



HAL
open science

AI Classification in Collaboration for Innovation of Electric Motors of Household Appliances

Asuman Firat, Gulgun Kayakutlu

► **To cite this version:**

Asuman Firat, Gulgun Kayakutlu. AI Classification in Collaboration for Innovation of Electric Motors of Household Appliances. 6th IFIP International Workshop on Artificial Intelligence for Knowledge Management (AI4KM), Jul 2018, Stockholm, Sweden. pp.107-123, 10.1007/978-3-030-52903-1_9. hal-03478005

HAL Id: hal-03478005

<https://inria.hal.science/hal-03478005>

Submitted on 13 Dec 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution 4.0 International License

AI Classification in Collaboration for Innovation of Electric Motors of Household Appliances

Asuman Firat¹ and Gulgun Kayakutlu²

¹ Arcelik, Washing Machine Plant R&D, Tuzla, Istanbul, Turkey
asuman.firat@arcelik.com

² Istanbul Technical University Energy Institute, Maslak, Istanbul, Turkey
gkayakutlu@gmail.com

Abstract. Electric motors are important components of household appliance that effects the energy efficiency and noise level with a social impact. Considering the evolution period of electric motors in household appliances, innovation can be seen at the end of each life cycle of motor technology for every single product. Therefore, it can be stated that electric motors are open for innovation. There are several ways for innovation. Collaboration is one of them. Recently, improvement in sharing economies also resulted with knowledge sharing due to shortage of resources. In order to achieve efficiency with limited sources collaboration is essential. However, collaborating partner is very important to get successful results. Unfortunately there are lots of examples that collaboration ends up without any beneficial. As a result of evaluation of previous studies and experiences, expert knowledge is established. Classification method based on expert knowledge is chosen to give the decision of collaboration for each candidate corporation. Artificial intelligence is used for this critical decision making.

Keywords: Innovation, Collaboration, Classification.

1 Introduction

Since 19th century electric motors are very popular in the industry thanks to important scientists such as Faraday, Oersted, Tesla, etc. for their innovative solutions. Electric motors are the machines that converts electrical energy to the mechanical energy. Mechanical energy is used so many areas that needs rotational movement and torque. Pumps, household appliances, elevators, conveyors are some of the examples of these application areas.

Previously most of applications used the motors whose input is other energies than electricity. Motors that convert chemical energy to the mechanical energy lose

their importance day by day. Since they use petroleum, they increase dependence on those countries who have this source. On the other hand, there are many resources to create electricity. Recent technologies give us chance to use natural resources such as sun and wind to obtain electrical energy, in order not to give harm to the nature.

Additionally, electric motors have such advantages like higher efficiency and silent working conditions. Due to limited resources of energy and shortage that is not far from today's world, efficiency is very important. Although there is a big history in conventional motors of vehicles, number of electric vehicles are increasing so that efficiency and silence advantages are given to the drivers.

1.1 Innovation of Electric Motors in Household Appliances

Most of the electric consumer appliances in a house are washing machines, driers, dishwashers and refrigerators. There are plenty of houses with these appliances, therefore electric motors are inside of the houses. As technology level increases, requirements from these appliances also changes. In ancient times, for example an idea of a machine that is washing clothes was so surprising for the people. On the other hand, nowadays energy level of a washing machine is very important argument for the people who buys it. Such development is also valid for other appliances.

Considering washing machines, there are two main operating points in motor point of view. One of them is washing period that is slow rotation with large torque requirement. The other one is spinning period that is high speed rotation with low torque requirement.

In order to satisfy these requirements induction motors were used. These motors are controlled via a big electronic card so that this two different operating condition is satisfied. However big electronic card and big motor couple were expensive. Due to these expensive parts, washing machine was also expensive and this was not the case people prefer.

Afterwards, universal motors are started to be used. Good news about this type of motor is that universal motors are plug-in motors. Only a few electronic component is needed in order to control two opposite operating point of the washing machine. On the other hand, disadvantage of this motor is that brushes that are used in these motors for commutation. Brushes are carbon structures and due to friction during operation, brushes wear down. This disadvantage results in lower life cycle of the motor and so that washing machine. Since customers want to use their washing machine more than 10 years, the need for innovation in motor technology is raised. Another disadvantage of this motor is that friction of brushes increases noise level of washing machine.

Due to the problems created by brushes, new motor technologies such as brushless motors became popular. One of them was direct drive motors that were so popular in that time period which is beginning of 2000's. These motors were directly mounted on the drum without any brush structure within the motor. Thanks to the permanent magnet technology included in direct drive motor, efficiency of these motors were higher than universal motors. Patents about permanent magnet usage limited motor applications until these years. Direct drive motor also used big electronic card in order to control operations of the motor. Although this solution was not the cheapest solution, it offered long-life and noiseless washing machines. Added to its cost problem,

direct drive motor assembly to the washing machine was so precise operation that is open to some faults coming from human operators.

About five years later a permanent magnet motor is designed by using an existing motor with minimum investment. Operation control is done by a big electronic card. This motor was assembled to the washing machine by belt-pulley system so that minimizing production problems. It also had long life time and noiseless structure. However, this motor and electronic driver system was not as cheap as universal motor system.

