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# Competitiveness analysis of automotive industry in Turkey using Bayesian networks

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ABSTRACT

The purpose of this study is to analyze the relations between the factors that enable national competitive advantage and the establishment of competitive superiority in automotive industry through a comprehensive analytical model. Bayesian networks (BN) are used to investigate the associations of different factors in the automotive industry which lead to competitive advantage. The results of the study focus on building a road map for the automotive sector policy makers in their way to improve the competitiveness through scenario analysis. Using the probabilistic dependency structure of the Bayesian network all of the variables in the model can be estimated. Thus, with the proposed model the automotive industry can be analyzed as a whole system and not only in terms of single variables. Findings of the model indicate that technological developments in automotive industry can alter the nature of competition in this industry.


## 1. Introduction

The rising trends in the globalized world are the key factors that make the business environment highly dynamic and competitive (Artto, 1987). This necessitates to focus on the comparative advantage and to build up technological competences for both developed and developing countries. As also emphasized in the UNIDO project of regional Europe (2011), policy makers face increasingly complex issues related to economic, technological, environmental and thus social challenges due to globalization and recent global financial crises. Therefore, they need to have a foresight process in order to see the interrelations among the factors that shape the economy and, thus, identify various development scenarios in face of different policy options.

In order to reveal the competitiveness of a country, different approaches have been used in literature. Each year, selected organizations, such as the World Economic Forum (WEF) and the Institute for Management Development (IMD), apply several hundred objective and subjective indicators to assess the wealth created by the world's nations, and subsequently publish rankings of national competitiveness. These rankings serve as benchmarks for policy-makers and other interested parties into judging the competitive success of their country within a global context. The IMD jointly with the WEF has produced listings of national competitiveness in their annual World Competitiveness Yearbook since 1989 (Sala-i-Martin & Artadi, 2004).

The WEF uses three indices to analyze nations' competitiveness levels from both macroeconomic and microeconomic perspectives. The Growth Competitiveness Index (GCI), developed by McArthur and Sachs (2001) and Blanke and Lopez-Claros (2004) is based on critical and, for the most part, macroeconomic environmental factors that influence sustained economic growth over the medium to long-term. More recently, the Global Competitiveness Index (Blanke & Lopez-Claros, 2004) was designed to help unify the GCI and BCI, and may eventually replace them in the Global Competitiveness Reports.

Global Competitiveness Index (GCI) of the World Economic Forum (WEF) is generally recognized by many countries in correctly defining competitiveness and measuring countries competitive strengths. Based on this index, released every year, in its Global Competitiveness Report, WEF measures the competitiveness of countries, providing a source of data for all sides concerned, including public and private sectors, with which they can work and create policies.

When Turkey's trend in terms of relative competitiveness is analyzed through consecutive WEF reports (2005, 2006, 2007, 2008, 2009, 2010), it can be seen that, with a significant improvement in competitive performance, Turkey moved up 18 places in the 2007–2008 Global Competitiveness Index ranking of the World Economic Forum. Turkey not only surpassed Bulgaria and Romania who became members to the EU during its 2007 expansion, but also ranked higher than Greece, Cyprus, and Malta which had joined earlier. Similarly, during the same period, Turkey also outranked two of the BRIC members, namely, Russia and Brazil. Therefore, it was believed that political reforms following the 2001 economic crisis were bearing fruit. However, the improvement in question was replaced by a dramatic fall in the 2008–2009 report where Turkey slipped down 10 places, only managing to be ranked the 63rd (Sala-i-Martin et al., 2008) (Table 1).

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**Table 1**
Turkey's rank in GCI.

| Year | Total number of countries | Turkey's rank |
|---|---|---|
| 2007 | 131 | 53 |
| 2008 | 134 | 63 |
| 2009 | 133 | 61 |
| 2010 | 139 | 61 |
| 2011 | 143 | 59 |

Turkey moved up two places in the 2009–2010 GCI thanks to a balanced performance (Sala-i Martin, Blanke, Hanouz, Geiger, & Mia, 2009). The 2010–2011 report indicates that Turkey has retained its ranking at 61. It has been pointed out that Turkey needs to intensify local competition, improve infrastructure for ports and electricity supply despite having built reasonably advanced infrastructure for roads and air travel, improve human resources through improved primary education and health systems, cut down inefficiencies in labor markets and to increase efficiency and transparency of public institutions (Sala-i Martin, Blanke, Hanouz, Geiger, & Mia, 2010).

In 2011–2012 report, however, Turkey again improved her rank and became 59th through 143 economies analyzed (Sala-i-Martin, Bilbao-Osorio, Blanke, Hanous, & Geiger, 2011).

In global competition, technological infrastructure, education system, public-private sector relations and economic policies are all integrated. Therefore, in dynamic markets where time becomes ever more significant, the success of businesses looking to gain competitive advantage depends on their ability both to perceive the changes around them and also to adapt to those changes in the short term. Success in an intensively competitive environment requires businesses to reduce production costs, improve quality and take the necessary steps to exceed customer expectations. However, as traditional competition becomes global, businesses fail to take the required measures on their own to become more competitive. Hence, in a globally competitive environment, national improvement has also become vital. In a country where an environment that will enable international competition has not been established, sector-based competitiveness is bound to be limited and obstacles emerge which undermine the protection and maintenance of this competitiveness. In international competition, dynamic and competitive management strategies of companies alone cannot sufficiently improve their chances. Therefore, businesses need to utilize and be supported by countries international competitiveness.

