genç nüfusu ve mühendis sayısıyla Türkiyenin insan sermayesinde avantajlı olduğu bulunmuştur. Sonuçta, Türkiye dijitalleşme sürecinde bu 10 ülkenin gerisinde kalıyor olsa da, doğru bir eylem planıyla insan sermayesinin eğitilmesi durumunda, Türkiye'nin Endüstri 4.0 devrimine hazır olamaması için hiçbir sebep yoktur.

Anahtar Kelimeler: Endustri 4.0, Dijital Tranformasyon, Network Analizi, Spearman Korelasyonu.

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LIST OF ABBREVIATIONS

AR	Augmented Reality
IoT	Internet Of Things
R&D	Research and Developments
3D	Three-dimensional.
GDP	Gross Domestic Product
BTU	British Thermal Units
JIT	Just In Time
kWh	Kilowatt Hour
CAD	Computer-Aided Design
CAM	Computer-Aided Manufacturing
CBM	Cloud Based Manufacturing
CPS	Cyber-Physical Systems
IMS	Intelligent Manufacturing Systems
MES	Manufacturing Execution Systems
MDC	Machine Data Collection
SaaS	Software as a Service
SCM	Supply Chain Management

1. INTRODUCTION

First industrial revolution started with the invention of the steam engine which requires coal extraction as an energy source which created an innovation in the agricultural environment and, later, in the economic structure of the society [1].

Second industrial revolution was the result of new types of energies called electricity, gas and oil. As technological advancements continue to grow, the development of the combustion engine took place at 1870s. Chemical synthesis resulted with faster and easier provocation of different fabric types, furthermore, transportation technology was advanced with the advent of cars and planes. With that in mind, construction of large factories was initialized by Taylor and Ford with new organizational models of manufacturing [1].

Third industrial revolution has started with inventions of transistors, microprocessors as rise of the electronics; telecommunication tools such as computers and a new type of energy named nuclear energy. This revolution let too many occasions of space researches and technological advancements in automation [1].

Nowadays, the fourth industrial revolution has begun with developments of digitalization as prominent technological improvements. With digitalization technologies manufacturing environment can renew itself automatically with the transformation of data [1].

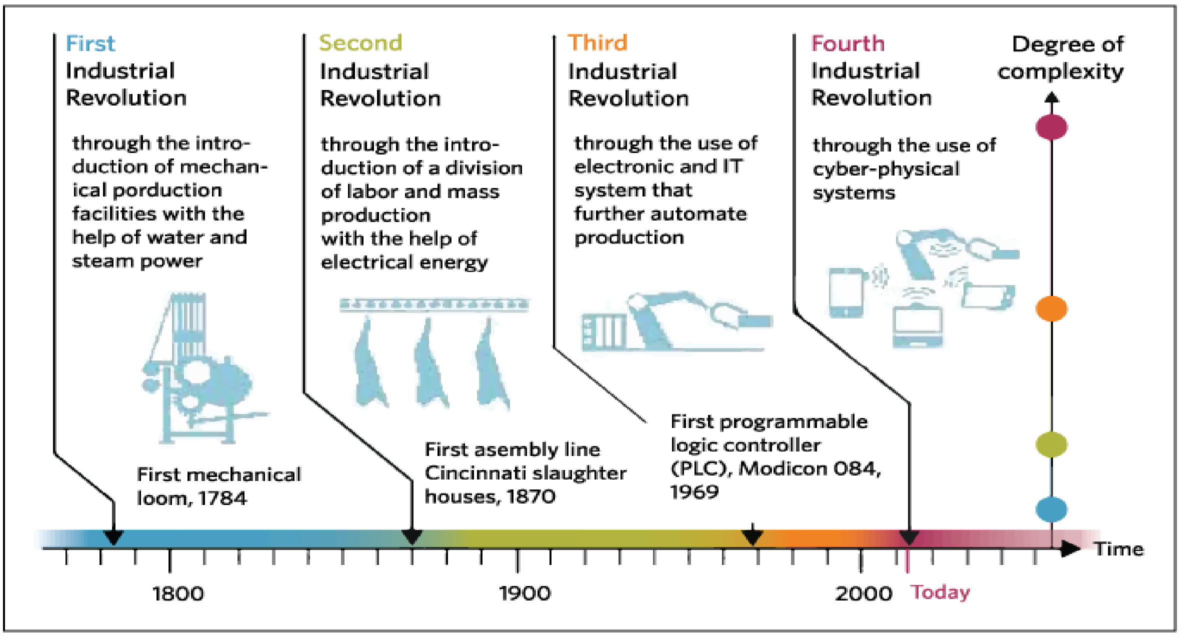


Figure 1.1: Representation of Industrial Revolutions

(Source: maximintegrated.com)

For the future of manufacturing environment, integration of digitalization technologies, utilization of artificial intelligence, to production environment in order to establish automation is the main goal of Industry 4.0[2].

Industry 4.0's components are big data analytics, simulation and virtualization, IoT (internet of things), the cloud, cybersecurity, autonomous robots, additive manufacturing, augmented reality.

To sum up, industrial revolutions take place to establish a more comfortable environment for people which would result in faster and easier manufacturing to satisfy the needs of increasing population.

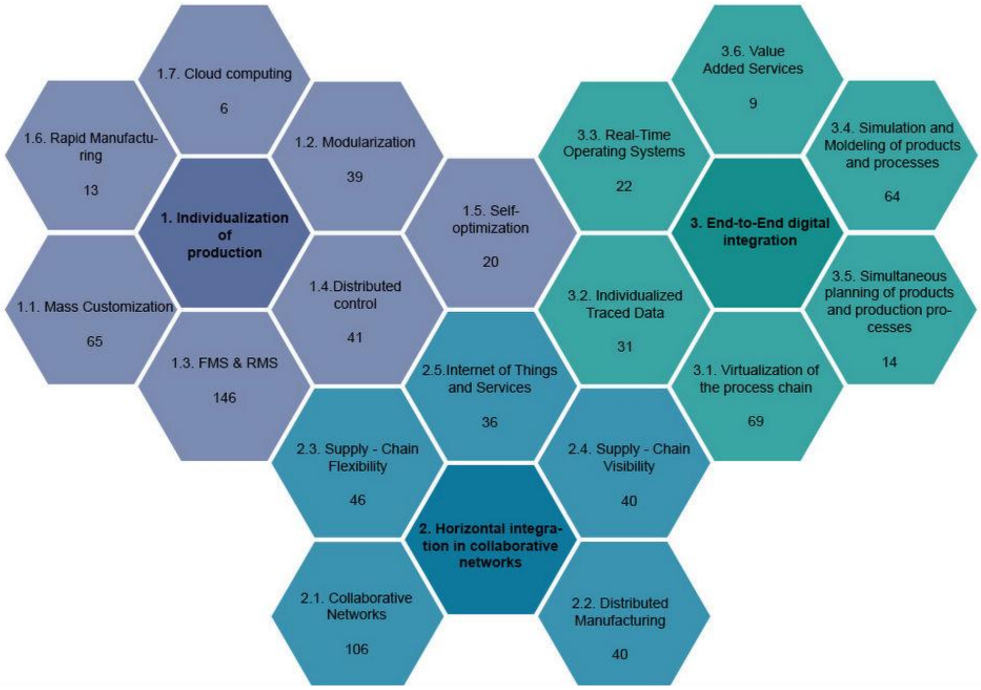


Figure 1.2: Industry 4.0 Components

(Source: Industry 4.0 the Future of Productivity and Growth in Manufacturing Industries)

However, the advent of a new revolution would bring possible problems and constraints with its application as expected. Does the country have the required energy production for the new digitalization and the autonomous machines, what will be the cost for R&D (Research and Development), how the unemployment rates and environment will be affected, and the most importantly does the country have the technological advancements to apply and move on with new industrial innovations.

Likewise, it is important to understand society's intellectuality level on the related subject. Society 5.0 is a perspective that signals the look of the people to the growing field of industry 4.0. According to Society 5.0, solutions for elder population's comfort and living conditions, virtual reality and real life's cooperation and environment's protection has to be considered as a fact before taking actions.

The word “Readiness” can be described as the craft of managing risks, evaluating possible future occasions at the right time, being responsive to unexpected problems and, most importantly, determination of main obstacles and their states with qualitative analysis [3].

This report examines the critical factors of Industry 4.0 by doing an extensive literature review, apply network analysis and correlation test to World Trade Network Data and explore different countries’ statuses on the determined factors in order to understand the obstacles to overcome.

2. LITERATURE REVIEW

2.1. Employment and Economy

Expand of Industry 4.0 would result in a 6% improvement rate on employment during the next decade. Especially, mechanical engineering jobs are expected to increase at a rate of 10% in the same period [4].

Industry and research experts state that internet will be the causation of the Industry 4.0, once factor of communication is endorsed among, not just humans, but machines as well with the Cyber-Physical-Systems (CPS). Especially for Germany, both GDP and employment will be significantly influenced since manufacturing brings more than 25% of the GDP and obtains seven million job occasions [5].

According to the forecasts, Industry 4.0 has the potential of barring old management models while establishing new business perspectives and future jobs that will change the industries and markets [6].

Figure 2.1: Advent of Machines and Its Influence on Employment

(Source: yenisafak.com & robohub.org)

Current jobs are highly vulnerable to be replaced by computerization, possibly resulting a 47% unemployment risk in the US industries. [7]

Problems start with the people who already have jobs. It is predicted that inconsistent events might occur at any time, challenging them to keep themselves being employed [8]. Even though they believe that solution lies in the continuous worker development, Sung (2018) opposes by stating, even the most creative and qualified educational system is not adequate for the elderly workers.

To sum up, advent of industry 4.0 results with improvements in many aspects of economy. Later, change in exports and imports values of different countries who utilize digitalization technologies will be presented. Even though, in most cases, employment rates tend to increase as an economical growth; unemployment rates of aged population is expected to increase with the technological advancements since aged workers would have hard time during the adaptation process. As a result, it has to be put in the calculation.

