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BUSI1693 – Global Networks and Innovation

A1. Company: Denso Corporation , Dataset: USPTO_2012_5

1 Introduction

This report entails analysis of Denso Corporation and provided Dataset: USPTO_2012_5. The data set has been analysed to understand the company's internal relationship among other subsidiaries across various continents and regions around the world. This report established a thorough data analysis by using Python code, in a notebook "Jupyter" format. The detailed analysis established data visualization, relation in-between the data and theoretical underpinnings to describe; how firms operate in an international context. Report also established; how firm subsidiary / suppliers or value chain helping firm to keep up its innovative approach towards the production.

2 Overview of the Company

Denso Corporation is one of the largest manufacturers of electronic and automobiles components. These include a motor ignition system, generator power, spark plugs, air bags, air conditioning and many other accessories. Another feature involves making mobile navigation systems and communication equipment. The corporation operates throughout the region of America, Asia-Pacific and Europe. It's headquartered in Kariya, Aichi, Japan. In the year of 2021- 2022, the company generated annual revenue of \$46.6B, which is around -4% less than previous financial year (Annual report, 2022). Companies global out rich might impact negatively due to the current geo-political crisis in Europe in the year of 2022.

3 DENSO Corporation's Internationalization Strategy

3.1 Rapid Global Expansion

DENSO Corporation has made strenuous efforts to grow globally and expand their commercial operations worldwide. To meet the global consumer demand, companies has invested their capital to grow as a reputable institution that can influence the wider stakeholders. Thus, companies are expanding their business rapidly to catch up with other competitors in the market that are helping them to create a web of strong networks with like minded businesses. So far the company has 188 subsidiaries across 35 different countries and regions. This shows, company has enormous ambition to expand their business through their existing network as well as through new networks (Goncalves and Perra, 2015).

3.2 Development of Local Leadership

For effective communication, local leadership and for better business strategies the company has created a regional headquarters that efficiently connects Asia, Europe and North America. These regional headquarters has given autonomous structure of decision making so that the region can develop and foster better business knowledge and innovations (Capaldo, 2007).

3.3 Business Agility

The operational structure of the company is created as groups while various wings/ sister concerns work together to accommodate in a systematic way. These operational strategies help them to be more agile when they have to make a crucial business decision to adopt business agility (Boschma and Ter Wal, 2007), in a critical time like Pandemic, Geopolitical turbulence and Economic shock etc.

3.4 Development of New Technology through International Partnership

The firm mainly focuses its internationalisation strategy mainly on its automotive operations. Company also pursuing partnerships with relatively smaller firms to create a wide range of business opportunities within robotics, machine learning and automotive sectors for new experience for the consumer market. Corporation has bold ambitions to develop and mass production of eco-friendly products and services that can minimise fossil fuel use. Firm also focusing on regenerative energy, emissions purifications through global partnership that will contribute towards global sustainable development goals.

4 Network Analysis and Visualizations

4.1 Company Network Analysis

DENSO Corporations Affiliates Accounted through Equity Method. The group has 200 companies. Company's network is connected through 35 different countries, and regions (Annual report, 2022). These help them to share common goals, shared concern, local and regional needs for societal solutions. While the company operates internationally, at the same time it operates as local. Which share a common goal and perspective for the country and society within it operates. Company accounts for 200 subsidiaries; these consolidated subsidiaries are accounted for manufacturing, sales and research & development (Annual report, 2022). Denso Corporation has a number of degrees = 6 which means it has a total of 6 unique direct connections with companies. (Honda Motor Co. Ltd., Nippon Soken Inc., Hitachi Metals Ltd., Advics Co. Ltd., DENSO International America Inc., Kyosan Denki Co. Ltd. (See Appendix Number: 1). From Figure 1 below we can see that the network is an industrial network.

```
[ ]: plt.figure(figsize=(20,10))
nx.draw_networkx(graph)
plt.title('Figure 1. network visualization of the companies')
plt.show()
```