In Turkey, a part of the Turkish market in labor intensive sectors has been lost to Asian economies rising due to cheap labor. Also in capital intensive sectors Turkey has lost a part of its market to countries like Poland, Czech Republic, Slovakia, Romania and Hungary, the new members of the EU (EU-12 countries). These losses happened particularly in capital intensive markets such as the automotive industry where direct foreign investment has shifted from Turkey to EU-12 countries recently. In order to get a complete look of the current state of the Turkish automotive industry and to prevent further losses, reasons for these losses need to be explored and exclusively designed long-term industrial and export strategies need to be implemented.

In this paper, automotive industry is selected as the target sector to foresight its future developments that might occur in Turkey in face of competitiveness. Hence, this research should act as a guide to decision makers on analyzing the essential factors in automotive industry to achieve sustainable competitive advantage. The main reason behind the choice of the automotive industry is that it is one of the leading industries in all industrialized countries. The reason for the driving-locomotive effect of this industry is that it is closely related to other industries in the economy. Automotive industry is the main buyer of iron-steel, petrochemical, and tires industries and the driving force behind the technological development in these industries. All kinds of motor vehicles needed by the tourism, infrastructure, transport and agriculture industries are produced by this sector. Therefore, any changes in the industry deeply affect the economy as a whole. The world's automotive industry, with around 70 million units yearly production is essential to the working of the global economy and is an important contributor to the well being of the societies. The automotive production chain has a strategic role in Czech Republic, Poland, Slovakia and Turkey on economic basis regarding its contribution to the national production and industrial development, employment (direct and indirect), and the level of technology enhancement.

The model developed in this study takes into account the variables used in comparison of the countries by WEF. A preliminary version of this model is prepared for a report sponsored by Automotive Manufacturer Association-OSD, TÜSİAD-Sabancı University Competitiveness Forum-REF and Federation of Industrial Associations-Sedefed (Ulengin, Onsel, Aktaş, & Kabak, 2010)

The second section analyses the current situation of the automotive sector in Turkey. The third section explains the steps of the proposed model as well as the guide map derived from it for the Turkish Automotive Industry. Finally conclusions and further suggestions are given.

## 2. Automotive industry in Turkey

Automotive Industry Strategic Report (2010) prepared by the Ministry of Industry of Turkey urges that in its present state the automotive industry, which is sensitive to global developments, does not promise a more competitive future. For that reason, under the conditions of global competition and considering the positive support provided to this industry in competing countries, there is an urgent need of support to the automotive industry in order to facilitate the necessary demand transfer in Turkey.

With the global financial crisis losing effect, determination and implementation of an automotive industry strategy is even more significant if the Turkish Automotive Industry is to benefit from post-crisis opportunities. This strategic report analyses the present situation, researches the problems and determines the action plan for those problems, predicts when and how this action plan is to be carried out and investigates how the present situation is expected to evolve.

A study of monthly reports of Turkish Exporters Assembly (TİM) (2011) reveals that Turkey's production levels in food, textiles, clothing, leather goods, chemicals, plastics, machines, and electrical machines have already exceeded June 2008 production figures and are back to pre-crisis levels. Two main industries that have failed to reach pre-crisis levels are automotive and base metal industries. In the period September 2009–March 2010, there are four countries (India, Romania, South Africa, and Taiwan) in the automotive sector who managed to push exports to pre-crisis levels. At this time period, Turkey's export was 23% behind compared to the pre-crisis figures (Turkish Exporters Assembly (TIM), 2010). However, according to Turkish Exporters Association (TIM), the sector – including motor vehicles, parts and accessories – generated $5.1billion export revenue, which indicated 12% expansion, and captured 16.1% share in Turkey's overall exports in 3M11. The sector is also at the top in March-only performance, with a share of 16.7%. In first three months of 2011 automotive sector export boosted by 5%, to 213,503 units. The growth in the export mainly stemmed from a hike in the commercial vehicles. Commercial vehicles depicted 9% growth, while passenger car export recorded meager increase as 2%. Despite these improvements, the automotive sector does not seem to reach its pre-crisis level in 2011.

Among the reasons for this is the fact that the commercial vehicles segment, which makes up most of Turkey's motor land vehicles exports, was excluded from the incentives package by the EU and that the contraction in investment has a greater influence on the commercial vehicles segment.

The detailed Strengths – Weaknesses – Opportunities – Threats (SWOT) analysis carried out within the Turkish Automotive Industry Strategic Report (2010) has determined seven basic policy priorities, namely, (a) improve Research and Development Infrastructure, (b) enhance design, production, branding abilities and capacities of businesses, (c) improve the effectiveness both in domestic and foreign markets, (d) improve legal and administrative regulations, (e) improve physical infrastructure, (f) improve human resources, (g) work on domestic provision of necessary raw materials.

As clearly seen, most of the above mentioned policies are in harmony with the policies suggested by CARS 21 report (CARS 21, 2006, http://ec.europa.eu/enterprise/sectors/automotive).

As a result of the global crunch, in Turkey, the market share in labor intensive sectors has been lost to Asian economies rising due to cheap labor, and in capital intensive sectors such as the Automotive Sector to the new members of the EU (EU-12 countries) such as Poland, the Czech Republic, Slovakia, Romania, and Hungary. These losses materialized in capital intensive markets have been due to the fact that direct foreign investment that previously found its way to Turkey has recently shifted to EU-12 countries. With the economic crisis waning, the shift in European Union's export demand toward non-EU countries should be considered as an opportunity for Turkey in general and the Turkish Automotive Industry in particular. Hence, the right and effective policies should be implemented in order to grasp this opportunity without any delay. Factors that will ensure competitive advantage have to be determined and long-term competitive strategies need to be implemented through a model which will investigate the reasons for these losses. The Bayesian network model proposed in this study is prepared for that purpose.