At that point new target was to have a motor system that has the same cost with universal motor system. Thanks to new technology coming from winding machines that is used in motor production, it was applicable to cancel some of the windings that are not used during operation of the motor. In other words, innovation came with simplification. Additionally, magnets are arranged so that their benefits are increased. Moreover, electronic driver technology continued to develop. As a result of it more capable drivers with cheaper components are available.

Finally washing machines can provide long life, noiseless and higher energy efficiency with reasonable prices. A brief illustration that shows this development period is given in **Error! Reference source not found.**

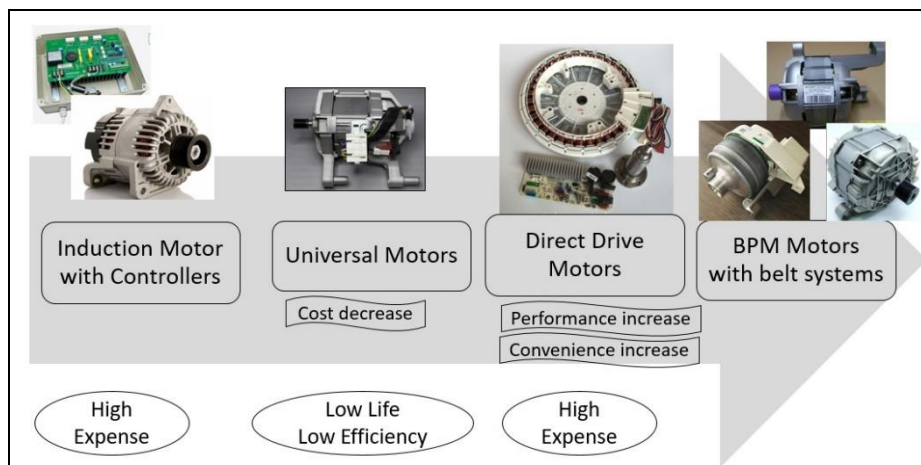


Fig. 1. Development period of washing machine motors

Considering all period; many innovation types are easily observed. Each type of the motor is examples of product innovation. Step from induction motor to universal motor includes physical characteristic change. Direct drive motors have different architecture form universal motors. Direct drive motors and Brushless Permanent Magnet (BPM) with belt systems are modular innovation. Since they include both change in subsystem and change in linkages between subsystems washing machines are clearly different between each other.

Motor technology development of dishwasher, drier and refrigerator was not so complicated. These machines have one operating conditions. Therefore, simple induction motor types without electronic control were used in these appliances. On the

other hand, in order to increase efficiency of these appliances, control of the motor is necessary. Permanent magnet motors are also used in these appliances for efficiency and controllability. For these appliances controllability provides low noise requirement too.

Additionally, customer expectations did not end up. Requirements that are related with motor of the household appliances are lower noise, higher efficiency with lower cost. In other words innovation is needed in this area to achieve these challenges.

2 Innovation

It is clear that in order to improve economy of a country for improving competitiveness, intellectual capital and innovation capability are two important parameters. Innovation is an invention that brings improvement together with money. Innovation is a road from ideas to values that someone prefers to pay for. A product or a process can be innovative. It starts from idea creation by means of lots of techniques. Experimentation is the second step.

Universities are considered to be necessary for innovation for the subjects coming from production areas. Thus academic-industry collaboration is established mostly. Universities and research institutes are the major drivers of scientific and technological advancement. However, technology breakthroughs cannot become an innovation until it is successfully commercialized. That is why university-industry collaboration is important. The intellectual resources continuously provided by university are a priceless intangible asset to a company. [7]

Academic-industrial partnerships have gains for both sides: intellectual property generation and exploitation for industrial competitiveness, enhanced research capabilities and updated research infrastructure for the universities and innovation diffusion that fosters links between the sectors. Publication opportunities for academia and employment creation for the industry can be also added to the benefits. [1]

2.1 Open Innovation

Open innovation is driven by a desire to realize: cost reduction for technology development, reduced risk for market entry, to achieve economies of scale for production, reduce lead times for product or service development, and to promote shared learning. In essence the ability to “tap into shared creativity is a considerable driver in the open innovation context and this creates the motivation for organizations to link with other organizations as they no longer have to make or source everything themselves. With the introduction of collaborate into traditional decisions of make or buy a company can extend its capabilities in interaction with others. [5]

In today’s global society, firms recognize they have much to gain from creating partnerships and engaging with the rest of the world. Open innovation refers to how organizations use internal and external sourcing and markets paths for innovation, or share innovation processes. Open innovation is recognized as a progression from the classical linear models of innovation, from technology-push, through supply-chains, to network or collaboration focused innovation. For example, in 2007 a number of organizations working in the IT industry came together to create the Open Handset Alliance and later to launch the globally successful “Android” operating system and software platform. The organizations included Samsung, Intel and Qualcomm (handset