Figure 1. network visualization of the companies

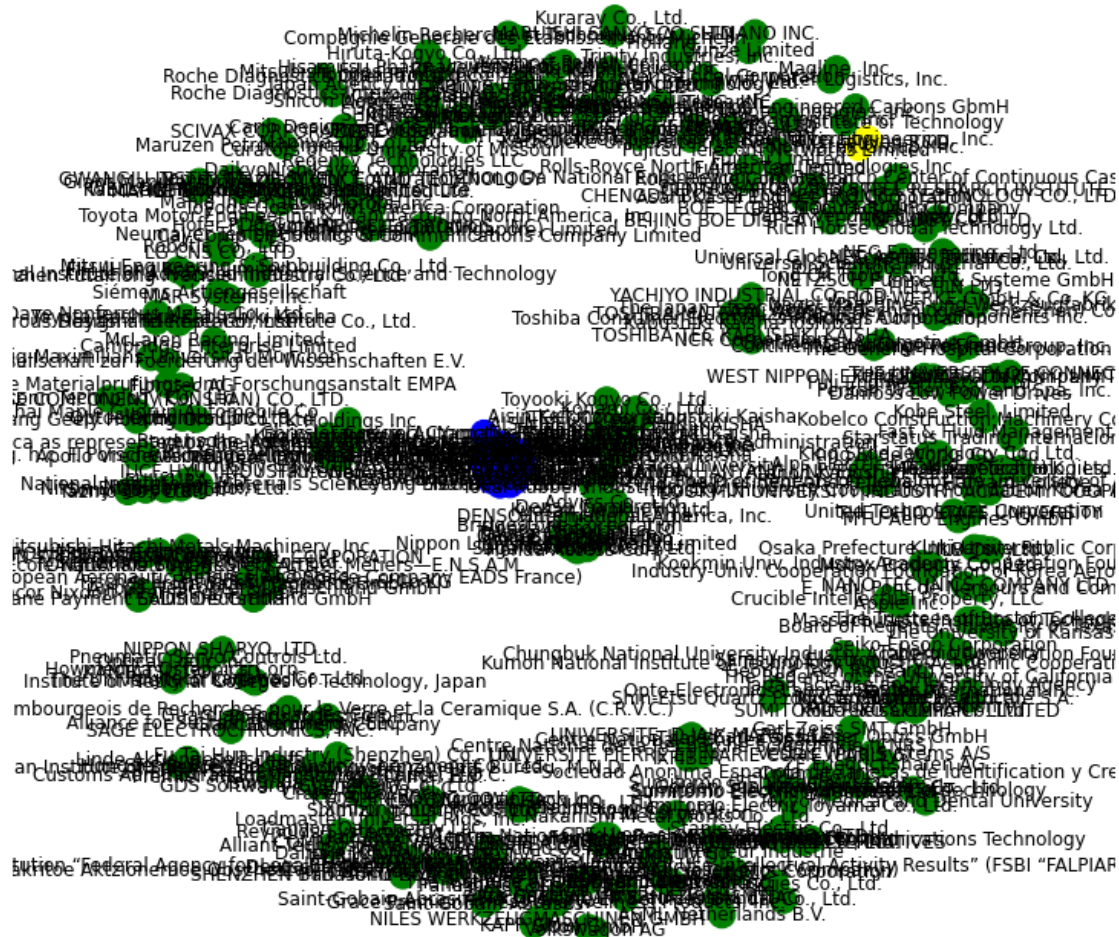


Figure 2 shows that the network is divided into two communities: the green community and the blue community. The girvan newman algorithm was used to detect the presence of a group of people. A graph's communities are discovered using the Girvan-Newman algorithm, which works by iteratively removing edges from the graph in order to maximize the edge betweenness and centrality value. The edge with the highest edge betweenness is removed first, followed by the other edges

```
[ ]: communities = girvan_newman(graph)
      groups = []
      for com in next(communities):
          node_groups.append(list(com))
      color = []
      for node in graph:
          if node in groups[0]:
              color.append('blue')
          elif node in groups[1]:
              color.append('yellow')
          else:
              color.append('green')

      plt.figure(figsize=(10,10))
      nx.draw(graph, color, with_labels=True)
      plt.title('Figure 2. girvan_newman community detection')
      plt.show()
```