## 3. A Bayesian network model for the automotive industry

A Bayesian network (BN) is a directed acyclic graph where nodes represent the variables and the arcs represent the conditional dependencies between the variables. If there is a directed arc from a variable $X_1$ to a variable $X_2$, then we call $X_1$ as the parent of $X_2$ and $X_2$ as the child of $X_1$. As given in Eq. (1), each variable in a Bayesian network $X_1, \ldots, X_N$ possess a probability distribution given its parents and the product of these conditional probability distributions constitute the joint probability distribution of the network

$$P(X_1, \ldots, X_N) = \prod_{i=1}^{N} P(X_i | Pa(X_i)) \tag{1}$$

where $Pa(X_i)$ denotes the set of parents of $X_i$. In table based BN the probabilistic part of the BN is represented by the conditional probability tables of each of the variables.

The purpose of this study is to analyze the effect of and the relations between the factors which determine a country's international competitive superiority in case of the automotive industry. A wide variety of different factors play a role in a firm's capability to attain competitive advantage. However, as discussed in the previous section, sector-based competitiveness is bound to be limited without an environment that will enable international competition. It is for that reason that businesses need to utilize and be supported by countries' international competitiveness. The evaluation of countries' international competitiveness is not an easy job for two main reasons: First of all there exists a wide domain of different variables which do have an effect on the international competitiveness. The variables to be considered for the evaluation should be based on the specific industry and the expert knowledge for the field. The second and the most important concern, is because of the fact that the variables to be analyzed do jointly represent the international competitiveness of a country. For that reason, methods for the analysis which force the selection of one or more dependent variables and limit the estimation for these variables only deteriorate both the quality of the model and also validity of the findings. In that instance BNs are the ideal candidates for the analysis since in a BN using the probabilistic dependency structure of the network, all of the variables in the model can be estimated.

Though predominantly used in the decision making context, BNs are also used for data mining purposes, especially after BN learning algorithms for creating BN from data were available. There exist a growing interest for BN, and Friedman, Goldszmidt, Heckerman, and Russell (1997) attributes this to semantic clarity and understandability of BNs by humans, the ease of acquisition and incorporation of prior knowledge, and the ease of integration with optimal decision-making models. Furthermore, (Lauría & Duchess, 2007) refers BN as probabilistic engines that can answer queries, or perform "what-if" analyses, about the variables in a network.

The objective of this study is to facilitate the selection and prioritization of policies to be followed in order to improve the Turkish automotive industry. For that purpose BN are used to investigate the associations of different factors which influence the competitive advantage in the automotive industry. To identify the factors that have an effect on the future of automotive industry, an online survey was conducted to a wide spectrum of participants, including members of automotive industry associations, suppliers, distributors and authorized dealers involved in the supply chain, a select group of related bureaucrats, press-media members, finance and private research institutions, and academics. Through the survey the participants were asked to assess the importance of 111 concepts (components) used in the World Economic Forum's Global Competitiveness Report in terms of their relationship to the automotive industry on a scale of 1 to 10. Variables that scored 8.5[1] and higher in the survey were decided to feature in the model. According to the results of the survey, based on the main pillars that they appear in, 15 variables were agreed upon as crucial to form competitive advantage in the automotive industry. The list of the variables selected according the survey results and the main pillars they appear in can be seen in Table 2 below.

In addition to the variables listed, in a meeting held for the assessment of survey results by the top executives from SEDEFED, REF and OSD three more variables were evaluated as crucial for the automotive industry. These additional variables, agreed to be included to the final model, are as follows: "Domestic automotive market size" (no of vehicles per 1000 people), "Automotive foreign market effectiveness" (Export competitiveness index) and "Automotive production process sophistication" To digitize the concept of automotive production process sophistication, "Revealed comparative advantage" (RCA), suggested by the State Planning Organization (Ministry of Industry, 2010) was used here. This value is calculated by dividing the share of an industry exports in total exports of the country by the share of that industry exports in total world exports.

$$\mathrm{RCA} = \frac{[(\text{Exports of automotive industry in the country})/(\text{total exports of the country})]}{[(\text{Exports of automotive industry in the world})/(\text{total exports of the world}]} \tag{2}$$

The RCA values work as an indicator of the experience level of the country of interest, with higher RCA values suggesting a country's superior experience in imports for that particular industry.

[1] The cutoff point, 8.5, is decided based on the consensus of the top executives from SEDEFED, REF and OSD.