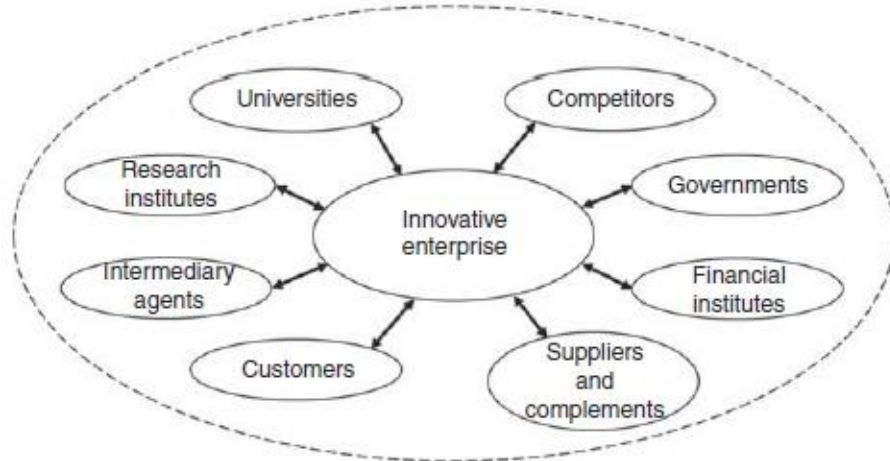
and component manufacturers); Google (a software developer) and T-Mobile (a mobile telephone operator) who loosely followed a vertical integration (or supply-chain) derived structure. This is a well versed example of open innovation around a multi-player venture that could be argued to be market driven-the needs of the customers (or users) creating the motivation for user-led innovation. Other examples indicate how firms may collaborate on horizontal level, in terms of complementary (co-operation) and competing organizations(co-opetition), such as the “Ecomagination” initiative that led General Electrics to collaborate with a range of smaller and less-established organizations to create emergent “green technology” solutions and the development activity between Sony, Samsung and a number of other high-tech electronics companies which enabled them to develop core technology that was then sold by each organization in competition with its collaborators.[5]

2.2 Innovation Ecosystem

An innovation ecosystem allows firms to create value that no single firm could create alone. The health and performance of each firm is dependent on the health and performance of the whole. Therefore, the competition is not limited to company to company, instead the competition takes places from ecosystem to ecosystem. An innovation ecosystem is a place where innovative enterprises can integrate resources and realize innovation.

The competition among innovative enterprises has shifted from their products and services to the innovation ecosystems they belong to. It is hard for a single firm to have all the elements required for successful innovation. Companies should cooperate with suppliers, outsourcers, distributors, intermediary agents, customers, research institutes, universities, and governments closely, and take full consideration of the interdependences between components and complements, to construct a healthy innovation ecosystem, and provide valuable products and services to their customers. Many companies are trying to build or join a vigorous innovation ecosystem in order to enhance their capabilities toward innovation and their market responses. Successful innovation usually depends on close collaboration among firms and their partners. [7]

An innovation ecosystem (**Fig. 2**) is the complex relationships that are formed between actors or entities whose functional goal is to enable technology development and innovation. The actors include the material resources (funds, equipment, facilities, etc.) and the human capital (students, faculty, staff, industry researchers, industry representatives, etc.) that make up the institutional entities participating in the ecosystem (universities, colleges of engineering, business schools, business firms, venture capitalists, industry-university research institutes, federal or industrial supported centers of excellence, state and/or local economic development and business assistance organizations, funding agencies, policy makers, etc.). There exists a lot of material, energy, and information exchanges within an ecosystem and between the ecosystem and the environment, which help maintain the stability and efficiency of the ecosystem.



Source: Adapted from Zhao and Zeng (2014)

Fig. 2. Innovation ecosystem

In innovation ecosystems, companies can adopt a coopetition strategy: they compete in gaining market share, but cooperate for defense, development and growing of their ecosystems at the same time. A single organization may participate in several linked ecosystems, and may have different roles in each. Companies such as Apple, IBM, Ford, and Walmart are regarded as leaders of innovation ecosystems and perform a critical role in enhancing innovation and productivity. They strategically nurture their innovation ecosystems by investing in innovation partners that help make their suppliers, customers, and other members of their ecosystem smarter, faster, richer, more innovative, and more creative. The core company that plays a central role in the innovation ecosystem is valued by all of the rest of the ecosystem. Other members can utilize the abilities of the ecosystem such as services, tools or technologies to enhance their own innovation performance as well as adding value to the ecosystem by providing new applications and complementary products. [7]

3 Collaboration

On 25th September of 2015, United Nations accepted 17 Goals to transform our world that is called Sustainable Development Goals. Sustainable development agenda includes goals such as zero hunger, end of the poverty, gender equality ... etc. (Fig. 3)



Fig. 3. Sustainable Development Goals accepted in 2015 by United Nations

Most of the global companies included these goals as their own development goals. In case these goals are achieved, national revenue of all world will increase dramatically. Sustainability will provide companies respectfulness and trust. As a result of it, its customers, investors and human resources will increase. According to Better Business Better World report (a call to action to business leaders to align with the Sustainable Development Goals); six action is listed for companies in order to let them to be leader in sustainable development. Two of these actions are related with collaborations.

1. Collaborate with other companies in your sector to transfer global transformation to all sustainable market.
2. Collaborate with government, civil society and regulations so that provide all natural sources to be priced transparently and provide human resources to be priced fairly.