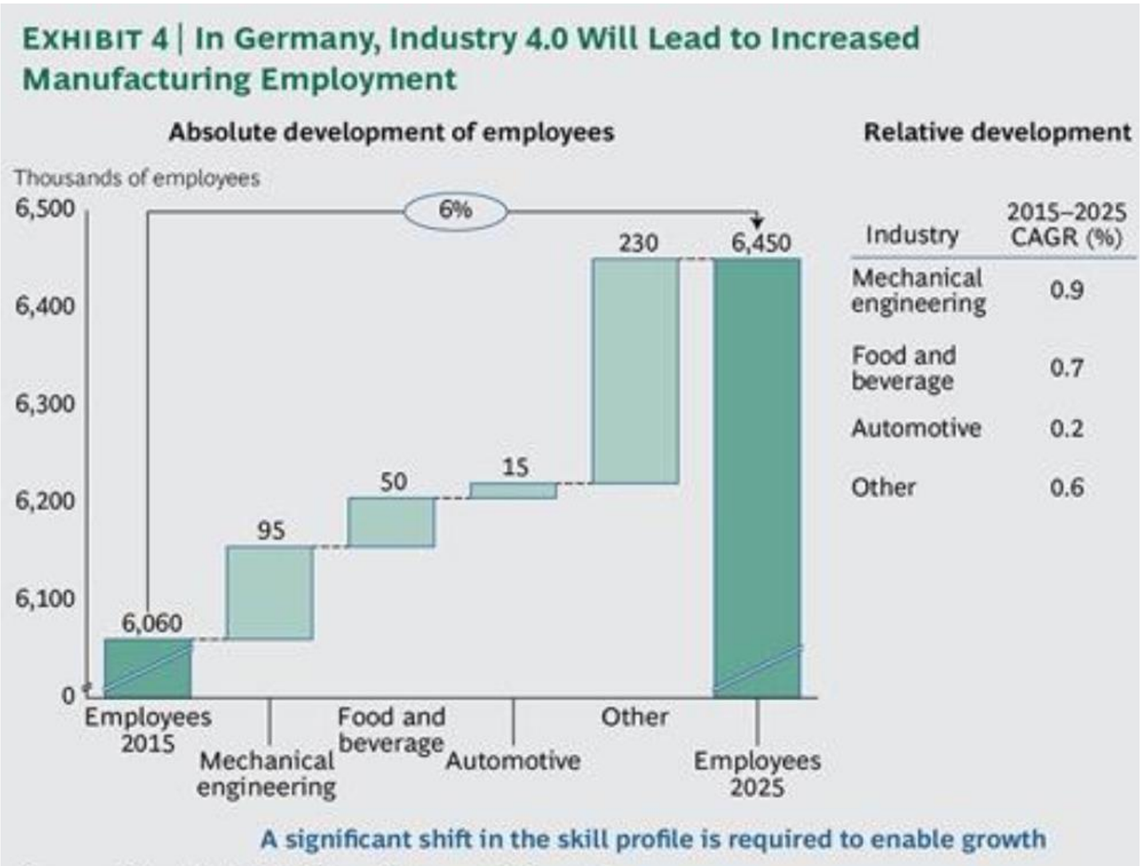


Figure 2.2: Employment Change

(Source: Federal Statistical Office of Germany, BCG analysis)

2.2. Technology

Computers and information Technologies were confusing once they were introduced in Industry 3.0. At the moment and in the future, computers will be connected and act collaboratively without needing any human attention as Industry 4.0 expands. Since the World is just starting out its reformation progress, there is no country who reached the full capacity of the industry 4.0, therefore, none can be considered as ready [9].

Different countries with different statuses have different positions for readiness. Some countries have lower labor cost, thus, have competitive advantage. However, they might have to confront risky outcomes because of their way of settlement to older versions of technology [10].

On the other hand, some countries will have to decide whether they ought to move on with conventional production strategies or begin following advanced production methods since most companies might have stuck in their years of legacies [10].

Industry 4.0 technology will bring new perspectives to quality management of products, efficiency in manufacturing, therefore, change in demands of customers and increases in market size. Since population is ascending, needs will be ascending as well. However, technology might not be affordable at first for most industries and, furthermore, even if the technology is adopted, industries will still be requiring employees who are able to apply it. In this case, number of software engineers, computer engineers, industrial engineers, mechanical engineers or, shortly, educated and well trained engineers have a substantial role. [11]

2.2.1. Internet of Things (IoT):

The connection between machines, sensors, middle-wares, software and storage systems is ensured by the utilization of the industrial internet [12].

All the integration in the manufacturing environment is the consequence of the internet of things (IoT) technology which is able to maintain an advanced way of data provocation [12].

2.2.2. Autonomous Robots:

Utilization of Internet of Things mainly aims to set up an association between various types of objects like machines, computers and other devices to create a sense of autonomous collaboration during manufacturing processes. Autonomous robots refers to just one concept for the current technology that is developed [13].

In general, robot arms are tend to cost between $28,000 - $40,000; furthermore, the equipment of safety might be sold for $50,000 if there isn't a price discount [14].

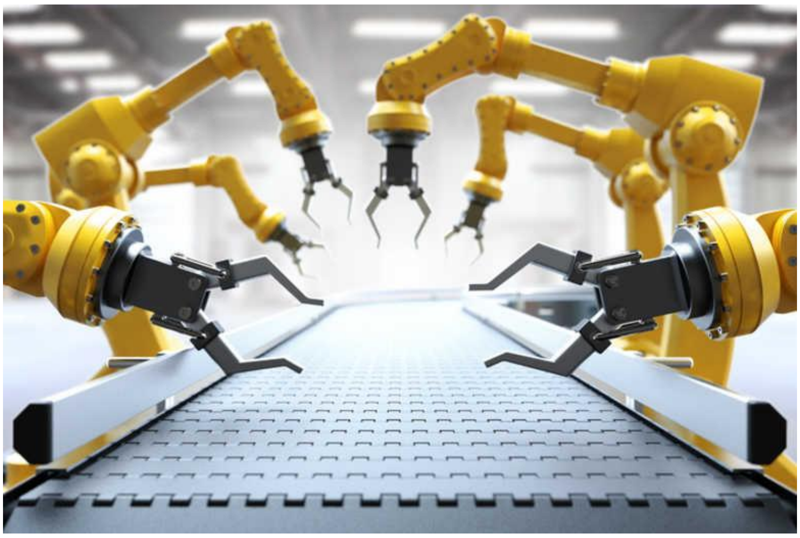


Figure 2.3: Autonomous Robots

(Source: slideshare.net)

2.2.3. Simulation & Virtualization

Simulation is a technique of using statistical information to assign virtual systems of processes to foresee the possible outcomes of an operation [15].

Main dilemma of simulation, especially in manufacturing environment, has been determined as the collection of data. Simulation models that are generated for manufacturing processes involves excessive amount of details to draw appropriate conclusions [15].

Unless a significant amount of data related to manufacturing processes is gathered and automated, utilization of simulation modelling would tend to decrease monumentally [16].

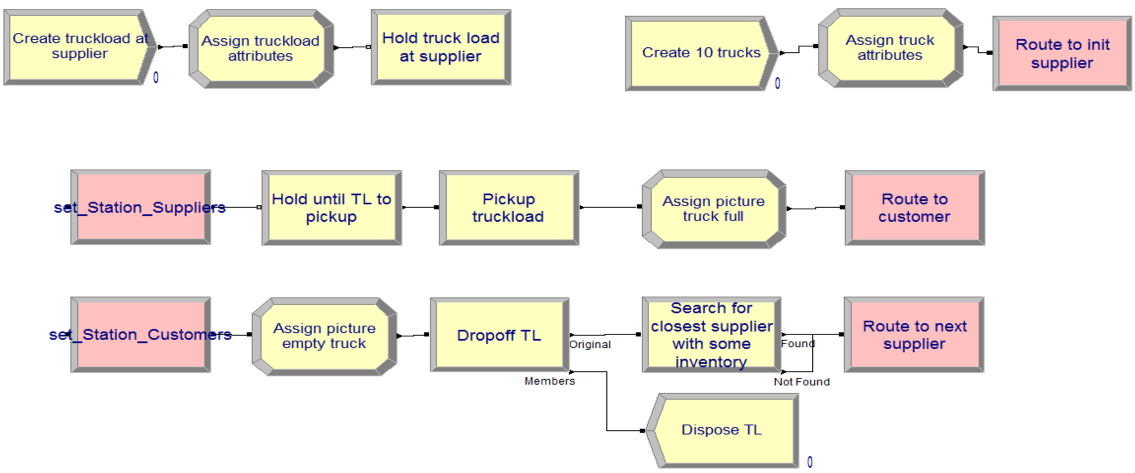


Figure 2.4: Arena Simulation

(Source: strongwindbrowser.weebly.com)

2.2.4. The Cloud

During the exchange and flow of massive amount of data in systems like remote service, color management, and performance benchmarking; the cloud technology is applied to store the data in the database. Its popularity will increase in different sectors [17].

The cloud technology is available on internet for any individual's use on different functionalities such as Dropbox for cloud storage or Online for cloud gaming. Such an immense amount of data storage brings up the possibility of increased risk of, so called, "Information Robbery". This mentioned environment, manages a requirement of a more advanced security system [18].

2.2.5. Cybersecurity

A source of data or information tends to be vulnerable to unauthorized access, modification or deletion in the case of the absence of a well-developed security system [19].

Errors, flaws or mistakes are straightforwardly described as "Software bugs" in computerization applications. Software bugs can also indicate that a regular system might be acting irregularly, therefore, could be assisting. Cybersecurity problems function because of the utilization of unsecured software applications. This happens when some traits of software's interfaces are attacked [20].

Cyber problems have become international issues in personal data security, banks and governments compared to last decade. For example, a company who provides an app to its customers to control their financial decisions has to form a security prioritized network. While an unusual action has taken inside an account such as a great amount of balance is transferred or immense amount of data is collected, a warning is sent to a chain of different software that are responsible for avoiding a security disaster whether by sharing the information with the customer or to the engineers to reverify the action. Thus, cyber problems can be adapted with the re-advancements of the technology [21].

2.2.6. Additive Manufacturing

According to an article by GE Additive [22], Additive manufacturing is a transformative process to industrial manufacturing that enables the production of lighter, more powerful parts and systems.

Additive manufacturing also known as 3d printing is a process that create a physical object from a digital design, an engineer designs the object using computer aided design or

CAD software, the 3d design file is the sliced into thin layers and uploaded to an additive manufacturing machine, the manufacturing process design once an extremely thin layer of metal powder is spread across the platform a heat source such as laser or electron beam then melts the first layer of the 3D design the platform is lowered and another layer of metal powder is spread across the platform, the layering and melting is then repeated until the part is completed.

2.2.7. Augmented Reality

Augmented Reality is an expansion of Virtual Reality, where it enable the user view three-dimensional digital information over the physical environment [23]. When talking about the smart manufacturing, Augmented Reality is one of the most advanced technologies implicated in industry 4.0 trend [24].

The developers who are creating the AR applications in companies are focusing firstly in service: manuals and instructions, customers self-service. And secondly in manufacturing like quality assurance, assembly instructions, performance dashboard. And then sales and marketing, design, operations (digital product control) and training. [25]