**Table 2**
List of the variables selected from WEF Report (2011) through the survey results and their respective pillars.

| Pillars | Number of subcomponents | Variables selected according the survey results |
|---|---|---|
| Institutions | 19 | – |
| Infrastructure | 8 | – |
| Macroeconomic environment | 5 | – |
| Health and primary education | 11 | – |
| Higher education and training | 8 | – |
| Goods market efficiency | 15 | • Extent and effect of taxation<br>• Total tax rate<br>• Degree of customer orientation |
| Labor market efficiency | 9 | – |
| Financial market development | 9 | • Ease of access to loans |
| Technological readiness | 9 | • Firm-level technology absorption<br>• Availability of latest technologies<br>• Domestic market size |
| Market size | 2 | • Index foreign market size index<br>• Local supplier quality |
| Business sophistication | 9 | • Production process sophistication<br>• Availability of scientists and engineers<br>• Capacity for innovation |
| Innovation | 7 | • Company spending on R&D<br>• Quality of scientific research institutions<br>• University-industry collaboration in R&D |

For all of the other variables, the data provided from WEF report is used. The final data set used to learn the BN constitute of the 3 years data for the 28 countries selected. These countries are automotive manufacturer countries in terms of global automotive market. The list of the countries contributing to the data set is given in Table 3 above.

To learn the associated Bayesian network with these 18 variables the data is first transformed into a form where the ratings of each variable are classified into three main states as low, middle and high. WinMine (Heckerman, Chickering, Meek, Rounthwaite, & Kadie, 2000), a tool developed by Microsoft Research, is used to learn BN. Using WinMine the data is divided into a training and a test set. In our model we performed a 70/30 percent train/test split. In the training case the dependency structure of the BN is learnt considering also the constraints for the variables defined by the user. In this research all of the variables in the model are used as input and output variables (both predicted and used to predict). During the learning case, a factor called kappa is used to set the granularity of the Bayesian network. The values of kappa range between 0 and 1. As kappa approaches closer to 1 the model become denser. Since we want to see the whole dependency structure between the variables, the kappa factor was determined to be 1.0. The Bayesian network learnt on the training set is tested using the test data where the accuracy of the learned model was evaluated using the log score. Log-score is a quantitative criterion to compare the quality and performance of the learned BNs. The formula for calculating the logscore is given as follows

$$Score(x_1,\dots,x_N) = \sum_{i=1}^{N} \log_2 p(x_i|\text{model})/nN, \tag{3}$$

where $n$ is the number of variables, and $N$ is the number of cases in the test set. Our model results in a log score of $-0.417334$, meaning on average, the log probability that each variable assigns to the given value in the test case, given the value of other variables, is 74.8807%. Using WinMine we can also compare the difference between the log scores of the provided model and the marginal model. A positive difference is desired signifying that the model out-performs the marginal model on the test set. In the same way that a regression model is more accurate than a simple baseline model chosen in the form of a mean dependent value, the "lift over marginal" log-score provides information on how well the model fits the data (Scuderi & Clifton, 2005). In our model we obtained a lift over marginal log score of 0.653831, meaning that the improvement rate we obtained with the provided model compared to the marginal model is about 27.2873%. Accordingly, the results indicate that the provided BN model in this study outperforms the marginal model, signifying that the BN created effectively represents the dependency relations of fundamental factors of competitiveness in the automotive industry. The learned BN using WinMine is given in Fig. 1 below.

**Table 3**
The list of 28 countries that contributed input to the Bayesian network.

| | | | |
|---|---|---|---|
| Austria | France | Korea | Slovak Republic |
| Belgium | Germany | Mexico | Slovenia |
| Brazil | Hungary | Netherlands | Spain |
| Bulgaria | India | Poland | Sweden |
| Canada | Indonesia | Portugal | Turkey |
| China | Italy | Romania | UK |
| Czech Rep. | Japan | Russia | USA |

As the next step of our research we created the same Bayesian network this time using the Netica software. This way we will be able to enter evidence for variables and observe the change in the posterior probabilities consequently. The BN created using the Netica software and the marginal probabilities of the variables in the network can be seen in Fig. 2 below.

In addition to what-if analysis, sensitivity analysis can also be performed in Netica, which allows us to identify the variables which affect the target variable at most. The results of the sensitivity analysis for each variable along with the top three variables influencing each variable at most are given in Table 4 below. Two pieces of information is provided in this table: Variance reduction and variance of beliefs. Variance reduction is the expected reduction in the variance of the output variable due to the value of an input variable. The variable with the greatest variance reduction rate is expected to be the one to alter the beliefs of the target variable at most. An indication of the uncertainty surrounding this estimate is variance of beliefs.

A detailed analysis of Table 4 shows the following: Suppose that the objective is to analyze "automotive domestic market size" and see what should be done in order to increase the current status of this variable in a country. Looking to Table 4, we see that with 14% variance reduction rate "Production process sophistication" is the variable which is expected to alter the beliefs of the "automotive domestic market size" at most. Thus, between all the variables in the network a finding in the variable "Production process sophistication" would have the greatest impact on "automotive domestic market size". Sensitivity analysis results declare that "local supplier quality" is the most informative variable in crystallizing the status of "production process sophistication".

And again from the Table 4, it can be seen that "Degree of customer orientation" is the variable that greatest impact on the "local supplier quality" variable. As a result, it can be said that, although there isn't a direct relationship between "Degree of customer orientation" and "automotive domestic market size" an increase in "Degree of customer orientation" leads to considerable growth in "automotive domestic market size". This case is illustrated in