Figure 2. Community detection



4.2 Global Value Chain

Company has a diverse global value chain system as it operates throughout numerous countries across the globe. Denso corporation is a good example due to its diverse portfolio. Such as electronic power train control system, thermal system and automation. Companies subsidiaries connected throughout Asia, Europe and America, this has given enormous efficiency in production. Since the supply chain has distributed across many borders, it shows excellent intra company connections that are well distributed and connected. Within the extreme complexity of automobile supply chain companies operating successfully to produce one finished good. The web of complexity of connection shows a firm's strength in relation to better connectivity.

5 Exploratory Data Interpretation

This analysis provides an exploration of the data through primary analysis to understand a firm's role in relation to firm's agility, inter-firm connectedness, operational closeness with other subsidiaries. This also established the locality of firm's geographical location, size of the firm, their activity and other relevant aspects of the firm

5.1 Degree Centrality

It is a simple count of the total number of connections linked to a vertex. It is the most straightforward method of determining node connectivity. The higher the degree centrality, the closer the node is to the center of the network. Given that many nodes with high degrees also have high centrality according to other measures, this can be a useful measure to employ (Grus, 2015). A high degree centrality score simply indicates that a node has a greater number of connections than the average number of connections for the graph in question. According to our example, a higher value of 7 degree centrality indicates that the company has more connections with other companies. When looking at the (Appendix- 1), it can be seen that the top three most connected companies were Hyundai Motor Company (0.05778894472361809), Honda Motor Co., Ltd. (0.035175879396984924), Toyota Jidosha Kabushiki Kaisha (0.035175879396984924). (0.17). While this is going on, Denso Corporation (0.01507537688442211) has a relatively lower degree centrality, which means that it has a lower number of connections than the companies with the highest degree centrality in the network.

5.2 Eigenvector Centrality

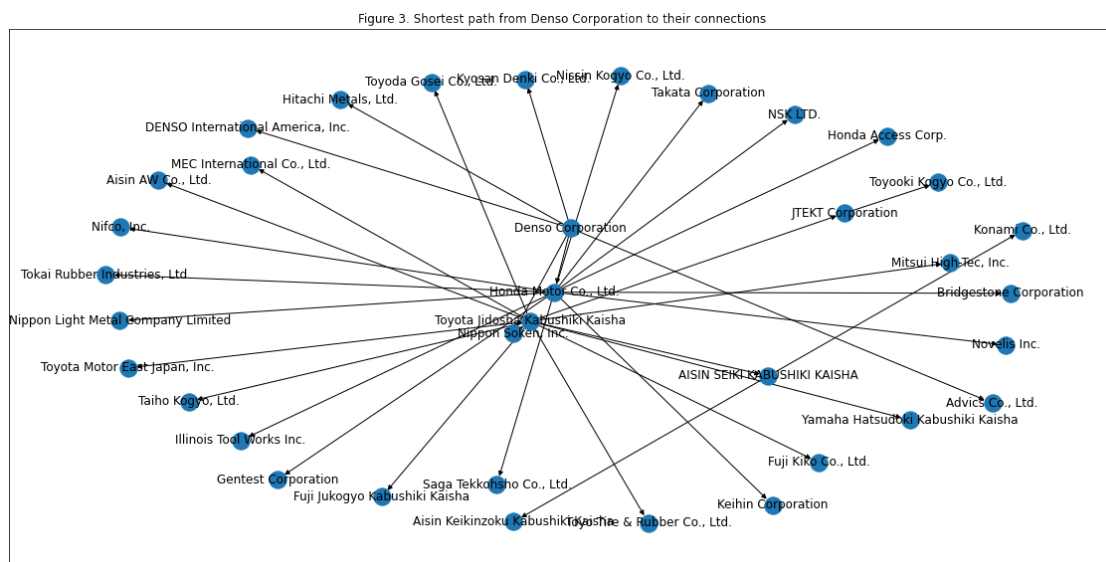
It assesses the significance of a node while also taking into account the significance of its neighbors (or neighbors' importance) (Grus, 2015). Eigen Centrality, like degree centrality, is a network measure of a node's influence based on the number of connections it has to other nodes in the network. Afterwards, Eigen Centrality goes a step further by taking into consideration how well connected a node is, as well as how many links their connections have, and so on through the network. (Appendix- 2) indicates that Hyundai Motor Company (0.626896526062543), Kia Motors Corporation (0.32492094129267035), and Kia Motors Corporation (0.21335170123268477) are the most significant companies in the network. This demonstrates that the ranking of companies based on Degree of centrality and eigenvector centrality are very similar. This is due to the fact that the companies with the greatest number of connections are the ones with the greatest importance in the network. Denso Corporation received a low score of 4.6127334988910404e-05 when compared to the scores of the other companies in the network. ## Betweenness Centrality It measure of centrality in a graph based on shortest paths Grus (2015). It is a way of detecting the amount of influence a company has over the flow of information in a network. It is often used to find company that serve as a bridge from one part of a network to another. it calculates unweighted shortest paths between all pairs of company in a network. Each node receives a score, based on the number of shortest paths that pass through the node. From (Appendix- 3) We found Toyota Jidosha Kabushiki Kaisha (0.005025125628140704), Honda Motor Co Ltd, Hyundai Motor Company, Tokai Rubber Industries Ltd, and Denso Corporation had the highest betweenness score in our dataset and they are the ones who influence the flow of information around the network. Cause they are the most connected companies, their removal from the network will have the greatest impact on other companies' ability to communicate. Betweenness scores of 0.13445378151260506 for Nippon Soken Inc., 0.1260504201680673 for AISIN SEIKI KABUSHIKI KAISHA and 0.0714285714285715.