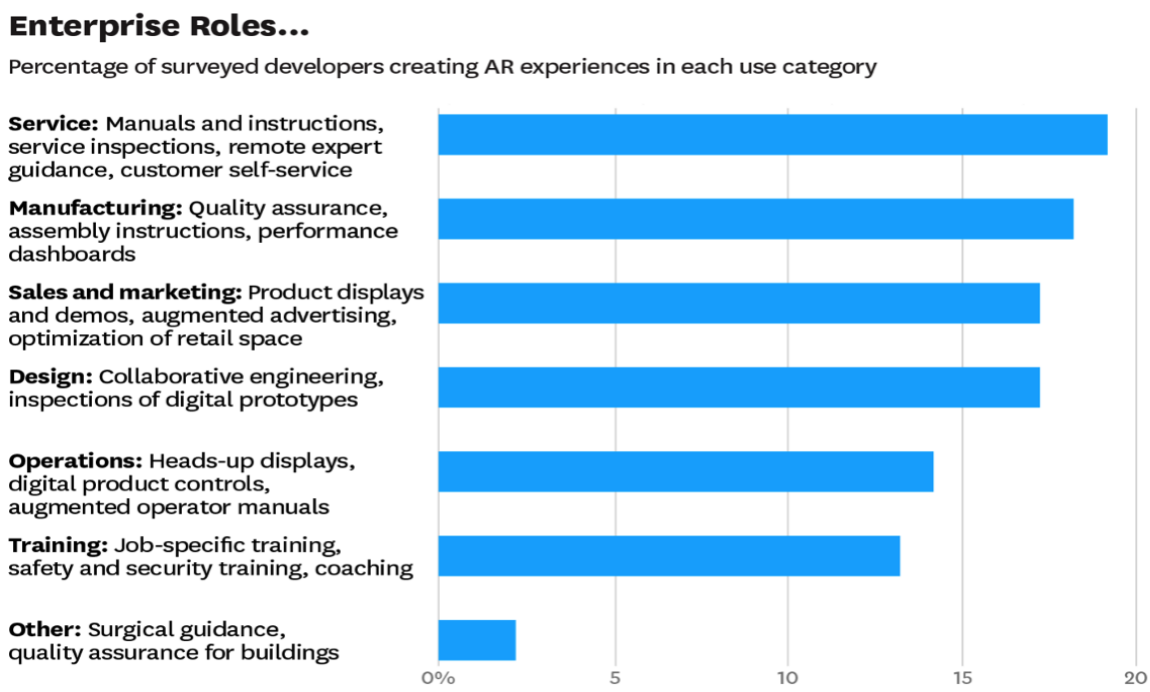
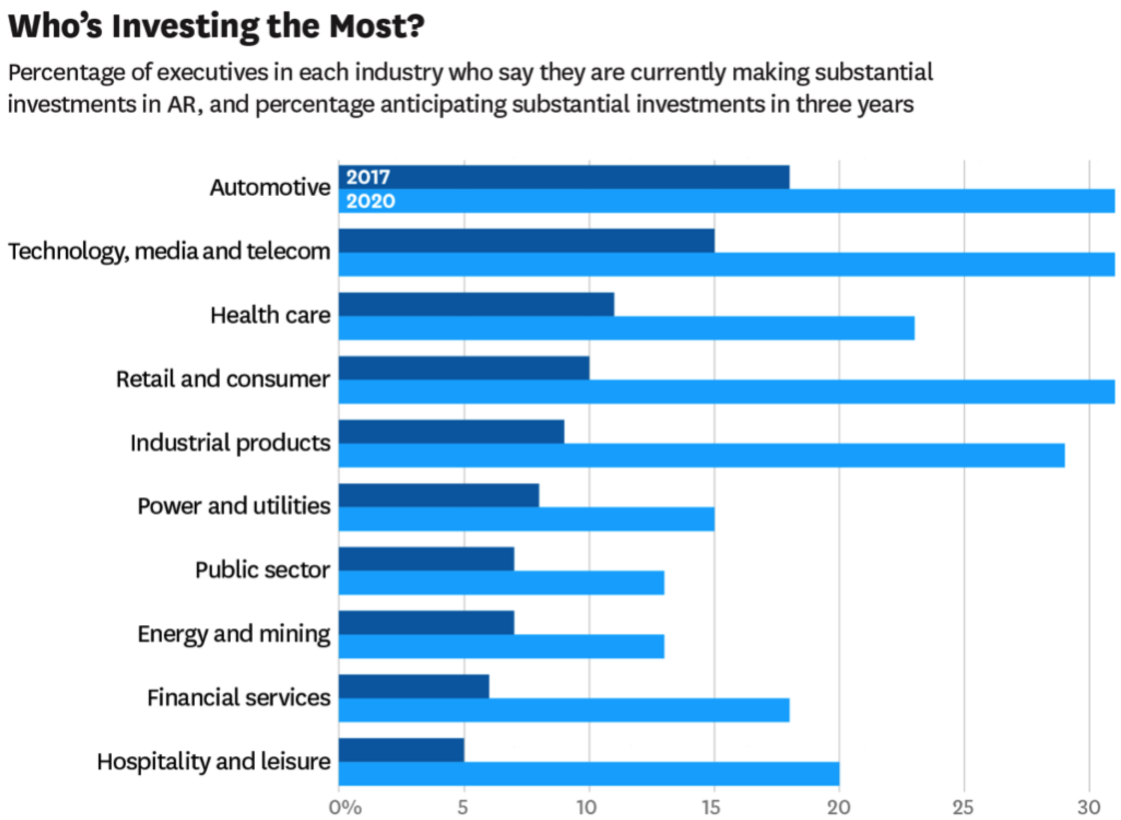


Figure 2.5: Developing AR Applications

(Source: Harvard Business Review Staff, 2017)

AR-based solutions are already used in many companies for production and engineering: Siemens, General Electric, Volkswagen, BMW, Airbus, Caterpillar, ABB, Schneider Electric, and Bosch [23].

In 2017 the highest investments in AR applications was in Automotive industry and then technology and telecom, health care, retail and consumer and industrial products, And in 2020 the investments in AR applications are going to be more in automotive and



technology industries as shown in the table [26] .

Figure 2.6: Investments in AR Applications

(Source: Harvard Business Review Staff, 2017)

AR utilization has been increased in Manufacturing usage such as Product-Manufacturing design, Training, Support, Simulated environments, Process Optimization and Logistic, Ford Motor company uses AR for Designing, Ford's design teams started using AR (Microsoft HoloLens) to overcome new parts in physical prototypes, and this gave the chance for the company’s designers to be more creative, and enabled them to improve decision making and collaborate better [27].

2.3. Energy Requirements

The total world energy consumption is predictable to increase 48%, from 549 quadrillion British thermal units (Btu) in 2012 to 815 quadrillion Btu in 2040. Renewable energy consumption rise between 2012 and 2040 by an average 2.6% per year and it is the world’s quickest increasing energy source over the prediction term [28].

In 2014, fossil fuels take a part of more than 78 % of global final energy consumption, and 10.3% of global final energy consumption was consumed by renewable energies with solar and wind power [29]. In 2015, more than 50 % of the world’s additional electricity capacity was participated by renewable energies making it a significant source for electricity supply. [30]. Worldwide, the number of countries has raised from 43 in 2005 to 164 countries in mid-2015, which achieving more suitable plan and regulatory cases for renewable energies has increased, [31]. The Difficulties of combining the renewable energy sources into small and large power grid could be provided by digital technologies, which need new approaches to grid management [32].

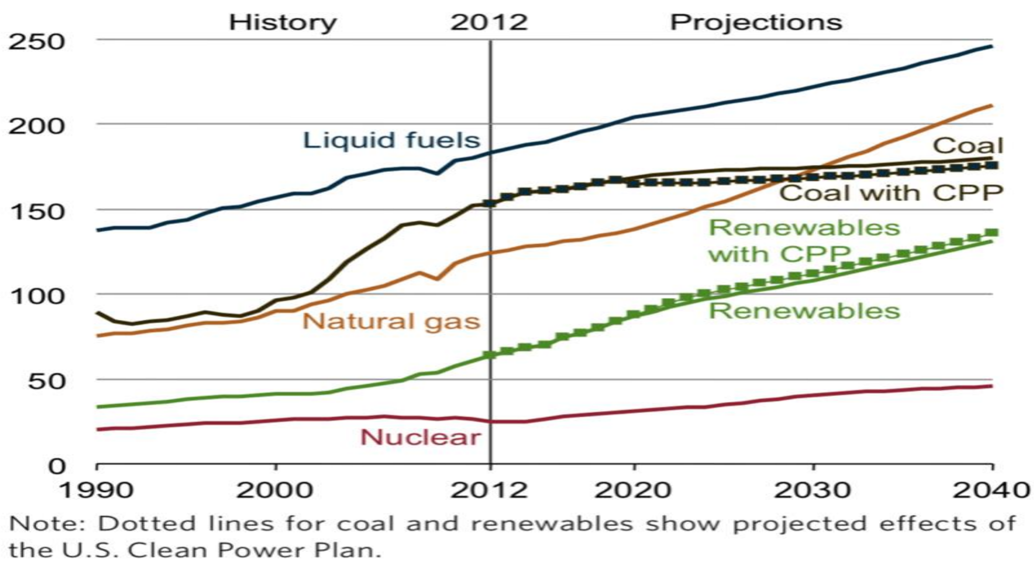


Figure 2.7: Total world energy consumption

(Source: U.S. Energy Information Administration, 2016)

2.4. Society 5.0:

Following the fourth industrial revolution's advancements in technology, Japan proposed a reshaped, smarter, a technology based society to accelerate the confrontation process which is named as Society 5.0. Internet of things will collect the big data that would be utilized by AI to explore new occasions and strengthen the people's skills providing them a life which is more qualified [33].

Society 5.0 origins from Society 1.0, the society of hunting, Society 2.0, society of agriculture, Society 3.0, society of industries and Society 4.0, society of information. Expand of information and skill of Research & Development wasn't very sufficient in Society 4.0 [34].

Since people have restricted abilities of getting the required information from a well-scattered sources and collecting it in a rational way, Society 4.0 is not very sophisticated. As inhibitory factors like decrease in birthrate and aged population, It is an obligation for society to get to the next level [34].

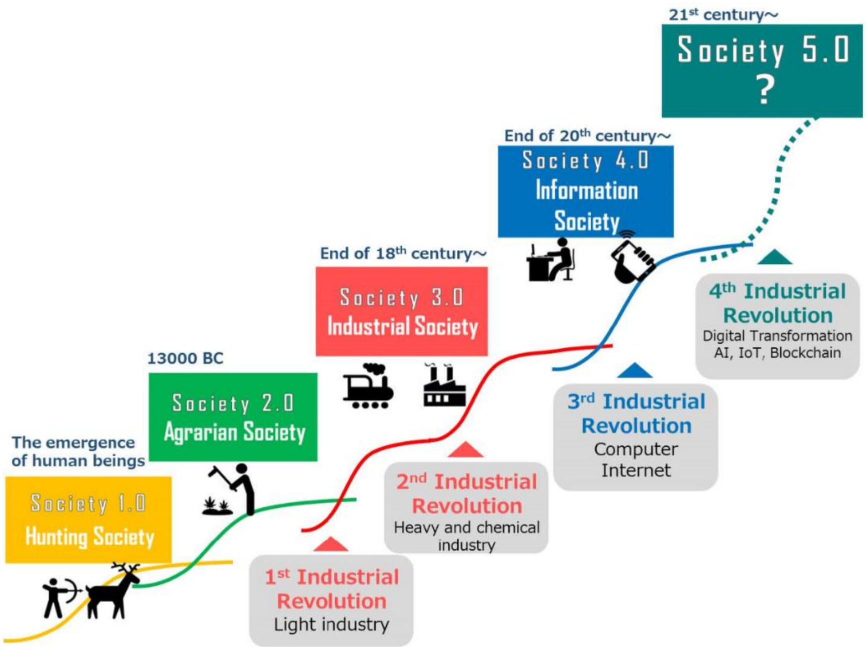


Figure 2.8: Evolution of Society

(Source: bluenotes.anz.com)

The conditions of systems change abruptly with the exceptional alterations in the environment. For the society, it would be both scary and challenging to confront a dramatic and unanticipated shift. It is called "Revolution" that acts differently and place more contemporary perspectives in both economic and social environments. Therefore, Industry

4.0, with its content, ability and entanglement, is a concept the World is not familiar with [35]

Familiar thing is, for the adaptation process of both industries and society, both private and public industries and both young and old people; readiness is a must. For instance, a patient receives the information related to his/her health by taking a pill which distributes nanoparticles to the blood and by looking at his/her smart phone. It is only a matter of time smart phone forwards the information to AI, to get the required diagnosis and possible treatments from the cloud and presents them to the patient. Later, patient visits the closest pharmacy to have the pill, 3D printed on demand [35].