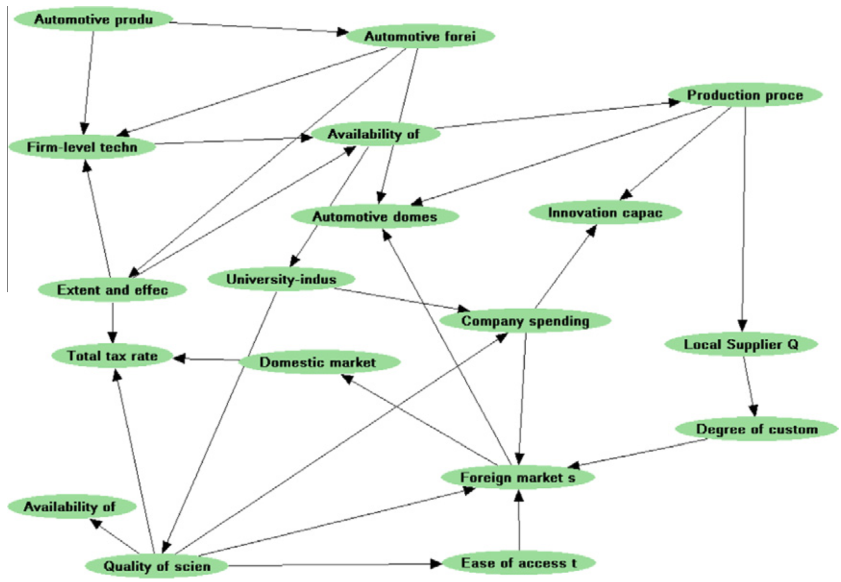


**Fig. 1.** Table based BN learned from data using WinMine.

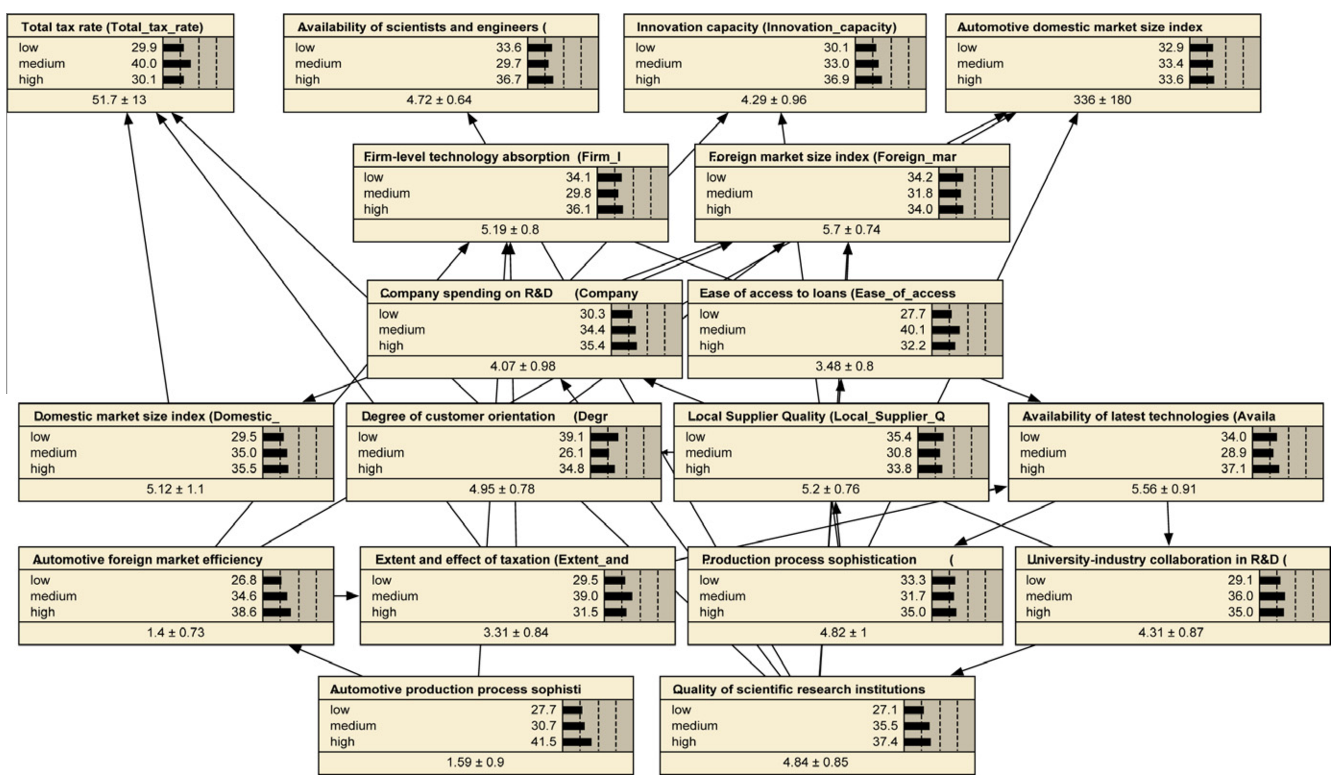


**Fig. 2.** The Bayesian network created using Netica.

Fig. 3 and 4 below where the state of "Degree of customer orientation" is first identified as "low" and then as "high" consequently. Accordingly the posterior probabilities of all the variables in the network can be observed. Notice that having high degree of customer orientation instead of low, increases the probability of having a "high" automotive domestic market size from 28% to 41.9%.

Looking at Table 4 above to variance reduction rates in particular, one can question the wide range of variance reduction rates which goes from 1.79% to until 76.9%. First of all notice that, in this table only the top three variables with the highest reduction rates are given, so the actual lower limit is 0. Secondly, variance reduction is only a measure to evaluate the impact of other variables on a selected target node. That the variance reduction rates for a target variable, is lower than the other variables' rates is only an indication of the low dependency structure of the target variable compared to the other ones. Evaluating the network, on the other hand, is done using the logscore and the lift over marginal scores which give numerical criteria about the performance of the provided network model as a whole.