There are only a handful of companies that have a betweenness score of zero or less. If you'd like to learn more, see Appendix 4.

5.3 Closeness Centrality

This indicates how close a company is to all other companies in the network. It captures the average distance between each company and every other company in the network. If information needed to flow through the network, some companies would be able to get a message to all the other companies relatively quickly (i.e., in few steps), whereas others may require many steps. According to Appendix- 4, Hyundai Motor Company (0.0578894472361809), Toyota Jidosha Kabushiki Kaisha (0.042748464494696), Honda Motor Co. Ltd. (0.041593100638326774), and Denso Corporation (0.041593100638326774) were the top four closely centered companies (0.037535237161416844). As a result, these companies have a high degree of closeness centrality. When it comes to disseminating information quickly, companies with high levels of closeness have relatively short distances to a large number of other companies.

```
[ ]: denso = nx.bfs_tree(graph, "Denso Corporation")
plt.figure(figsize=(20,10))
nx.draw_networkx(denso)
plt.title('Figure 3. Shortest path from Denso Corporation to their connections_↪')
plt.show()
```

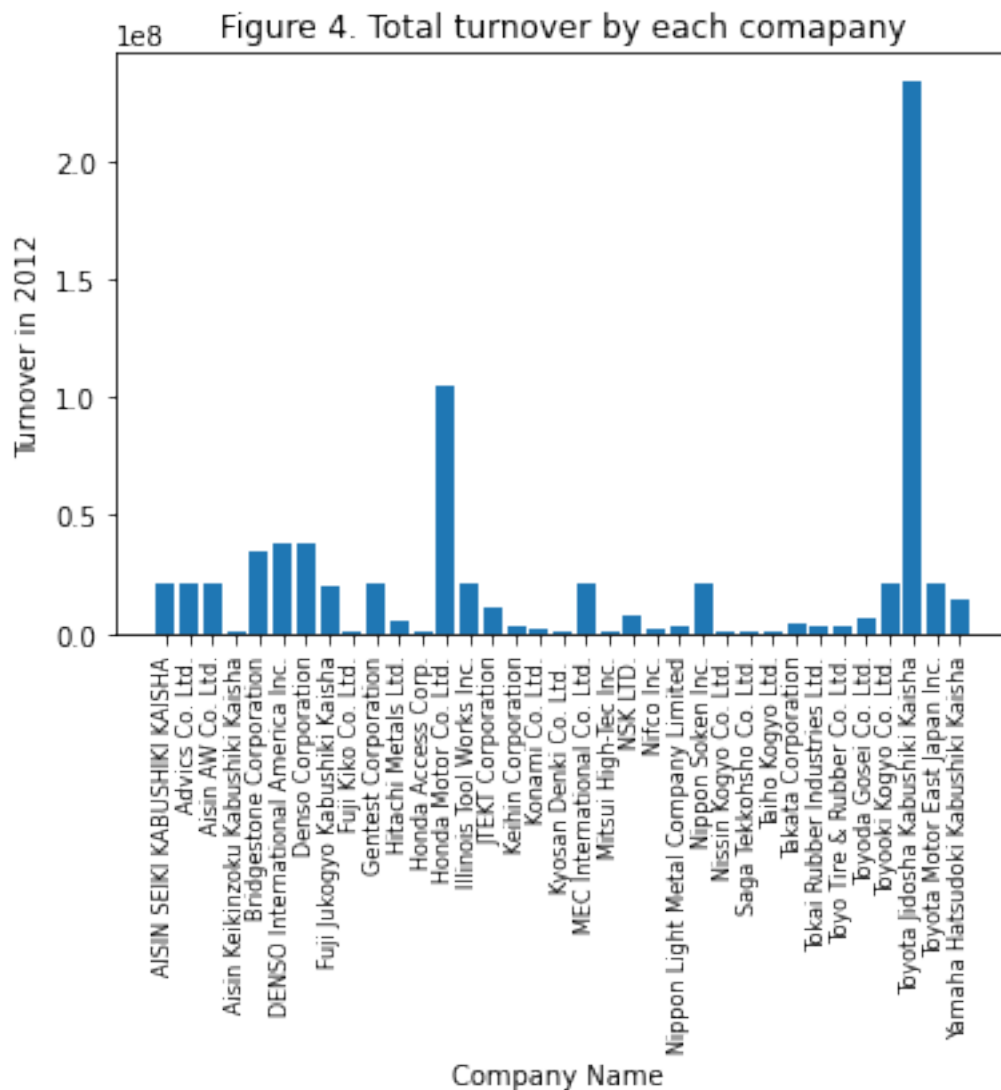


5.4 Analysis on Turnover and it's Correlation with Total Assets

From the given data, the analysis established the data visualization through a bar chart to show revenues by the company. It shows different companies have differences in turnover, total assets, number of employees and expenditure on research & development as well as patent count. In the figure below (See figures:4) shows annual turnover of the company in the year of 2012.

```
[ ]: keys = [company for company, df in df.groupby(['ID'])]

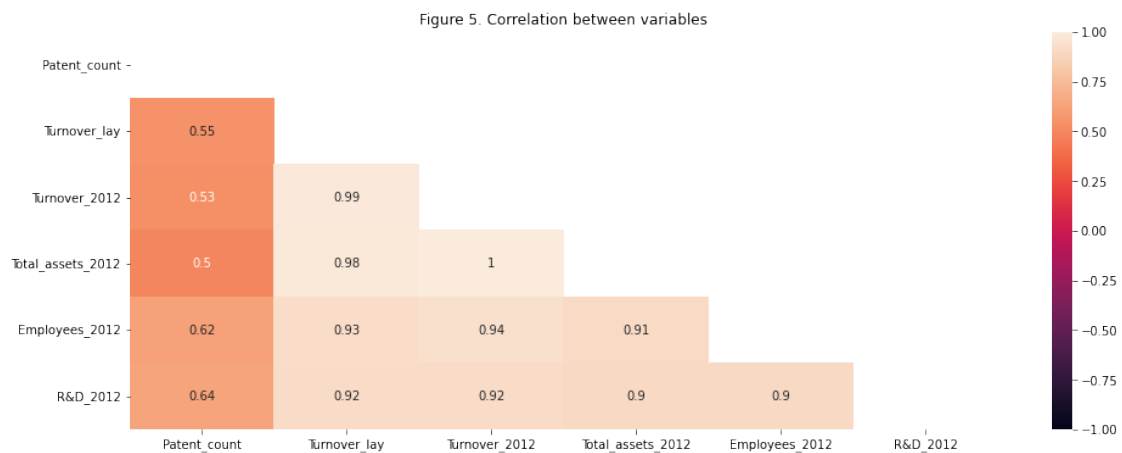
plt.bar(keys,df.groupby(['ID']).sum()['Turnover_2012'])
plt.ylabel('Turnover in 2012')
plt.xlabel('Company Name ')
plt.xticks(keys, rotation='vertical', size=8)
plt.title('Figure 4. Total turnover by each comapany')
plt.show()
```