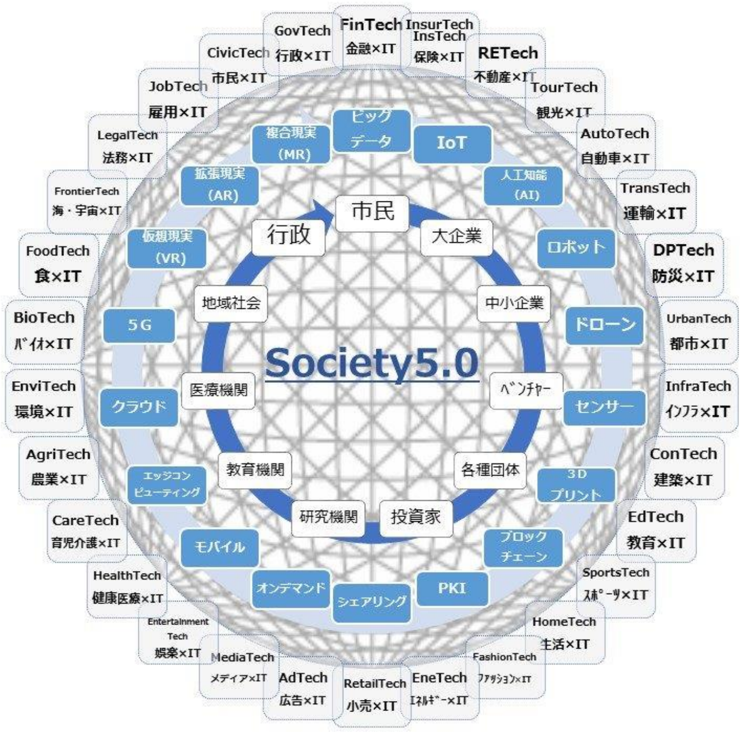


Figure 2.9: Society 5.0 Influence

(Source: globalbusinesscoalition.org)

To conclude, both society and industry keep their influences on each other just like in the last few hundred years. Similar to biology and psychology, albeit they might be separated and placed as different fields, they unarguably act with some level of causations. Industry 4.0 has the potential of reshaping so many fields such as environment, health or agriculture which are certainly related to society. Therefore, society 5.0 is a must for a country's readiness to the new industrial revolution.

2.5. Costs and Investments

During the regulation of the new industrial revolution, German manufacturers estimate that €2.5 billion will be spent as investment during the upcoming 10 years [36].

On the other hand; labor, overhead, operating costs are estimated to be reduced by 30% in 10 years, if an increase of 35% is taken into account for new technology investments. Albeit product design is 5-10% of its manufacturing process, it is possible to stress that it contains 80% of the production cost [36].

Furthermore, with the advanced technology use manufacturers are going to be able to produce multiple designs of multiple car models using a single production line which, evidently, will decrease costs of logistics and operations by being expanded to multiple product life cycles at once and maximizing Just in time (JIT). During the industry 4.0's application in Germany, productivity in manufacturing environment is expected to increase from €90 billion to €150 billion [36].

To sum up the facts, fourth industrial revolution would cause differentiations in the economy, work environment and qualification improvements [37].

3. STATISTICAL ANALYSIS:

3.1.World Trade Network

A straight line that associates two countries, or nodes in other words, is the renowned description for trade flow. This straight line segment can be presented as a line or an arrow if flows come from one country to the other. To draw an appropriate conclusion from the graphs, pictures and other representations; all the information about vertices and links are placed which shapes the World Trade Network [38].

The aim of the network analysis is providing a visual perspective for partnerships between countries to form the trade network. Stressing the connection of vertices on the system instead of vertices' attributes is preferably more assisting [38].

Four main parts are the elements of World Trade Network [N = (V, L, W, P)]. First are the structured nodes (V) which represent countries, second are links (L) that shows relations, third are line value function (W). It defines the strengths of links, and fourth, vertex value function (P) collects variety of data and places them into the graphs for analysis [38]. If vertices of the trade network increase among specific nodes, they clear out the strengths of each line segment and, therefore, strength of the network [38].

To do a network analysis, the network itself has to consist the data that has the highest relevancy, meaning a limit for data selection has to be determined. As a result, the data that cannot reach to 0.01% of the Total World Trade Network must be excluded. [39]

3.2. Network Analysis

3.2.1. Centrality Measures

3.2.1.1. Degree Centrality

One of the most basic concept of network analysis is the search of centrality values. These values are meant to find out the most prominent member or, in other words, center of the social network. By deciding the definition of prominent the finding may vary or one the most common centrality measure “degree” can be applied to measure the network. Number of edges that are connected to a vertex indicates the degree of that vertex [40].

On the other hand, nodes that have more edges have stronger influence in the network, albeit degree is very powerful way to calculate the prominence [41].

3.2.1.2. Betweenness Centrality

Every member of the social network has connections to other members and quantity of connections each member represent the value of betweenness [42]. This value is related to the most monumental member of the chain and ones with higher betweenness values tend to have the highest level of knowledge about the network. Once vertices that have top values are removed, the distance among all others would increase [43]

3.2.1.3. Eigenvector

The next step in determining measures, unlike the degree centrality measure, can provide the strength of each connection of the node. Degree centrality assumes that all nodes and edges have same weight in the measure whereas eigenvector centrality distinguishes the influence levels of each connection value [43].

In that perspective eigenvector centrality is determined with not just number of connection node has but also with their level of influence. More edges indicate a higher value still, however; now with the second factor, strength of each edge has the ability to shift whether one node is more influential or less [43].

3.2.1.4.Closeness

Closeness centrality depends on the distance concept. Focus is on a node's availability or, so to speak, closeness to the other nodes. If a node is has connections to too many nodes, the ability to act independently of that node might decrease substantially [44].

As a node become more reachable, implying the distance between a node and other nodes is verified and utilized as a value. How difficult it is to share knowledge with other members of the network in order determines the value of closeness centrality [45].

Countries by Top Exporters	2003/Degree centrality	2008/Degree centrality	2013/Degree centrality	2018/Degree centrality
Germany	217	216	220	204
Japan	208	209	209	199
France	212	217	220	204
United States of America	214	216	217	202
South Korea	195	202	208	200
Italy	213	217	220	203
United Kingdom	215	215	218	203
Spain	200	207	216	203
China	200	213	218	203
Belgium	212	215	217	205
Netherlands	206	210	218	203
Turkey	194	206	215	203

Table 3.1: Degree Centrality

Countries by Top Exporters	2003/Closeness Centrality	2008/Closeness Centrality	2013/Closeness Centrality	2018/Closeness Centrality
Germany	4,42E-05	4,8077E-05	4,66E-05	6,05E-05
Japan	4,44E-05	4,8063E-05	4,66E-05	6,05E-05
France	4,42E-05	4,9371E-05	4,66E-05	6,05E-05
United States of America	4,43E-05	4,8084E-05	4,66E-05	6,05E-05
South Korea	4,42E-05	4,8063E-05	4,66E-05	6,05E-05
Italy	4,43E-05	4,8082E-05	4,66E-05	6,05E-05
United Kingdom	4,43E-05	4,8077E-05	4,66E-05	6,05E-05
Spain	4,32E-05	4,8070E-05	4,66E-05	6,05E-05
China	4,44E-05	4,8068E-05	4,66E-05	6,05E-05
Belgium	4,43E-05	4,8082E-05	4,66E-05	6,05E-05
Netherlands	4,42E-05	4,8072E-05	4,66E-05	6,05E-05
Turkey	4,42E-05	4,8068E-05	4,66E-05	6,05E-05

Table 3.2: Closeness Centrality

Closeness, betweenness, Eigenvector and degree concepts might be confusing in the first impression. Even though they seem equivalent, slight differences might be meaningful once the information is understood.

In a simpler definition, closeness centrality can represent the popularity of a vertex. Popularity of a node, just like popularity of a person, causes that node to become the center of attention among other nodes and, thus, makes it difficult for that node or, in this case that country, to be always invisible.

Likewise, popular brands can be center of attention and, thus, can easily be reliable but their actions will never be missed. Their audience will always have information about them. For instance, once apple publishes the next I-phone product, people will line up to own it.

Unfortunately, almost all countries in the world have somewhat a trade network and, as a result, closeness centrality values end up being almost equal at each repetition. Since the aim of network analysis is getting information of the top countries especially, closeness centrality values won't be helping the research.

Countries by Top Exporters	2003/Eigenvector centrality	2008/Eigenvector centrality	2013/Eigenvector centrality	2018/Eigenvector centrality
Germany	1	1	1	0,996149653
Japan	0,939170694	0,92362903	0,918895686	0,942291742
France	0,989743033	0,999138619	0,994264316	0,996757917
United States of America	0,958056245	0,957242316	0,954283539	0,964952421
South Korea	0,950361128	0,953225236	0,959235162	0,979644961
Italy	0,986621066	0,990997968	0,991948706	0,989951197
United Kingdom	0,992222894	0,986521404	0,985258392	0,986535547
Spain	0,955568453	0,973209345	0,982724817	1
China	0,943653914	0,984297307	0,985646188	0,989543576
Belgium	0,983788642	0,988027808	0,983922333	0,996598241
Netherlands	0,971019501	0,979157607	0,986744573	0,988777577
Turkey	0,951445225	0,966205902	0,980044862	0,989273921

Table 3.3: Eigenvector Centrality

Eigenvector centrality value is drawn by the values of each vertices that connects each ordinary node to nodes that have higher betweenness values. Even if betweenness values are considered assisting, eigenvector ends up being almost equal in all countries since almost all countries have trades with each other similar to closeness centrality.

Besides being non-necessary eigenvalues can only be accurately calculated if the data is symmetric. Meaning only if skewness number ends up being between -1 and 1, eigenvectors can be useful for analysis.

Countries by Top Exporters	2003/Betweenness Centrality	2008/Betweenness Centrality	2013/Betweenness Centrality	2018/Betweenness Centrality
Germany	957,0161979	542,7029588	485,7815208	422,360651
Japan	680,1377647	501,4508228	552,4508228	380,2303965
France	907,0161979	708,5321979	749,5321979	348,1479756
United States of America	1122,441326	1023,504077	920,7704692	403,2223433
South Korea	478,9428444	415,8288212	403,7169055	248,7087778
Italy	692,322975	642,0436979	709,5794528	313,1607202
United Kingdom	807,0161979	678,5321979	564,0563852	469,0566382
Spain	480,1185873	452,5435348	396,5751778	243,721712
China	907,0161979	880,0161979	881,0161979	782,0161979
Belgium	710,1377647	586,687767	475,145287	364,2919685
Netherlands	582,1837643	539,6031485	617,6049804	318,3029483
Turkey	530,1329908	545	485,8443717	367

Table 3.4: Betweenness Centrality

Betweenness value of a node would, in fact, have a correlation with degree values which before had correlation with technology scores for each data of each year. Therefore, it is possible to state that betweenness values or, in other word, quantity of trading relations a country serves as a bridge also has a correlation with technology levels of countries and their GDP values.

Furthermore, as betweenness value increases, countries earn more and more sales data related to the market. Which would eventually turn into a strategy to control the market sales as information increases. With that amount of market information countries can shape their investment strategies and result with higher export and lower import numbers.

To specifically talk about Turkey, this country has a betweenness value that approaches the world's average almost at each time period (besides 2013). Turkey's advantage can be considered as its location which is available to most word in terms of distance and disadvantage might be considered as, especially for 2013, political reasons and continuous wars around it.

3.3 Digitalization and Import & Export

Import and export numbers might have valuable indications for countries' GDP values. However, that does not imply that these numbers have to reflect a country's success in production environment. These data is world trade network of automobile industry, which is mostly presented as the industry that is the most related industry for digitalization technologies.

Even though these values are anticipated to be supportive to higher GDP values and higher technology levels, different data of different industry sales could be disproving this idea. Since it is much more difficult look for accurate and correct data of different industries, it would be much more efficient to seek a relationship between country import & export values and technology scores of countries. If the relation confirms the possible causation, the network analysis that is applied previously can be utilized to determine the top countries of industry 4.0 technology and, later, can be investigated on related factors to draw a conclusion for future of production in Turkey.