**Table 4**
Sensitivity of the variables in the model due to a finding at another variable.

| Target node | Top 3 variables influencing the target variable at most | Variance reduction (%) | Variance of beliefs |
|---|---|---|---|
| Automotive domestic market size index | Production process sophistication | 14 | 0.018 |
| | Local supplier quality | 9.12 | 0.013 |
| | Availability of latest technologies | 8.61 | 0.012 |
| Automotive foreign market efficiency | Automotive production process sophistication | 59 | 0.12 |
| | Firm-level technology absorption | 9.06 | 0.01 |
| | Availability of latest technologies | 6.33 | 0.01 |
| Automotive production process sophistication | Automotive foreign market efficiency | 58 | 0.12 |
| | Extent and effect of taxation | 1.84 | 0.003 |
| | Firm-level technology absorption | 1.79 | 0.02 |
| Availability of latest technologies | Firm-level technology absorption | 76.9 | 0.022 |
| | Production process sophistication | 71.3 | 0.19 |
| | University-industry collaboration in R&D | 53.8 | 0.10 |
| Availability of scientists and engineers | Quality of scientific research institutions | 58 | 0.12 |
| | University-industry collaboration in R&D | 41.6 | 0.14 |
| | Company spending on R&D | 39.9 | 0.07 |
| Company spending on R&D | Quality of scientific research institutions | 67.8 | 0.19 |
| | Innovation capacity | 61.6 | 0.17 |
| | University-industry collaboration in R&D | 60.8 | 0.12 |
| Degree of customer orientation | Local supplier quality | 75 | 0.19 |
| | Production process sophistication | 57.7 | 0.12 |
| | Availability of latest technologies | 43.3 | 0.07 |
| Domestic market size index | Foreign market size index | 75.7 | 0.21 |
| | Total tax rate | 7.9 | 0.01 |
| | Company spending on R&D | 7.06 | 0.01 |
| Ease of access to loans | Quality of scientific research institutions | 12.9 | 0.014 |
| | University-industry collaboration in R&D | 8.79 | 0.01 |
| | Company spending on R&D | 8.78 | 0.01 |
| Extent and effect of taxation | Total tax rate | 9.28 | 0.02 |
| | Automotive foreign market efficiency | 7.34 | 0.01 |
| | Firm-level technology absorption | 4.59 | 0.01 |
| Firm-level technology absorption | Availability of latest technologies | 76.8 | 0.21 |
| | Production process sophistication | 55 | 0.11 |
| | University-industry collaboration in R&D | 41.7 | 0.07 |
| Foreign market size index | Domestic market size index | 75.8 | 0.22 |
| | Company spending on R&D | 9.37 | 0.01 |
| | Quality of scientific research institutions | 7.18 | 0.01 |
| Innovation capacity | Company spending on R&D | 61.6 | 0.17 |
| | Production process sophistication | 56.2 | 0.12 |
| | University-industry collaboration in R&D | 54.7 | 0.10 |
| Local supplier quality | Degree of customer orientation | 73.9 | 0.19 |
| | Production process sophistication | 73.6 | 0.19 |
| | Availability of latest technologies | 55.1 | 0.10 |
| Production process sophistication | Local supplier quality | 73.9 | 0.196 |
| | Availability of latest technologies | 73.6 | 0.185 |
| | Degree of customer orientation | 57 | 0.11 |
| Quality of scientific research institutions | University-industry collaboration in R&D | 71.8 | 0.19 |
| | Company spending on R&D | 67.3 | 0.18 |
| | Availability of scientists and engineers | 58.9 | 0.11 |
| Total tax rate | Extent and effect of taxation | 13.9 | 0.018 |
| | Domestic market size index | 7.48 | 0.008 |
| | Foreign market size index | 5.92 | 0.005 |
| University-industry collaboration in R&D | Quality of scientific research institutions | 71.4 | 0.195 |
| | Company spending on R&D | 60.4 | 0.116 |
| | Availability of latest technologies | 58.4 | 0.09 |

Conducting a similar analysis for the variable "Automotive foreign market efficiency" we see the following: The variable with the greatest variance reduction rate for "Automotive foreign market efficiency" is "Automotive production process sophistication" and vice versa the variable with the greatest impact on "Automotive production process sophistication" is "Automotive foreign market efficiency". A more detailed look to Table 4 indicates the following: "Firm-level technology absorption" is the second variable with the highest variance reduction rate for target variable "Automotive foreign market efficiency". For "Firm-level technology absorption" on the other hand the variable with the highest variance reduction rate is "Availability of latest technologies" which is also the third biggest influencer for the variable "Automotive foreign market efficiency". Looking to the BN created on the other hand we notice that there is no arc between these two variables. That the variable "Availability of latest Technologies" is listed as one of the most influencer variables on "Automotive foreign market efficiency" is because of the fact that there exists a serial connection between the variables "Automotive foreign market efficiency", "Firm-level technology absorption" and "Availability of latest Technologies" in the order given. Consequently, unless the state of the middle variable ("Firm level technology absorption" in this example) is known the flow of information is allowed, meaning that any changes made in the parent variable (Automotive foreign market efficiency) or its descendant (Availability of latest Technologies) would affect the other one. As illustrated in Figs. 5 and 6 given below an increase in "Availability of latest technologies" leads to considerable growth in "Automotive foreign market efficiency".