In the figure- 5 below, it represents correlation between variables which suggests turnover and total assets had the highest positive correlation of 1. Thus, the findings of the figure- 5 above, established highest turnover has positive correlation with total assets. That means, as turnover goes high, the value of assets goes up.


```
[ ]: data = df[['Patent_count', 'Turnover_lay', 'Turnover_2012', 'Total_assets_2012', 'Employees_2012', 'R&D_2012']]
plt.figure(figsize=(16, 6))
corr = data.corr()
mask = np.triu(np.ones_like(corr, dtype=bool))
heatmap = sns.heatmap(data.corr(), mask=mask, vmin=-1, vmax=1, annot=True)
heatmap.set_title('Correlation Heatmap', fontdict={'fontsize':12}, pad=12);
plt.title('Figure 5. Correlation between variables')

plt.show()
```



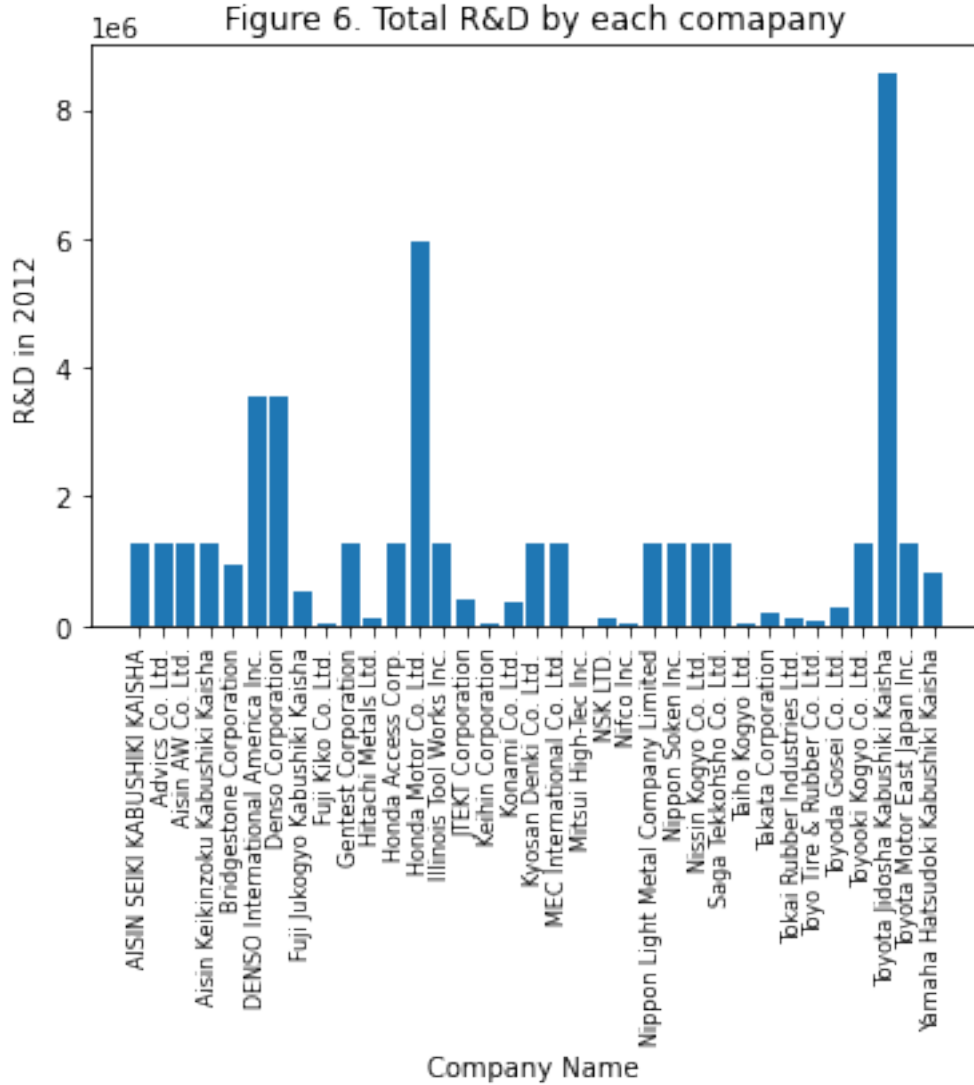
6 Denso's innovation strategy in the country context and their implication with the industry