In order to find a possible relationship between digitalization and country imports & exports, manufacturing technology scores of countries of three different years has been collected and prepared for an appropriate correlation test. By determining the type of distributions for each data of technology scores, appropriate correlation test can be decided. If data ends up being normally distributed, a parametric statistical test can be applied, otherwise, parameters like mean and standard deviation would become untrustworthy and a non-parametric statistical test would become a must.

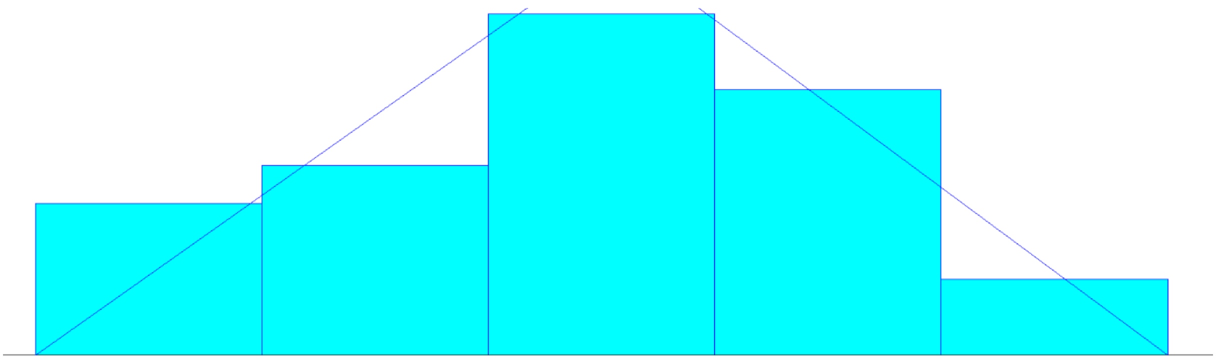


Figure 3.3: 2008 Technology Scores Data - Triangular Distribution

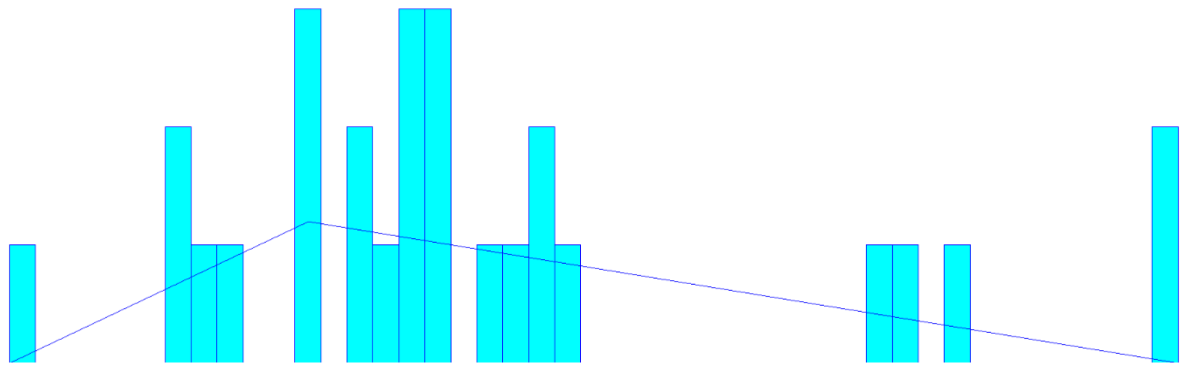


Figure 3.4: 2014 Technology Scores Data - Triangular Distribution

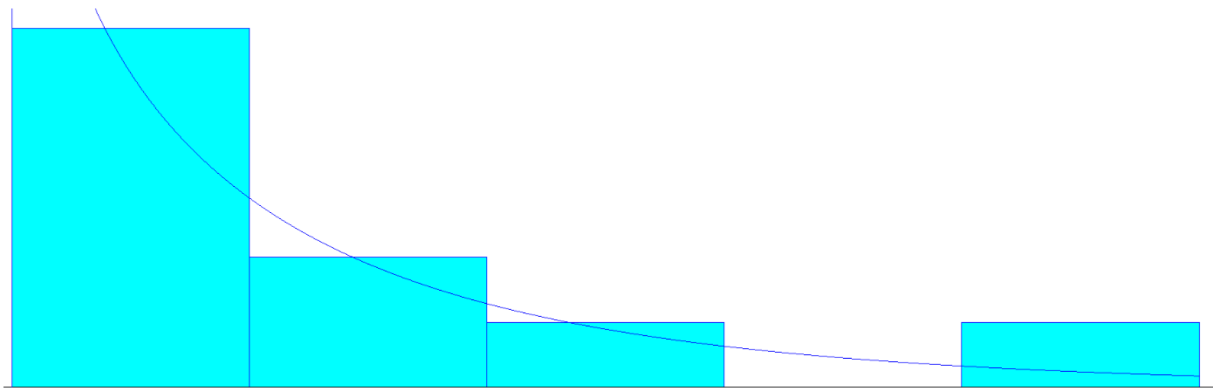


Figure 3.5: 2018 Technology Scores Data - Weibull Distribution

When data are placed into the input analyzer for a goodness of fit test, it appeared that none of the data is distributed normally. Even though the idea was applying a Pearson's Correlation test, now a non-parametric correlation test is a must. Therefore, Spearman's Correlation test will be applied.

3.4. Spearman's Correlation Coefficient:

$$r_s = 1 - \frac{6\sum_{k=1}^{n} d^2}{n^3 - n}$$

Spearman's Correlation Coefficient is a statistical test, used in order to find regular relationship between two different data. The ratio of the test imply the strength of the relationship.

0.00-0.19 (Very Weak)

0.20-0.39 (Weak)

0.40-0.59 (Moderate)

0.60-0.79 (Strong)

0.80-1.00 (Very Strong)

As ratio gets away from "0.00", relationship becomes stronger as a positive or negative correlation.

2008 – GDP and Export & Import Degrees of Countries

Country	Import Degree	GDP	Import Degree Ranks	GDP Ranks	Difference	Square
United States	29	11510	5	19	-14	196
Japan	38	4446	10,5	18	-7,5	56,25
Germany	21	2506	2	17	-15	225
United Kingdom	38	2038	10,5	16	-5,5	30,25
France	41	1840	13	15	-2	4
China	33	1660	7	14	-7	49
Italy	35	1570	9	13	-4	16
Spain	34	906,9	8	12	-4	16
Canada	47	892,4	14,5	11	3,5	12,25
Mexico	24	729,3	3	10	-7	49
South Korea	16	680,5	1	9	-8	64
India	58	599,6	19	8	11	121
Netherlands	56	571,9	18	7	11	121
Brazil	48	558,3	16	6	10	100
Russia	40	430,3	12	5	7	49
Switzerland	47	352,9	14,5	4	10,5	110,25
Turkey	28	311,8	4	3	1	1
Indonesia	49	234,8	17	2	15	225
Poland	31	217,5	6	1	5	25

Table 3.5: Import Degrees of Countries

Country	Export Degree	GDP	Export Degree Ranks	GDP Ranks	Difference	Square
United States	111	11510	16	19	-3	9
Japan	124	4446	19	18	1	1
Germany	112	2506	17	17	0	0
United Kingdom	45	2038	5	16	-11	121
France	89	1840	15	15	0	0
China	114	1660	18	14	4	16
Italy	84	1570	14	13	1	1
Spain	68	906,9	13	12	1	1
Canada	31	892,4	3	11	-8	64
Mexico	35	729,3	4	10	-6	36
South Korea	57	680,5	9,5	9	0,5	0,25
India	57	599,6	9,5	8	1,5	2,25
Netherlands	67	571,9	12	7	5	25
Brazil	46	558,3	6,5	6	0,5	0,25
Russia	28	430,3	2	5	-3	9
Switzerland	27	352,9	1	4	-3	9
Turkey	60	311,8	11	3	8	64
Indonesia	46	234,8	6,5	2	4,5	20,25
Poland	47	217,5	8	1	7	49

Table 3.6: Export Degrees of Countries

As shown in the tables 3.5, 3.6; it is seen that there is an inverse correlation between GDP rank order and ranking of import ranks as it is a correct correlation between GDP rank order and export rank order. Accordingly, the increase in Export degree values positively affect GDP, while the increase in Import degree values negatively affected GDP.

According to the Tables 3.5, 3.6, China's export value is higher than that of the US, but American GDP is higher than China’s. Although there is a correlation between GDP and export degree, it should be kept in mind that the only factor is not related to export and import degrees.

2008	Export Degree	Import Degree	GDP(Billion$)
Turkey	60	28	311.8
China	114	33	1160
United States	111	29	11510

In 2008, Turkey ends up being at the mediocre level with its export degree whereas being at a lower level with its import degree. This might be a causation of Turkey's GDP value of 311, 8 billion dollars.

2014 – GDP and Export & Import Degrees of Countries & Import Degrees of Countries

Country	Import Degree	GDP	Import Degree Ranks	GDP Ranks	Difference	Square
United States	39	17430	28	35	-7	49
China	38	10480	27	34	-7	49
Germany	21	3891	6,5	33	-26,5	702,25
United Kingdom	16	3023	3	32	-29	841
France	35	2852	24	31	-7	49
Brazil	29	2456	14	30	-16	256
Italy	35	2152	24	29	-5	25
Russia	35	2064	24	28	-4	16
Australia	30	1465	15	27	-12	144
South Korea	19	1411	4	26	-22	484
Spain	31	1377	18,5	25	-6,5	42,25
Mexico	26	1314	10,5	24	-13,5	182,25
Turkey	31	934,2	18,5	23	-4,5	20,25
Indonesia	20	890,8	5	22	-17	289
Netherlands	31	879,6	18,5	21	-2,5	6,25
Switzerland	27	709,2	12	20	-8	64
Saudi Arabia	26	654,3	10,5	19	-8,5	72,25
Argentina	56	594,7	32	18	14	196
Sweden	31	573,8	18,5	17	1,5	2,25
Poland	31	545,2	18,5	16	2,5	6,25
Belgium	37	530,8	26	15	11	121
Nigeria	59	481,1	33	14	19	361
United Arab Emirates	34	403,1	22	13	9	81
South Africa	31	350,9	18,5	12	6,5	42,25
Malaysia	15	338,1	2	11	-9	81
Egypt	45	332,7	29	10	19	361
Singapore	21	311,5	6,5	9	-2,5	6,25
Colombia	79	291,5	35	8	27	729
Ireland	25	290,6	9	7	2	4
Finland	24	272,6	8	6	2	4
Czech Republic	28	207,8	13	5	8	64
Portugal	46	199,4	30	4	26	676
Greece	67	195,5	34	3	31	961
Vietnam	11	186,2	1	2	-1	1
Romania	49	177,9	31	1	30	900

Table 3.7: Import Degrees of Countries 2014

Country	Export Degree	GDP	Export Degree Ranks	GDP Ranks	Difference	Square
United States	106	17430	32,5	35	-2,5	6,25
China	127	10480	35	34	1	1
Germany	115	3891	34	33	1	1
United Kingdom	92	3023	31	32	-1	1
France	84	2852	30	31	-1	1
Brazil	28	2456	13	30	-17	289
Italy	78	2152	28	29	-1	1
Russia	20	2064	8,5	28	-19,5	380,25
Australia	18	1465	7	27	-20	400
South Korea	106	1411	32,5	26	6,5	42,25
Spain	68	1377	26	25	1	1
Mexico	49	1314	18	24	-6	36
Turkey	60	934,2	24	23	1	1
Indonesia	46	890,8	15	22	-7	49
Netherlands	72	879,6	27	21	6	36
Switzerland	21	709,2	10,5	20	-9,5	90,25
Saudi Arabia	12	654,3	5	19	-14	196
Argentina	16	594,7	6	18	-12	144
Sweden	51	573,8	19	17	2	4
Poland	52	545,2	21	16	5	25
Belgium	81	530,8	29	15	14	196
Nigeria	30	481,1	14	14	0	0
United Arab Emirates	61	403,1	25	13	12	144
South Africa	47	350,9	16,5	12	4,5	20,25
Malaysia	23	338,1	12	11	1	1
Egypt	3	332,7	1,5	10	-8,5	72,25
Singapore	54	311,5	23	9	14	196
Colombia	20	291,5	8,5	8	0,5	0,25
Ireland	4	290,6	3	7	-4	16
Finland	21	272,6	10,5	6	4,5	20,25
Czech Republic	52	207,8	21	5	16	256
Portugal	47	199,4	16,5	4	12,5	156,25
Greece	3	195,5	1,5	3	-1,5	2,25
Vietnam	5	186,2	4	2	2	4
Romania	52	177,9	21	1	20	400

Table 3.8: Export Degrees of Countries 2014

In Tables 3.7, 3.8; China, USA and Turkey's import and export degree and GDP values are as follows.