As another case assume that one wants to see the effects of "Availability of scientists and engineers", "Degree of customer orientation" and "University-industry collaboration in R&D" on the automotive sector related variables. As it can be seen from Figs. 7

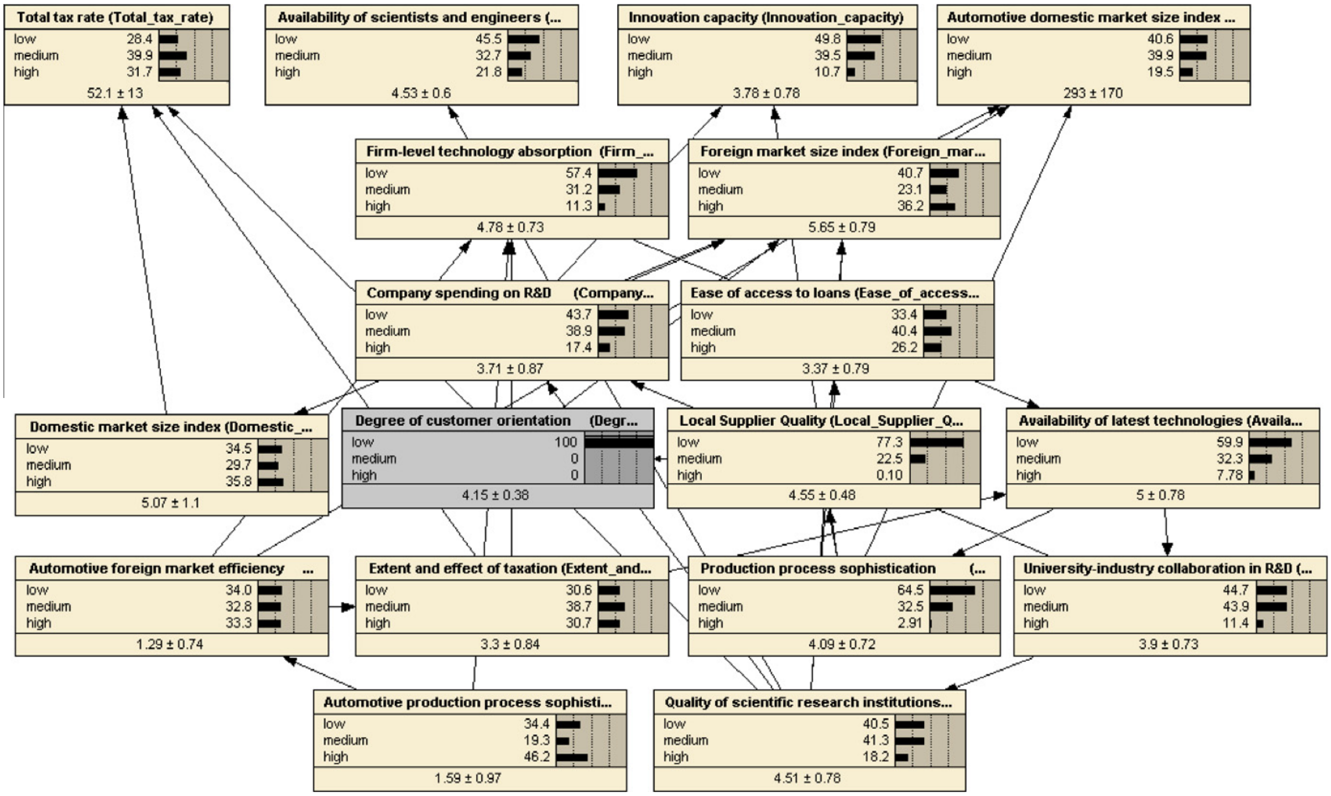


**Fig. 3.** The updated BN when "Degree of Customer Orientation" is observed as "low".

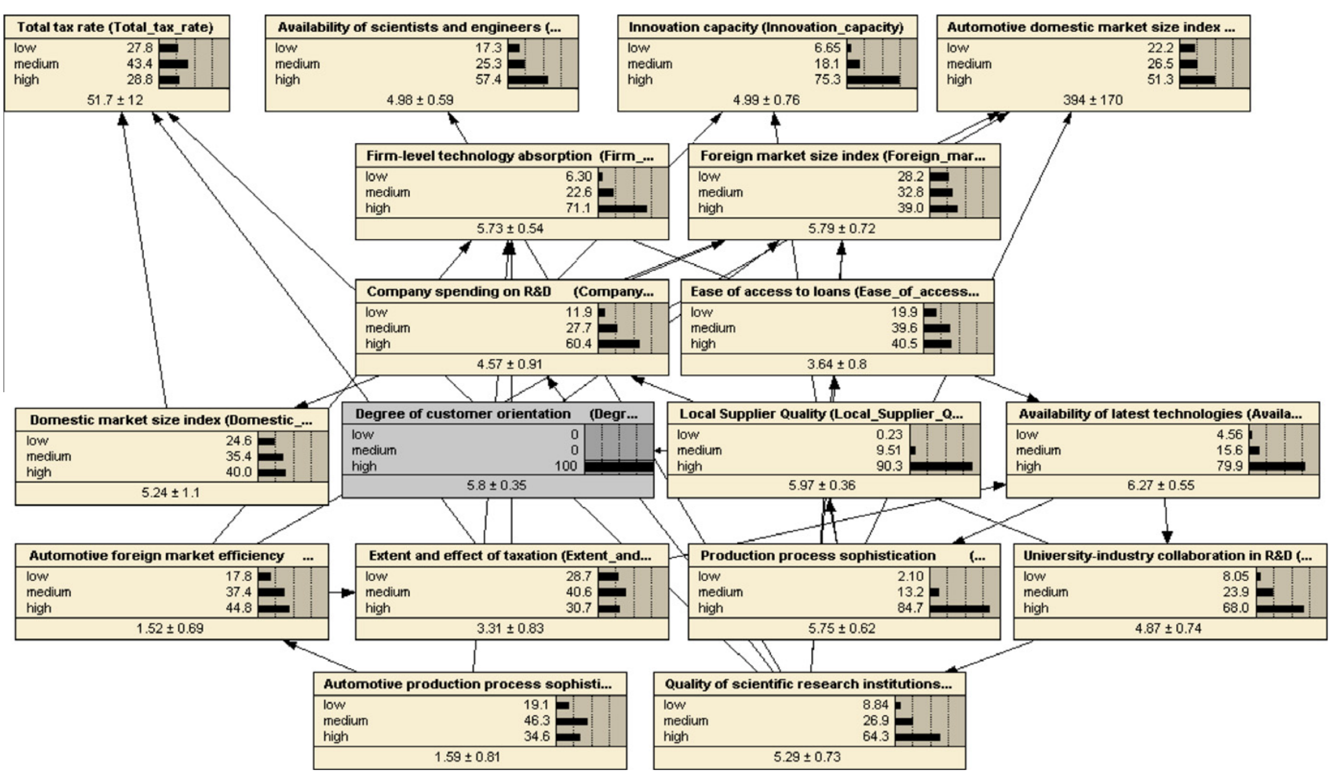