6.1 Research and Development

DENSO Corporation has excellent ambition towards research development. Compared to other companies, DENSO corporation placed in third position in expenditure on the given data within the year of 2012 (Figure:6).

```
[ ]: keys = [company for company, df in df.groupby(['ID'])]

plt.bar(keys, df.groupby(['ID']).sum()['R&D_2012'])
plt.ylabel('R&D in 2012')
plt.xlabel('Company Name ')
plt.xticks(keys, rotation='vertical', size=8)
plt.title('Figure 6. Total R&D by each comapany')
plt.show()
```



Recently the company boosted its investment on a digital engineering program in Aachen, Germany (The Hansen Report on Automotive Electronics, 2022). The research primarily focuses on digital development on transportation efficiency and management optimization. Along with that company has research and innovation centres in Japan, Montreal, Seattle, Texas, Finland and Israel.

6.2 Collaborative Approach

Company has a collaborative approach with other small local suppliers in terms of producing new technology and product innovation. Recently the company has had significant success in development of autonomous vehicles (The Hansen Report on Automotive Electronics, 2022). Company also invested heavily in collaboration on Qualcomm Technologies that help to improve integrated cockpit system. Another example, where a company collaborated with a German start up firm to develop basic software control for electronic vehicles.

This ability to invest in R&D and Collaborative approach shows the company has an effective innovation strategy in place that will meet future demand (O'Reilly et al., 2009; Gilsing et al., 2008). From the business strategy perspective, this can be considered as a strength of the firm to achieve competitive advantage in the market.

7 Conclusion

From the given data, the analysis shows; DENSO Corporation has strong market presence in relation to effective communication within the subsidiary. Their global value chain and interconnectedness and interdependence provide them with excellent business agility to achieve the lowest cost manufacturing. On the other hand, regional operational autonomy provides them an advantage to take a quick decision in the shortest period of time by avoiding organisational complexity. Company's ambition to collaborate with small start-up companies shows societal obligation for betterment of the people such as investing in innovative digital solutions for better transportation.

8 References

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- O'Reilly Media, Inc. Conway, S., & F. Steward (2009) *Managing and shaping innovation* Oxford University Press.

9 Appendix

1. Degree Centrality

```
Samsung Electronics Co., Ltd. 0.03924646781789639
International Business Machines Corporation 0.03296703296703297
Toyota Jidosha Kabushiki Kaisha 0.02197802197802198
STMICROELECTRONICS S.R.L. 0.020408163265306124
Kabushiki Kaisha Toshiba 0.020408163265306124
Denso Corporation 0.01883830455259027
Fuji Electric Co., Ltd. 0.017268445839874413
Sumitomo Electric Industries, Ltd. 0.017268445839874413
Sony Corporation 0.015698587127158558
COMMISSARIAT A L'ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES 0.015698587127158558
Honda Motor Co., Ltd. 0.015698587127158558
Hyundai Motor Company 0.0141287284144427
Panasonic Corporation 0.0141287284144427
Rohm Co., Ltd. 0.0141287284144427
IMEC 0.012558869701726845
Centre National de la Recherche Scientifique (CNRS) 0.01098901098901099
National University Corporation Nagoya University 0.01098901098901099
Electronics and Telecommunications Research Institute 0.009419152276295134
The Regents of the University of California 0.009419152276295134
```