2014	Export Degree	Import Degree	GDP(Billion$)
Turkey	60	28	934.2
China	127	33	10480
United States	106	29	17430

Between 2008 and 2014, there was no significant difference between the export and import rates of degrees, while GDP values increased significantly. The increase in GDP values, one of the points that should be considered, the development of technology between 2008-2014 and the emergence of the economic crisis that has affected all the world in 2008 can be considered.

2018 – GDP and Export & Import Degrees of Countries

Country	Import Degree	GDP	Import Degree Ranks	GDP Ranks	Difference	Square
United States	21	21100	5	27	-22	484
China	31	12237	18	26	-8	64
Japan	29	4872	16	25	-9	81
Germany	24	3693	7	24	-17	289
India	49	2650	25	23	2	4
United Kingdom	28	2637	13	22	-9	81
France	34	2582	22	21	1	1
Brazil	57	2053	26,5	20	6,5	42,25
Italy	33	1943	20,5	19	1,5	2,25
Canada	19	1647	2,5	18	-15,5	240,25
Russian Federation	47	1578	24	17	7	49
Korea, Rep,	13	1530	1	16	-15	225
Australia	26	1323	9,5	15	-5,5	30,25
Spain	57	1314	26,5	14	12,5	156,25
Turkey	28	851,8	13	13	0	0
Netherlands	32	830,5	19	12	7	49
Switzerland	28	678,9	13	11	2	4
Sweden	26	535,6	9,5	10	-0,5	0,25
Belgium	33	494,7	20,5	9	11,5	132,25
Norway	24	399,4	7	8	-1	1
Israel	27	353,2	11	7	4	16
Ireland	29	331,4	16	6	10	100
Denmark	29	329,8	16	5	11	121
Singapore	19	323,9	2,5	4	-1,5	2,25
Finland	24	252,3	7	3	4	16
Portugal	46	219,3	23	2	21	441
Estonia	20	26,6	4	1	3	9

Table 3.9: Import Degrees of Countries 2018

Country	Export Degree	GDP	Export Degree Ranks	GDP Ranks	Difference	Square
United States	121	21100	26	27	-1	1
China	123	12237	27	26	1	1
Japan	101	4872	23	25	-2	4
Germany	112	3693	24,5	24	0,5	0,25
India	16	2650	1	23	-22	484
United Kingdom	112	2637	24,5	22	2,5	6,25
France	78	2582	19,5	21	-1,5	2,25
Brazil	21	2053	2,5	20	-17,5	306,25
Italy	21	1943	2,5	19	-16,5	272,25
Canada	88	1647	22	18	4	16
Russian Federation	23	1578	5	17	-12	144
Korea, Rep,	86	1530	21	16	5	25
Australia	68	1323	15,5	15	0,5	0,25
Spain	37	1314	6	14	-8	64
Turkey	64	851,8	13	13	0	0
Netherlands	68	830,5	15,5	12	3,5	12,25
Switzerland	78	678,9	19,5	11	8,5	72,25
Sweden	65	535,6	14	10	4	16
Belgium	73	494,7	18	9	9	81
Norway	55	399,4	12	8	4	16
Israel	43	353,2	7	7	0	0
Ireland	45	331,4	8,5	6	2,5	6,25
Denmark	46	329,8	10	5	5	25
Singapore	72	323,9	17	4	13	169
Finland	50	252,3	11	3	8	64
Portugal	22	219,3	4	2	2	4
Estonia	45	26,6	8,5	1	7,5	56,25

Table 3.10: Export Degrees Of Countries 2018

In Tables 3.9, 3.10; China, USA and Turkey's import and export degrees and GDP values are as follows.

2018	Export Degree	Import Degree	GDP(Billion$)
Turkey	64	28	1943
China	123	31	12237
United States	121	21	21100

As for the relationship between 2008 and 2014, it is observed that there is no change in export and import degreases between 2014 and 2018 but there are serious increases in GDP.

By analyzing this table, it shows the increase and decrease in the GDP of the countries, In Tables 3.8 and 3.10 the data observes the changes in GDP between 2008 - 2014 years, the China's GDP has increased %531, USA's %51 and Turkey's GDP %199.

Between 2014 - 2018 the tables shows also the changes in the GDP of the countries, the GDP of China has raised by %16.76, and USA shows an increased by %21.05, but Turkey's GDP has decreased by %8.82.

The reasons of this changed in the GDP ratio between 2008 - 2014 years, could be because of the quick developments in the technology and industrial sectors that happened after world economic crisis in 2008, also, the geopolitical position of the countries affecting the import and export, especially in the countries that are competing in such automotive sector. For example, if we look at the table 3.10, it can be observed that countries like Holland, Sweden and Norway, which have high technology and education levels, but they still far behind in terms of Germany's GDP.

As the ban imposed by the world's giants led to great impacts on the economic conditions of the countries, they also moved their objectives to become more self-sufficient countries, which influenced the strategies of the countries in their trade policies.

This is one of the reasons why some countries have more GDP despite the low export and import rates as it showed in the above tables. Of course, another point that should not be forgotten is the brand. As mentioned before, since the brand competition in the sector is very high, it could be observed the power the new brands in the sector.

2008 – Data of Technology Scores and Export & Import Degrees

Country	Technology Score	Import Degree	Technology Score Ranks	Import Ranks	Difference	Squared
China	40,2	33	19	7	12	144
United States	37,34	29	18	5	13	169
Germany	23	21	17	2	15	225
Japan	21,26	38	16	7,5	8,5	72,25
United Kingdom	16,88	38	15	7	8	64
France	15,48	41	14	8	6	36
South Korea	13,44	16	13	1	12	144
Spain	10,06	34	12	4	8	64
India	5,96	58	11	12	-1	1
Italy	5,28	35	10	4	6	36
Mexico	3,5	24	9	1	8	64
Canada	2,96	47	8	5,5	2,5	6,25
Brazil	2,92	48	7	6	1	1
Russia	2,78	40	6	3	3	9
Turkey	2,5	28	5	1	4	16
Indonesia	2,3	49	4	6	-2	4
Poland	2	31	3	1	2	4
Switzerland	1,86	47	2	4	-2	4
Netherlands	1,76	56	1	5	-4	16

Table 3.11: Technology Import Degrees 2008

Technology scores represent the number that could be useful for determining countries situation for utilizing the technology. Table 3.11 demonstrates, unsurprisingly, first five countries as China, USA, Germany, Japan and United Kingdom. Even though correlation confirms the negative relationship between degree and technology scores, countries like Mexico have low technology scores (3.5) and low import degrees (24).

Low technology supposed to present high import degrees since country cannot have sufficient production feasibility for itself. Likewise, China has a high technology but has a mediocre import degree and Spain acquires a higher degree value than Russia has when it has a higher score as well as Italy and Indonesia.

Country	Technology Score	Export Degree	Technology Score Ranks	Export Ranks	Difference	Squared
China	40,2	114	17	18	-1	1
United States	37,34	111	16	16	0	0
Germany	23	112	15	16	-1	1
Japan	21,26	124	14	16	-2	4
United Kingdom	16,88	45	13	5	8	64
France	15,48	89	12	14	-2	4
South Korea	13,44	57	11	8,5	2,5	6,25
Spain	10,06	68	10	11	-1	1
India	5,96	57	9	8	1	1
Italy	5,28	84	8	10	-2	4
Mexico	3,5	35	7	4	3	9
Canada	2,96	31	6	3	3	9
Brazil	2,92	46	5	3,5	1,5	2,25
Russia	2,78	28	4	2	2	4
Turkey	2,5	60	3	4	-1	1
Indonesia	2,3	46	2	2	0	0
Poland	2	47	2	2	0	0
Switzerland	1,86	27	1	1	0	0
Netherlands	1,76	67	1	1	0	0

Table 3.12: Technology Export Degrees 2008

These countries might possibly have a better network for trade, causing them break the equation.

As expected higher technology scores result with higher export degrees. Meaning countries with higher production technology level end up having more sales to abroad, at least in automobile sector.

But technology score may not only be meant for automobile sector. By looking at the Table 3.12, Italy seem to have a low technology score while having an intermediate export degree. Italy has well positioned network but these trade might be done in other sectors such as textile. Different sectors where technology isn't, yet, utilized satisfyingly can still have a work with its export degrees.

2014 – Data of Technology Scores and Export & Import Degrees

Country	Technology Score	Import Degree	Technology Score Ranks2	Import Ranks	Difference	Squared
China	100	38	19	18	1	1
United States	99,5	39	19	19	0	0
Germany	93,9	21	19	6,5	12,5	156,25
South Korea	80,4	19	19	4	15	225
United Kingdom	76,7	16	19	3	16	256
Mexico	72,9	26	19	6	13	169
Singapore	69,5	21	19	4	15	225
Switzerland	68,7	27	19	6	13	169
Sweden	68,4	31	19	11,5	7,5	56,25
Poland	63,6	31	19	11	8	64
Turkey	62,1	31	19	11,5	7,5	56,25
Malaysia	60,4	15	19	2	17	289
Vietnam	59,1	11	19	1	18	324
Netherlands	59	31	18,5	9	9,5	90,25
Indonesia	59	20	19	1	18	324
Australia	56,5	30	19	6	13	169
France	55,8	35	19	10	9	81
Czech Republic	55,7	28	18	4	14	196
Spain	55,5	31	16,5	5,5	11	121
Finland	55,5	24	16	1	15	225
Belgium	55,3	37	15	8	7	49
South Africa	52,5	31	14	4	10	100
Italy	50,6	35	13	5,5	7,5	56,25
Brazil	48,3	29	12	3	9	81
United Arab Emirates	48,1	34	11	3	8	64
Ireland	46,5	25	10	1	9	81
Russia	46,2	35	9	2	7	49
Romania	45,4	49	8	4	4	16
Saudi Arabia	44,7	26	7	1	6	36
Portugal	37,9	46	6	2	4	16
Colombia	35,7	79	5	8	-3	9
Egypt	29,2	45	4	2	2	4
Nigeria	23,1	59	3	7	-4	16
Argentina	22,9	56	2	6	-4	16
Greece	10	67	1	8	-7	49

Tables 3.13: Technology Import Degrees 2014

Turkey, in this table, has the lowest technology score compared to others and still has the import degree of Japan who has one of the highest technology scores. Perhaps, geopolitical location of the country allows it to be center when it comes to trade network. As a result, these countries may decide to focus more on investing in imports instead of technology for short term goals.