Companies that can optimize their resource usage will be in a better position than the others. Humans are existing for each other. Therefore, in future, collaboration will be more important than past. Leaders of future will be determined by their collaboration competency. [2]

The road that goes to perfect collaboration is given in **Fig. 4.**

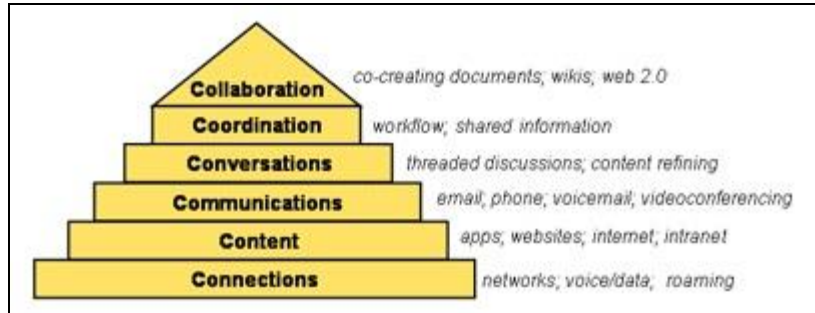


Fig. 4. Roadmap for perfect collaboration

Like any pyramid, the bottom layers provide essential foundations for those above. The diagram illustrates the 6Cs of collaboration:

- **Connections.** Before collaboration can start, the participants must connect with each other, irrespective of location. Good high bandwidth networks are an essential pre-requisite in this day and age.
- **Content.** Explicit content is usually an input and output of collaboration. Documents and databases, accessible through web-based portals are prominent in this layer.
- **Communications.** Much collaborative work takes place through personal communications and conversation. This layer includes both voice and data communications. It also covers a variety of communications patterns, ranging from one-to-one, one-to-many and many-to-many.
- **Conversations.** Conversations are sequences of communications. This layer adds the much overlooked function of orchestrating and recording the essence of conversations in a reusable way.
- **Coordination.** At this layer, a systematic approach is involved to ensure that functions at lower layers, such as content sharing and conversations, "function together or occupy their proper place as parts of an interrelated whole".
- **Collaboration.** This layer represents the highest level of collaboration capability. Each piece of work, however large or small, is done in a collaborative way. Key features at this level are a collaborative style of working and technology tools to match.

(For completeness, there is a 7C version which includes as the second layer Computation - for computer-computer collaboration without human intervention.)

Transformation as a technology network requires collaborative networks including all business units, joint ventures and R&D Centers. With a wider aspect, universities, other companies, national labs, information systems and legal advisers are part of this ecology. Collaborative networks result in new discoveries with saved time and costs. In order to get success from this system the following six key aspects should be considered well.

- Strategic selection of project - selecting the development method (such as acquisition, in-house or partnership) based on a business-competitive strength matrix.
- Selecting partners based on key criteria - world class competency, commitment, trust etc.
- Matching projects and partners - meshing complementary competencies, matching interests, and in general creating a win-win situation.
- Effective project management, with clear understanding of goals
- A strong co-manager (business champion) who sets the pace, respects cultural diversity and has high credibility
- Effective communications and networking, not forgetting the importance of face-to-face communications and local support infrastructures.
- Shift from a competitive to a collaborative mentality, both externally and internally
- Proper protection of intellectual property when knowledge is shared more freely; preventing leakage of vital knowledge
- Capable of working across different cultures, both company and national
- Entry and exit strategies for collaborations should be clearly identified.
- Exactly determination of boundaries between companies and between employees, contractors, suppliers and partners

Especially R&D Managers have to move much further if their companies are to be leaders in innovation. [6] The role of the orchestrator requires the ability to collaborate with several partners simultaneously, while not having direct control, and the skills of complex project management. It is clear that government regulations have a strong influence on innovation at the national, regional and company levels. [7]

3.1 Collaboration in Innovation

Economic competitiveness capability depends on capital, export, infrastructure, competences/skill and process& technology. “Technology” and “skills” dimensions are two main dimensions contributing to play a significant role in enhancing the RD capacity. Knowledge creation, technology diffusion and development of R&D should be attracted from the biggest countries. Building industrial capabilities requires technology cooperation between local and international companies, government and research/education institutions. [9]

Technological innovation is the driving force for the development of electric motors. At each time period of change, competitors are waiting just behind to get more share in the market. Sustainable innovation is needed to continue the business. This is valid for all industrial sectors such as electrical vehicles. Since their aim is also lower energy consumption, it is understandable to check their way of innovation. Innovation method differs between companies in the meaning of ecological environment, market positioning, innovation path and business model. For example, Toyota made optimized configuration in the global and built enterprise ecosystem to make progressive disruptive innovation and develop the middle and low-end market. Toyota created a good innovation environment by the way of cooperating with local universities, enterprises and research institutes in various regions. On the other hand, Tesla being in a technology innovation environment preferred quick disruptive innovation for high-

end market. Tesla like to stand in the preface to the era of early adaptors. In order to promote the development of electric vehicle technology, Tesla shared all the Tesla's patented technology with other companies. As a result, it promoted the development of electric vehicle industry innovation environment. Additionally, BYD a company in Shenzhen, formed a plurality of core technologies through cooperation with domestic and foreign for niche-based market. BYD cooperated with the United States, Chrysler and other international giants such as Daimler-Benz and Intel, to further enhance its technical level and international brand influence. [4]