2. Eigenvector centrality

```
International Business Machines Corporation 0.45813003028955307
Samsung Electronics Co., Ltd. 0.4316882680143975
STMICROELECTRONICS S.R.L. 0.33897072011146945
COMMISSARIAT A L'ENERGIE ATOMIQUE ET AUX ENERGIES ALTERNATIVES 0.24047786993028206
FREESCALE SEMICONDUCTOR, INC. 0.21000175507774457
GLOBALFOUNDRIES Inc. 0.20634328236519153
STMICROELECTRONICS (CROLES 2) SAS 0.16941578123418422
Kabushiki Kaisha Toshiba 0.16120311083141994
Centre National de la Recherche Scientifique (CNRS) 0.12871241958293347
Samsung Display Co., Ltd. 0.11558633904181562
IMEC 0.10138705794847949
Industry-Academic Cooperation Foundation, Yonsei University 0.09419447698017736
SNU R&DB FOUNDATION 0.09181066170812134
Korea Advanced Institute of Science & Technology 0.0897007605188954
STMicroelectronics Limited 0.08736606969814834
Taiwan Semiconductor Manufacturing Company, Ltd. 0.08704546490027698
Sumitomo Bakelite Co. Ltd. 0.0867079764713347
Dacom Corporation 0.0867079764713347
Renesas Electronics Corporation 0.08348029548942879
```

3. Betweenness centrality

Samsung Electronics Co., Ltd. 0.09045562104861295
 IMEC 0.05288860585356546
 International Business Machines Corporation 0.04846897636655047
 Panasonic Corporation 0.04114988036820923
 Toyota Jidosha Kabushiki Kaisha 0.03232065927483717
 Sony Corporation 0.01850524438125521
 Denso Corporation 0.017879933782898746
 STMICROELECTRONICS S.R.L. 0.01649174425454749
 The Regents of the University of California 0.01621463292622325
 Honda Motor Co., Ltd. 0.016060938163364007
 The Board of Trustees of the Leland Stanford Junior University 0.015055504543375155
 Sumitomo Electric Industries, Ltd. 0.014384776648927617
 Kabushiki Kaisha Toshiba 0.011540271648088367
 Fuji Electric Co., Ltd. 0.011184009162445828
 Industry-Academic Cooperation Foundation, Yonsei University 0.010130031693374012
 National University Corporation Nagoya University 0.009936679074145383
 Rohm Co., Ltd. 0.009703010376864826
 Seoul National University Industry Foundation 0.00837768101919044
 King Abdulaziz City for Science and Technology 0.007948026815951345

4. Closeness centrality

Samsung Electronics Co., Ltd. 0.11556670253543498
 IMEC 0.10819312151476919
 International Business Machines Corporation 0.10100503325834695
 Panasonic Corporation 0.1005443489561424
 The Regents of the University of California 0.09775764305381031
 STMICROELECTRONICS S.R.L. 0.09732604198072504
 Taiwan Semiconductor Manufacturing Company, Ltd. 0.0968982352027878
 Sony Corporation 0.09615855401803369
 GLOBALFOUNDRIES Inc. 0.09574092729048522
 Seoul National University Industry Foundation 0.09491646290047027
 Toyota Jidosha Kabushiki Kaisha 0.09175587308484588
 Samsung Display Co., Ltd. 0.09053120537426786
 Industry-Academic Cooperation Foundation, Yonsei University 0.09016093459564099
 Korea Advanced Institute of Science & Technology 0.08961117279932611
 SNU R&DB FOUNDATION 0.08906807478236049
 Georgia Tech Research Corp. 0.0886204965171225
 Osaka University 0.0886204965171225
 Sumitomo Electric Industries, Ltd. 0.08853152011499688
 University of Seoul Industry Cooperation Foundation 0.08826565969423113

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