Country	Technology Score	Export Degree	Technology Score Ranks	Export Ranks	Difference	Squared
China	100	127	19	19	0	0
United States	99,5	106	19	17,5	1,5	2,25
Germany	93,9	115	19	19	0	0
South Korea	80,4	106	19	19	0	0
United Kingdom	76,7	92	19	19	0	0
Mexico	72,9	49	19	9	10	100
Singapore	69,5	54	19	12	7	49
Switzerland	68,7	21	19	4,5	14,5	210,25
Sweden	68,4	51	19	10	9	81
Poland	63,6	52	19	11	8	64
Turkey	62,1	60	19	13	6	36
Malaysia	60,4	23	19	7	12	144
Vietnam	59,1	5	19	2	17	289
Indonesia	59	46	18,5	9	9,5	90,25
Netherlands	59	72	19	16	3	9
Australia	56,5	18	19	5	14	196
France	55,8	84	19	19	0	0
Czech Republic	55,7	52	18	13,5	4,5	20,25
Spain	55,5	68	16,5	15	1,5	2,25
Finland	55,5	21	16	8	8	64
Belgium	55,3	81	15	15	0	0
South Africa	52,5	47	14	10,5	3,5	12,25
Italy	50,6	78	13	13	0	0
Brazil	48,3	28	12	8	4	16
United Arab Emirates	48,1	61	11	11	0	0
Ireland	46,5	4	10	3	7	49
Russia	46,2	20	9	5,5	3,5	12,25
Romania	45,4	52	8	8	0	0
Saudi Arabia	44,7	12	7	3	4	16
Portugal	37,9	47	6	6	0	0
Colombia	35,7	20	5	4	1	1
Egypt	29,2	3	4	1,5	2,5	6,25
Nigeria	23,1	30	3	3	0	0
Argentina	22,9	16	2	2	0	0
Greece	10	3	1	1	0	0

Tables 3.14: Technology Export Degrees 2014

Albeit technology scores of China and United States are at the top of the list, they seem to have mediocre import degrees for automobile industry. Countries like China and United States are fully capable of producing cars of their own, however, these data includes information of raw materials' sales as well. So to speak, these countries may intent of purchasing raw material from other countries.

It is possible to state that countries with very low technology scores like Greece, Nigeria and Colombia have to depend on the abroad sources since they are not very capable of manufacturing of their own.

Even though Brazil has mediocre technology score and export degree, the country has a GDP value that is placed at the top five of the list in the Table 3.14. Therefore, it is possible to express that a single industry isn't sufficient to consider the technology for application. Brazil is fully capable of utilizing the technology it has for other industries that contribute to its GDP, in order to get more profitable results from it.

2018 – Data of Technology Import & Export Degrees of Countries

Country	Technology Score	Import Degree	Technology Score Ranks	Import Ranks	Difference	Squared
United States	8,52	21	27	5	22	484
United Kingdom	8,05	28	26	13	13	169
Switzerland	7,87	28	25	13	12	144
Netherlands	7,73	32	24	19	5	25
Finland	7,45	24	23	7	16	256
Singapore	7,36	19	22	2,5	19,5	380,25
Sweden	7,31	26	21	9,5	11,5	132,25
Germany	7,16	24	20	7	13	169
Canada	7,08	19	19	2,5	16,5	272,25
Australia	6,91	26	18	9,5	8,5	72,25
Denmark	6,9	29	17	16	1	1
Norway	6,86	24	16	7	9	81
France	6,82	34	15	22	-7	49
Israel	6,79	27	14	11	3	9
Japan	6,58	29	13	16	-3	9
Korea, Rep,	6,57	13	11,5	1	10,5	110,25
Ireland	6,57	29	11,5	16	-4,5	20,25
Belgium	6,41	33	10	20,5	-10,5	110,25
Estonia	5,8	20	9	4	5	25
China	5,74	31	8	18	-10	100
Spain	5,69	57	7	26,5	-19,5	380,25
Italy	5,66	33	6	20,5	-14,5	210,25
Portugal	5,49	46	5	23	-18	324
India	4,84	49	4	25	-21	441
Russia	4,65	47	3	24	-21	441
Brazil	4,49	57	2	26,5	-24,5	600,25
Turkey	4,18	28	1	13	-12	144

Tables 3.15 : Technology Import Degrees 2018

Country	Technology Score	Export Degree	Technology Score Ranks	Export Ranks	Difference	Squared
United States	8,52	121	27	26	1	1
United Kingdom	8,05	112	26	24,5	1,5	2,25
Switzerland	7,87	78	25	19,5	5,5	30,25
Netherlands	7,73	68	24	15,5	8,5	72,25
Finland	7,45	50	23	11	12	144
Singapore	7,36	72	22	17	5	25
Sweden	7,31	65	21	14	7	49
Germany	7,16	112	20	24,5	-4,5	20,25
Canada	7,08	88	19	22	-3	9
Australia	6,91	68	18	15,5	2,5	6,25
Denmark	6,9	46	17	10	7	49
Norway	6,86	55	16	12	4	16
France	6,82	78	15	19,5	-4,5	20,25
Israel	6,79	43	14	7	7	49
Japan	6,58	101	13	23	-10	100
Korea, Rep,	6,57	45	11,5	8,5	3	9
Ireland	6,57	86	11,5	21	-9,5	90,25
Belgium	6,41	73	10	18	-8	64
Estonia	5,8	45	9	8,5	0,5	0,25
China	5,74	123	8	27	-19	361
Spain	5,69	37	7	6	1	1
Italy	5,66	21	6	2,5	3,5	12,25
Portugal	5,49	22	5	4	1	1
India	4,84	16	4	1	3	9
Russia	4,65	23	3	5	-2	4
Brazil	4,49	21	2	2,5	-0,5	0,25
Turkey	4,18	64	1	13	-12	144

Tables 3.16 : Technology Export Degrees 2018

As mentioned previously, result of focusing more on investing in imports instead of technology causes Turkey move to the bottom of the list in the Table 3.16, As long as a country aims on short term projects, it would be a victim of technology advancements of inevitable future.

The technological advancements in manufacturing sector that suddenly skyrocketed between 2014 and 2018. Turkey has missed the opportunity or, in other words obligation of changing, causing the country to became the country with the lowest technology score. Furthermore, at the same period the country's GDP value has decreased at rate of 8% without considering the inflation.

Correlation Values;

2008	Import Degree	Export Degree
Technology Score	-0,957236842	0,682017544
GDP	-0,791230656	0,742465502

2014	Import Degree	Export Degree
Technology Score	-0,810986842	0,731098684
GDP	-0,710483193	0,553291317

2018	Import Degree	Export Degree
Technology Score	-0,966447368	0,625877193
GDP	-0,59186104	0,682550609

4.Factor Statuses

At the end, GDPs, Technology Scores and Import & Export Degrees of each country are determined. Furthermore, positive and negative spearman correlation confirmed the causation between them. Therefore, network analysis can be used for determination of top 10 countries in their industry 4.0 statuses and be analyzed for the mentioned factors in the literature part.

4.1 Investment

Cost of industry 4.0 technology is one of the main obstacles for the fourth revolution. In order to get the data several sources has been searched and resulted with different sources providing investment data for different time periods. For example, Germany states the value of its investment for a 10 years' time period whereas Italy states its investments for a three years' time period (2018 - 2021) and also forecasts some level of increases as the time goes by.

To draw an appropriate conclusion, time periods are optimized to three years and currency is accepted as US dollars, written in billions.

4.2. Energy Consumption

Besides the first cost; autonomous robots, additive manufacturing and all components of industry 4.0 requires some level of energy for functioning. To find the required amount of energy, first possible way is getting the data of energy production for each country and moving on with the rest. However, none of the countries rely on fully self-generated energy. Each country has a level of energy imports and exports which significantly changes the reliability of the information related to a country's energy requirements. Since information of required energy for industry 4.0 technologies isn't very available. The dilemma of finding the requirements was figured out with a different solution.

Total amount of consumed energy of each country is found. Some of the data of consumed energy was in Btu, some in kg of oil and some in kWh. After all units were transformed to kWh, energy consumption rate of manufacturing industries were found and multiplied with total amount of consumed energy, revealing the consumed energy in manufacturing environment.

Finally, in order to find energy level consumed by industry 4.0 technology, data of technologies' consumption rate for energy is placed into table and multiplied with energy consumption values of manufacturing. As a result, energy consumption that has to be provided for industry 4.0 technologies is found and written in billions of kWh.

Country	Total Consumption(kWh)	Manufacturing(%)	Manufacturing(kWh)	Industry 4.0(%)	Industry 4.0(kWh)
China	6310	%9,0	567,90	%30,0	170,37
USA	3911	%12,0	469,32	%26,0	122,02
Germany	533	%21,1	112,46	%21,5	24,18
Japan	934	%5,5	51,37	%30,0	15,41
UK	309	%4,6	14,21	%28,0	3,98
South Korea	495	%6,2	30,69	%30,0	9,21
France	431	%4,6	19,83	%25,0	4,96
Belgium	81	%3,8	3,08	%25,0	0,77
Italy	291	%4,6	13,39	%30,0	4,02
Spain	234	%3,2	7,49	%25,0	1,87
Turkey	207	%7,9	16,35	%8,0	1,90

Table 4.1: Energy Requirements

4.3. Aged Workers

Industry 4.0 has so much influence on economy. In the point of view of employment effects, industry 4.0 is predicted to increase ratio of employment. The theory accepts that people shall be employed and unemployed, however, employed ones will outnumber unemployed, thus, in that perspective it is beneficial to economy.

On the other hand, aged workers who stayed in businesses for a long period of time would have serious issues learning new perspectives of the manufacturing environment. To make a comparison with the top 10 countries, percentages of workers who are above 50 years old are collected.

4.4. Engineers

Even though technology and energy are acquired, they still require experts who can utilize them. According to Industry 4.0 Careers of Future by Matthew Kirchner (2018), futurism that will be born with the fourth industrial revolution, opportunities for app developers, automation engineer, electric engineer, industrial engineer and all types of people with engineering backgrounds will skyrocket. With that considered, it is crucial to investigate the states of each country for their human capitals.

4.5. Knowledge

Knowledge could seem as a something that cannot be measured, however, since people of the previous generation or, in other words, people who encounter an unrecognizable reality might become frightened as long as the reality is unfamiliar. Therefore, critical fact is described as the society's need for transformation.

The knowledge part examines the percentage of people who are familiar, educated or somehow convinced that new technology can emerge a new reality that could be difficult to adapt.

4.6. Aged Population

Adaptation process occurs mostly among older people according to Cabinet Office (2016). To determine the velocity of industry 4.0's expanding, quantity or rate of people who would have a more difficult progress before adaptation can signify a point of view for society's transformation.