It is notable that for industrial partners just in time information is a major requirement. Industrial communities often follow the money and cannot be sustained without the financial benefits received. Here, other benefits need to be built into the model to ensure sustainability of the cluster and ongoing interest in the communities. The supply of skilled workers and specialized facilities has a draw for new companies and can be a magnet for growth, many lessons remain for how academic and industrial communities can interwork and co-relate best practices. [1]

During research and development activities of electric motors, many other partners contributed to the design stage of the motor. Requirements are collected from different customers. Additionally, regulations also determine the limitations of the designs. Both of them determine specifications of the design. It is clear that heart of the innovation comes from material, production equipment or design. Suppliers of motor producers can be either component supplier or equipment supplier. Both of them have some advantages as they work with different types of companies. Therefore, they give different aspects to achieve design targets. In some stages competitors also offer different motor designs. They also contributed innovation of the motor by showing advantages and disadvantages of some design types. Istanbul Technical University performed magnetic and mechanical analysis about different configurations of new motor designs. Several researches from different Universities of all over the world are studied deeply. **(Error! Reference source not found.)**

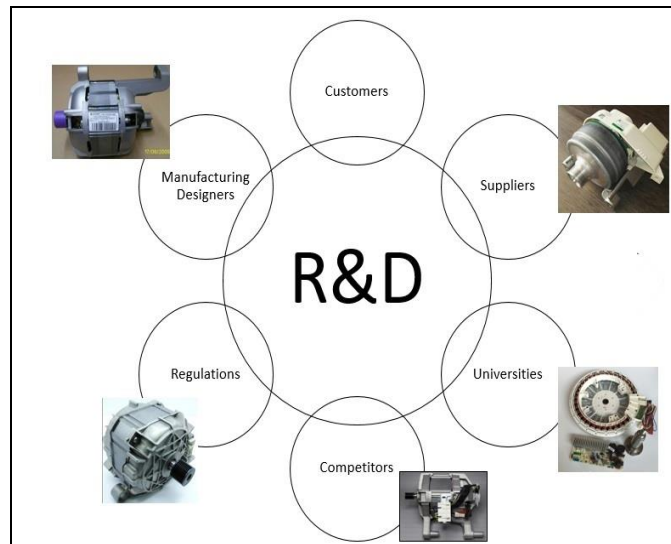


Fig. 5. Collaboration in innovation

All of these collaborations will also lead to achieve better and better designs. Many types of transformations of knowledge can be obtained from each of these collaborations. Such innovation will lead to competency advantage and increase in revenue.

3.2 Collaborative Innovation in Turkey

According to European statistics database Eurostat, collaborative innovation in Turkey is given in following charts.

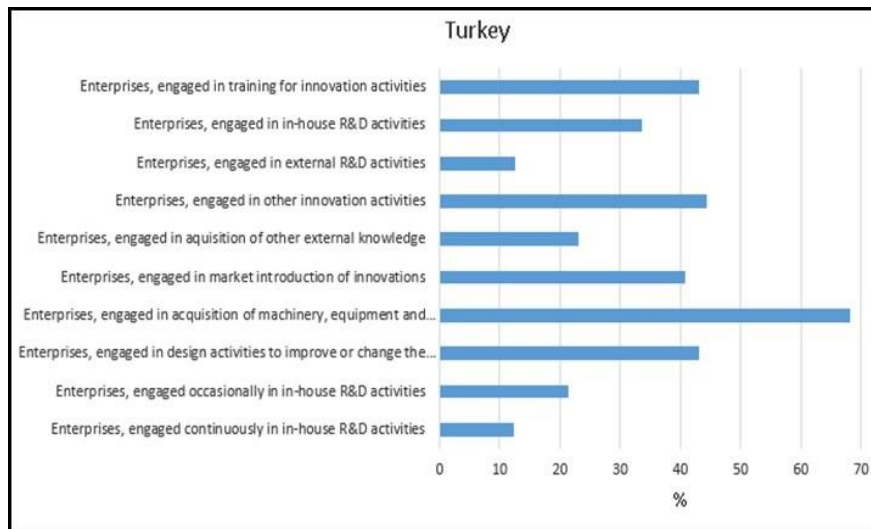


Fig. 6. Innovation ways in Turkey

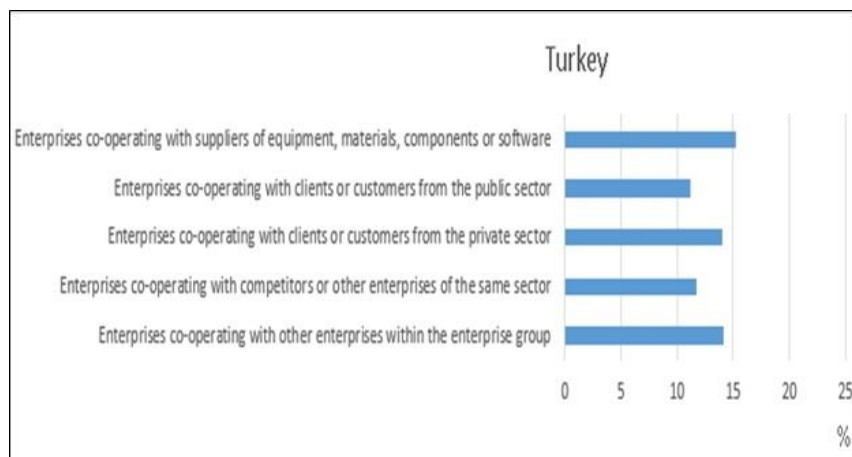


Fig. 7. Turkey cooperation distribution

As can be seen from the graphics, percentage of collaboration with suppliers in Turkey very low. Private sector is more preferred partner compared to public sector partner. Enterprises prefer to collaborate with other enterprises rather than competitors.