Factors’ Matrix

FACTORS' MATRIX	GDP	COST		EMPLOYMENT		SOCIETY 5.0	
		INVESTMENT	ENERGY CONSUMPTION(-)	AGED WORKERS (-)	ENGINEERS	KNOWLEDGE	AGED POPULATION (-)
CHINA	12237	$ 98,00	170,37	22,4%	465,652	5,5%	11,4%
USA	21100	$ 94,20	122,02	22,5%	237,826	26,9%	19,5%
GERMANY	3693	$ 90,00	24,18	15,0%	93,329	19,4%	31,6%
JAPAN	4872	$ 80,70	15,41	28,4%	168,214	29,3%	36,0%
UK	2637	$ 85,00	3,98	14,7%	71,302	23,6%	25,2%
SOUTH KOREA	1530	$ 69,00	9,21	17,0%	147,858	25,6%	15,2%
FRANCE	2582	$ 67,00	4,96	17,9%	104,746	19,7%	25,9%
BELGIUM	494,7	$ 53,80	0,77	20,2%	12,274	23,2%	26,0%
ITALY	1943	$ 23,76	4,02	20,5%	47,943	10,4%	30,9%
SPAIN	1314	$ 27,00	1,87	32,0%	56,235	21,7%	25,2%
TURKEY	851,8	$ 9,20	1,9	9,6%	74,762	8,7%	10,6%

Table 4.2 : Factors’Matrix

5.READINESS OF TURKEY

The table 4.2 includes so much information that have the capability of forecasting future on industry 4.0 revolution. It provides data of 1o different countries besides Turkey, in fact, the most advanced countries in technology according to the network analysis that is applied before. By interpreting the table, so many strategies and planning can be prepared for Turkey's Readiness on the subject.

Beginning with investment values, by looking at the table, it is easy to state that Turkey is way back in the investment numbers. Perhaps, continuous economic problems such as the excessive value loss of Turkish lira against other currencies, put country in a problematic status. This status would eventually return as lagging in the future in manufacturing environment.

However, it is still possible to say that, even though Turkey has a very low number like 9.6 billion USD, country still seems to have high GDP in its statues compared to others. Especially, Belgium has very high amount of investment and, yet, it has a much less GDP value. This condition can be considered as an opportunity for Turkey's future if later investments can be reclaimed beneficially.

If economic problems like increase in unemployment and inflation are continuous events of future in Turkey, value of Turkish lira will keep decreasing and causing investors to struggle. Therefore, investments must be done optimally and wisely if better results are aimed.

For a country like Turkey who has high import & export degrees for automobile industry as shown in the table 3.1, investment number seems too low and, furthermore, number of engineer graduates seem to have a satisfying value. If investment value stays too low compared to others, opportunities will be missed ongoingly as a consequence.

Moreover, once table is investigated with more attention, a possible correlation can be realized between energy consumption level and GDP values. As mentioned before in the literature part, investments can be possibly done for energy requirements which presents again that energy is a crucial aspect of industry 4.0 technology.

Additionally, Germany which is considered one of the most developed countries in manufacturing and engineering, and also has a high investment value seems to consume a much lower energy level compared to USA and China. As technology increases efficiency increases with it. Hence, limited resources can be utilized more effectively.

In the comparison of USA and China, the countries with highest level of investments and energy consumptions, China seems to have more investments, spends more energy and, likewise, more engineer graduates annually. However, USA still seems to have higher GDP values and continues to be the best economy in the world. This brings up the idea of education levels for each country since USA has a five times higher value in the knowledge column of the table 4.2. It is renowned that United States is very sensitive about the educations of individuals.

By referring to this information, Turkey is supposed act like United States and not like China. Turkey might have limited sources but has young population to educate and engineers to benefit from. Since aged worker rate seems to be the lowest value on the table 4.2, young people who can be educated properly is considered a huge occasion for the country.

Again, Turkey has a low percentage value in the aged workers column of the table 4.2. Therefore, it can be said that Turkey will not have as much of problematic state as other European countries will since aged workers are in the danger of being unemployed as industry 4.0 technology expands.

Considering the prosperity level of countries that are placed into the table 4.2, Turkey seems to have a much lower status in that perspective. These countries have higher salaries and more comfortable conditions for their people. Thus, instincts and points of view of Turkish people, apparently, turns to living and working abroad. As a result, country loses its needed educated people who can contribute the fourth industrial revolution.

Perhaps, a sudden increase of the prosperity or GDP aren't possible, but if numbers of educated people are increased which has a very low value on the knowledge column of table 4.2, prosperity, GDP and also technology utilization of the country can be heightened substantially.

To conclude, Turkey is lagging in values of investment, energy consumption levels and knowledge according to the table 4.2. The country seems to have satisfying level of trade in the world when export & import degrees are checked from the table 3.1, furthermore, has an advantage in the human capital with its engineers and young population. The country may not be able to afford the costs of the technology yet; but if the advantage of the young population is exploited with better education trends, country has the opportunity of utilizing industry 4.0 technology with its transformed society.

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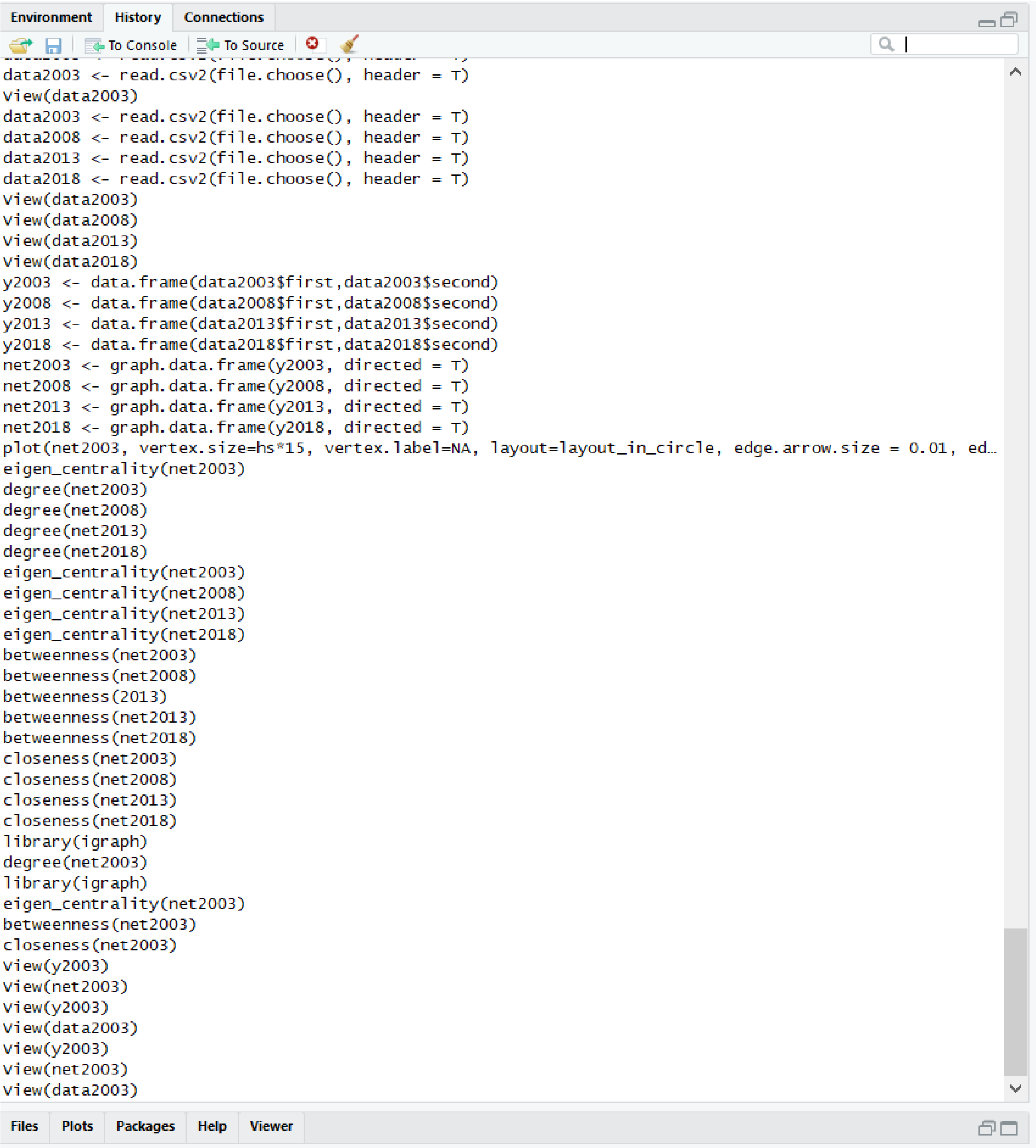
APPENDIX




```
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View(data2003)
data2003 <- read.csv2(file.choose(), header = T)
data2008 <- read.csv2(file.choose(), header = T)
data2013 <- read.csv2(file.choose(), header = T)
data2018 <- read.csv2(file.choose(), header = T)
View(data2003)
View(data2008)
View(data2013)
View(data2018)
y2003 <- data.frame(data2003$first,data2003$second)
y2008 <- data.frame(data2008$first,data2008$second)
y2013 <- data.frame(data2013$first,data2013$second)
y2018 <- data.frame(data2018$first,data2018$second)
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net2008 <- graph.data.frame(y2008, directed = T)
net2013 <- graph.data.frame(y2013, directed = T)
net2018 <- graph.data.frame(y2018, directed = T)
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degree(net2008)
degree(net2013)
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library(igraph)
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closeness(net2003)
View(y2003)
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Car Export By Countries

Rank	Exporter	2017 Car Exports	% World Total
1.	Germany	US$157.4 billion	21,3%
2.	Japan	$93.4 billion	12,6%
3.	United States	$53.6 billion	7,2%
4.	Canada	$46.4 billion	6,3%
5.	United Kingdom	$41.9 billion	5,7%
6.	Mexico	$41.7 billion	5,6%
7.	South Korea	$38.8 billion	5,2%
8.	Spain	$35.8 billion	4,8%
9.	Belgium	$33.1 billion	4,5%
10.	France	$22.1 billion	3%
11.	Czech Republic	$21.5 billion	2,9%
12.	Italy	$18 billion	2,4%
13.	Slovakia	$16.4 billion	2,2%
14.	Turkey	$11.8 billion	1,6%
15.	Thailand	$10.9 billion	1,5%
16.	Netherlands	$9.3 billion	1,3%
17.	Sweden	$9 billion	1,2%
18.	Hungary	$8.7 billion	1,2%
19.	Poland	$7.5 billion	1%
20.	China	$7.2 billion	1%
21.	Brazil	$6.7 billion	0,9%
22.	South Africa	$5.7 billion	0,8%
23.	India	$5 billion	0,7%
24.	Slovenia	$5 billion	0,7%
25.	Austria	$4.9 billion	0,7%

Car Import By Countries

Rank	Importer	2017 Car Imports	% World Total
1.	United States	US$179.6 billion	23,9%
2.	Germany	$58.5 billion	7,8%
3.	China	$49.9 billion	6,6%
4.	United Kingdom	$44.1 billion	5,9%
5.	Belgium	$36.4 billion	4,8%
6.	France	$34.7 billion	4,6%
7.	Italy	$31.2 billion	4,1%
8.	Canada	$28.7 billion	3,8%
9.	Spain	$20.2 billion	2,7%
10.	Australia	$17.5 billion	2,3%
11.	Netherlands	$12.8 billion	1,7%
12.	Mexico	$11.5 billion	1,5%
13.	Japan	$11.1 billion	1,5%
14.	Switzerland	$10.5 billion	1,4%
15.	Austria	$10.1 billion	1,3%
16.	South Korea	$9.7 billion	1,3%
17.	Saudi Arabia	$9.5 billion	1,3%
18.	United Arab Emirates	$9.3 billion	1,2%
19.	Poland	$9.1 billion	1,2%
20.	Sweden	$9.1 billion	1,2%
21.	Turkey	$8.6 billion	1,1%
22.	Russia	$6.7 billion	0,9%
23.	Norway	$6.3 billion	0,8%
24.	Argentina	$6.3 billion	0,8%
25.	Portugal	$5 billion	0,7%