It is clear that Turkey should increase collaboration competency in order to be one of the most innovative countries.

3.3 Parameters Effecting Collaboration Quality

Unfortunately, some of the collaborations end up with failure. Studies have shown that between 30% and 70% of alliances fail; in other words; they neither meet the goals of their parent companies nor deliver on the operational or strategic benefits [3]. Many reasons can be listed for this failure. Companies prefer to sign contract in order to prevent failure. However, in case structure of the candidate is not suitable for the collaboration; contract will not solve the problem. As a result of it money and time is spent and the amount is depending on importance of the project.

There are many parameters that have impact on collaboration quality. Referring study done by Worasinchai and Bechina [9], many techniques used to determine parameters that effects collaboration quality. Lots of surveys, interviews were conducted with different managers from both sides of collaboration units in order to formulate parameters to understand the knowledge flow and the learning processes between foreign companies and local Universities.

Additionally, experience from a Turkish Well-known R&D Center is also evaluated for collaboration quality. Although effectiveness of some of the parameters differ according to implicit and explicit knowledge, the difference is not considered to determine collaboration quality.

- Corporations that are collaborated previously has good impact in collaboration decisions.
- Collaboration with supplier has positive impact.
- Collaboration with a corporation from private sector brings better result than a corporation from public sector.
- Although according to some sectors collaboration with a competitor has a positive impact, it has negative impact in collaboration with the aim of innovation.
- Collaboration with a corporation that has in-house R&D activities results with innovation.
- Corporations that has higher percentage of employers with university education creates good collaborations.
- Collaborations that has top executive decision power of all corporations increases the collaboration quality. Strong involvement of leadership in the decision making is crucial for a successful collaboration.
- Corporations from foreign countries, also local countries that spend many years on related subject increases collaboration quality.
- Corporations that have own R&D strategy are good choices for innovative collaborations. The intensiveness of R&D strategy has a positive effect on the intention to share knowledge

- Most of the companies do not want to share confidential information. Because protection of knowledge seen as having a competitive advantage to the corporations. The clear lack of an intellectual property strategy makes the companies quite often reluctant to involve outside people in their business routines or within the premises of the enterprise. Trust is seen as a fundamental core value. Therefore, as confidential information increases within collaboration, quality of the results decreases.
- Benefit level of all the companies should be as much as high for innovative collaborations. The level of benefits has a positive effect on the intention to share knowledge. Benefits should be clearly evaluated and highlighted in order to promote stronger collaboration. The benefits as stated in the interviews are related to cost reduction, enhancing the skills of employees, gaining a better position in the market place, and so forth.

3.4 Classification and Constraint Programming for Collaboration

Knowledge engineering is a core part of artificial intelligence in research. Machines can often act and react like humans only if they have abundant information relating to the world. Artificial intelligence must have access to objects, categories, properties and relations between all of them to implement knowledge engineering. Initiating common sense, reasoning and problem-solving power in machines is a difficult and tedious task. [8] AI is mostly used to do this tedious task.

Selection of a collaboration partner may be subjective decision sometime. As a result of being human, decision maker may be effected from any other properties of corporation and leads to wrong judgment. Thus AI is used to give such decision. It should be also added; opposite to the general idea implying that AI will take place of human; the valuable output comes from collaboration of AI and common sense of human.

One of the advantages of AI is to speed up the process of decision making. Rules are listed and according to definitions, AI decides the best solution. Compared to human decisions, AI will prefer the most objective option, fastly.

In general, a classification includes following steps. Firstly, a set of data is collected. Observations are extracted from those data. Answer of a question is determined according to these observations. In case of machine learning new observations are added to the observations and answer of the question converging to the best solution. **(Fig. 8)**

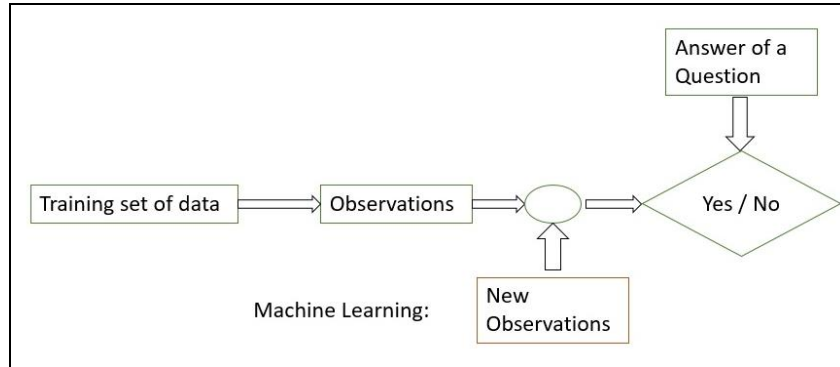


Fig. 8. Steps of a classification

Constraint programming is performed as shown in **Fig. 9**. Training set of data includes all the data of different corporations. Observations that are shown with colored boxes show the result of the collaboration quality.

Corporation	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20
Is this the first time to collaborate with this Corporation?	[y/n?] y	n	y	n	y	y	y	y	y	y	y	y	y	n	y	y	n	y	y	y
Is this corporation one of the supplier?	[y/n?] y	n	n	n	y	n	y	n	y	n	y	y	y	y	y	y	y	y	n	y
Is this corporation University?	[y/n?] y	n	y	n	n	y	n	y	n	n	y	y	y	y	y	y	y	y	n	y
Advisers/consultant	[y/n?] y	y	n	n	n	n	y	n	n	n	y	y	y	y	y	y	y	y	n	n
Is the company local or from abroad?	local	local	local	local	local	abroad	local	local	local	local	local	local	local	local	local	local	local	local	local	local
Does the company have any relation with government policy?	[y/n?] y	n	y	y	n	n	n	n	n	y	y	y	y	y	y	y	y	y	y	y
Is the company from Public or Private Sector?	private	private	public	public	private	private	private	public	private	public	private	private	private	private	private	private	private	private	private	private
Is the company one of the Competitors?	[y/n?] y	n	n	n	n	n	n	n	y	n	y	y	y	y	y	y	y	y	y	y
Does the company have in-house R&D activity continuously?	[y/n?] y	y	y	y	n	y	n	y	y	n	y	y	y	y	y	y	y	y	y	y
Percentage of employees that have university education	60%	80%	90%	100%	30%	95%	100%	100%	80%	90%	65%	85%	40%	83%	75%	70%	90%	80%	70%	90%
Top Executive Decision Power	[y/n?] y	y	y	y	y	n	y	n	y	n	y	y	n	y	n	y	n	y	n	y
Years (Experience on corporation subject)	5	10	14	10	16	4	10	20	2	2	5	8	18	22	1	3	12	17	4	9
R&D Strategy	[y/n?] y	y	y	y	n	y	y	n	y	n	y	y	y	y	y	y	y	y	n	y
Confidential Information	[y/n?] y	y	y	y	n	y	y	y	n	n	y	y	y	n	y	y	y	y	n	y
Benefits level	[y/n?] y	y	y	y	y	y	y	y	y	n	y	y	y	y	y	n	y	y	n	y
Collaboration? [Yes/No]	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes

Fig. 9. Training set of data and observations

As mentioned earlier; expert knowledge is used to determine collaboration parameters. Rules regarding these parameters are created and defined in a conditional programming environment such as Excel, Python, etc. Conditional statements check result of a parameter with a value. If the result is the same with the value, the action will be in one way. If the result is not the same with the value, the action will be in opposite way.

Question list (**Table 1**) also shows the parameters that effect collaboration quality. Certainly all of those questions do not have the same effect on collaboration quality. Therefore each question has its own weight. All answers with weighted values are summed to get a total score. According to expert knowledge limit score for good collaboration is 80. In case score is higher than 80, collaboration has high potential for good results.

Table 1. Question list

Questions	
Weight	Corporation
3	Is this the first time to collaborate with this Corporation? [y/n?]
1	Is this corporation one of the supplier? [y/n?]
2	Is this corporation University? [y/n?]
1	Advisers/consultant [y/n?]
1	Is the company local or from abroad?
1	Does the company have any relation with government policy? [y/n?]
2	Is the company from Public or Private Sector?
1	Is the company one of the Competitors? [y/n?]
2	Does the company have in-house R&D activity continuously? [y/n?]
6	Percentage of employees that have university education
15	Top Executive Decision Power [y/n?]
8	Years (Experience on corporation subject)
10	R&D Strategy [y/n?]
12	Confidential Information [y/n?]
8	Benefits Level [y/n?]

A new corporation or improved corporation is checked whether it is suitable or not for innovation subjects. Furthermore the list also shows improvement ways for better collaborations. Since this is the most objective solution, it also speeds up decision making process. As a result of this study, collaboration with 5 partner that has the highest score brought a motor design with given results. (Fig. 10)

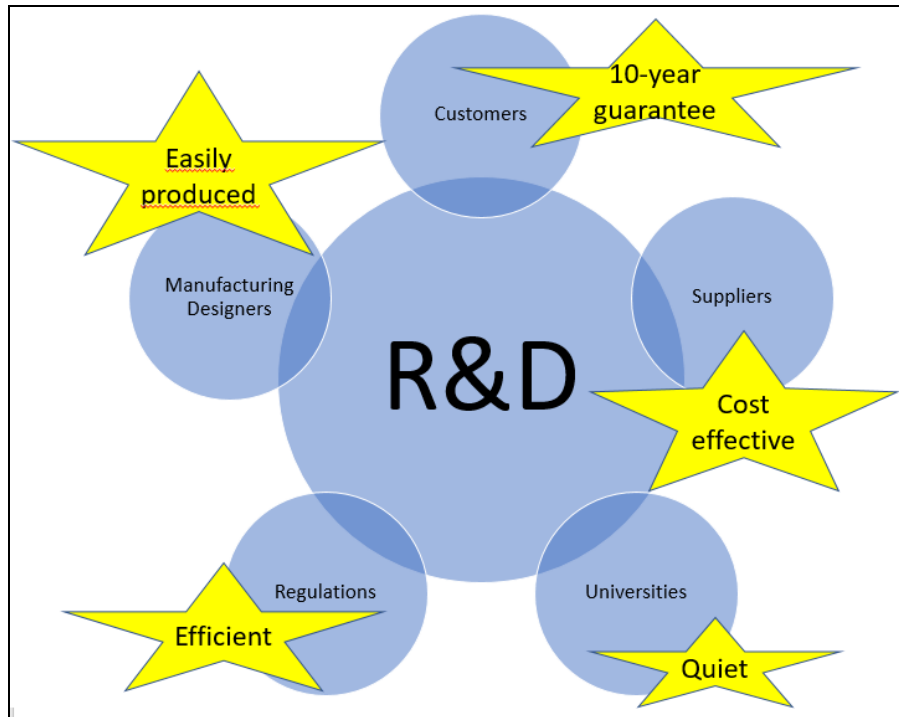


Fig. 10. Collaboration partners and their contributions

As a conclusion, innovation in electric motors will never end up. In order to get better results collaborative innovation has to be supported. This study classifies the success in collaborative innovation by constraint programming. Additionally other intelligent methods can be integrated to have dynamic solution. Behavioral models could improve decisions.

4 Conclusion

Energy that can be used by people is limited and quantity that can be used is decreasing day by day. There are some searches and studies for new energy resources. On the other hand, some group of people are working on efficient use of energy. Electric motors mounted on household appliances are one of the basic energy consumer that is used by many people all around the world. Therefore, in order to decrease energy consumption in houses electric motors are one of the components that should be considered.

In recent years' technology is the main component that brings money to the countries. All big countries try to develop products or services that have low weight with high values. Additionally, life cycle of these products are very short. Therefore, sustainability in innovation is mandatory. Popularity of sharing economies are increasing day by day in all areas. As a mirror of it knowledge sharing through good collaborations are necessary.

Due to shortages in resources collaboration is one of the tool for innovation. Borders are disappearing between people, companies or even countries with the help of worldwide web. As a result of it many technology developer company use collaborations in order to have the best product. Collaboration can be a way of innovation in order to solve a part of a big problem such as energy shortage. Thus efficient products with reasonable prices can be developed.

In this study first of all, innovation is described including open innovation. Importance of collaboration for innovation is described clearly. Afterwards parameters that effect collaboration quality are listed with the help of previous studies and R&D experiences. Moreover, a knowledge management method is suggested to choose the right corporation for better collaborations in order to get innovation. Considering the parameters, artificial intelligence classification is used in order to determine if a candidate is suitable for collaboration. Application of this method created 5 good collaboration. As a result of it, a motor with advantages of efficient, quiet, cost effective, easily produced and 10-year guarantee is designed.

Innovation in electric motors will continue, as it is clear from today's technology. The result will also get more beneficial with lower sources. Therefore in order to get better results collaborations also needed to have higher qualities. Future work for better collaborations may include to get more accurate answers from fewer questions. Additionally, it is clear that next future will be established with the help of collaborations. Therefore methods that define perfect collaborations will be on the table.

References

1. Freitas, S., Mayer, I., Arnab, S., and Marshall I.: Industrial and academic collaboration: hybrid models for research and innovation diffusion. *Journal of Higher Education Policy and Management* Vol. 36 No. 1, 2-14 (2014).
2. <https://hbrturkiye.com/blog/surdurulebilir-kalkinma-liderligi>, last accessed 2020/04/25.
3. Kale, P., Singh, H.: Managing strategic alliances: what do we know now, and where do we go from here? *Academy of Management Perspectives*, 23(3), pages 45-62, (2009).
4. Liu, J., Meng, Z.: Innovation model analysis of new energy vehicles: taking Toyota, Tesla and BYD as an example. 13th Global Congress on Manufacturing and Management, GCMM (2016).
5. Öberg, C., Alexander, A.T.: The openness of open innovation in ecosystems – integrating innovation and management literature on knowledge linkages. In *Journal of Innovation & Knowledge*, pages 1-10 (2018).
6. <https://www.skyrme.com/kmthemes/web2.htm>, last accessed 2020/04/25.
7. Su, Y., Zheng, Z., Chen, J.: A multi-platform collaboration innovation ecosystem: The case of China. *Management Decision*, Vol. 56 No. 1, pp. 125-142 (2018).
8. <https://www.techopedia.com/definition/190/artificial-intelligence-ai>, last accessed 2018/04/17.
9. Worasinchai, L., Bechina, A. A. A.: The role of multinational corporations (MNC's) in developing R&D in Thailand: The knowledge flow between MNC's and University. *Electronic Journal of Knowledge Management* Volume 8 Issue 1 (pp. 171-180) (2010).
10. Zhao, F., Zeng, G.P.: Innovation ecosystem under multiple perspectives. *Studies in Science of Science*, Vol. 32 No.12, pp. 1781-1788 (2014).