**Fig. 4.** The updated BN when "Degree of Customer Orientation" is observed as "high".

and 8, just one level increase in the above mentioned 3 variables (from low to medium) will utterly raise the levels of "Automotive domestic market size index", "Automotive foreign market efficiency" and "Automotive production process".

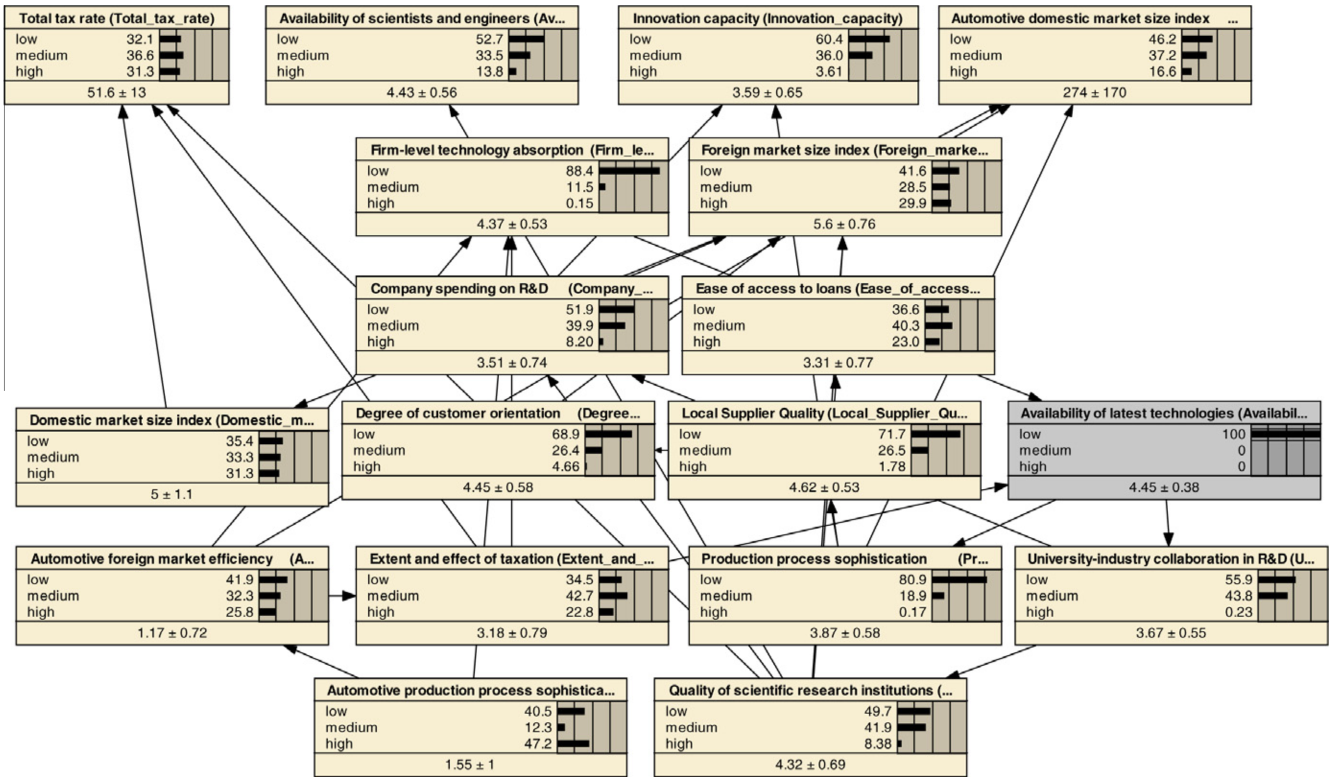


**Fig. 5.** The updated BN when "Availability of latest technologies" is observed as low.

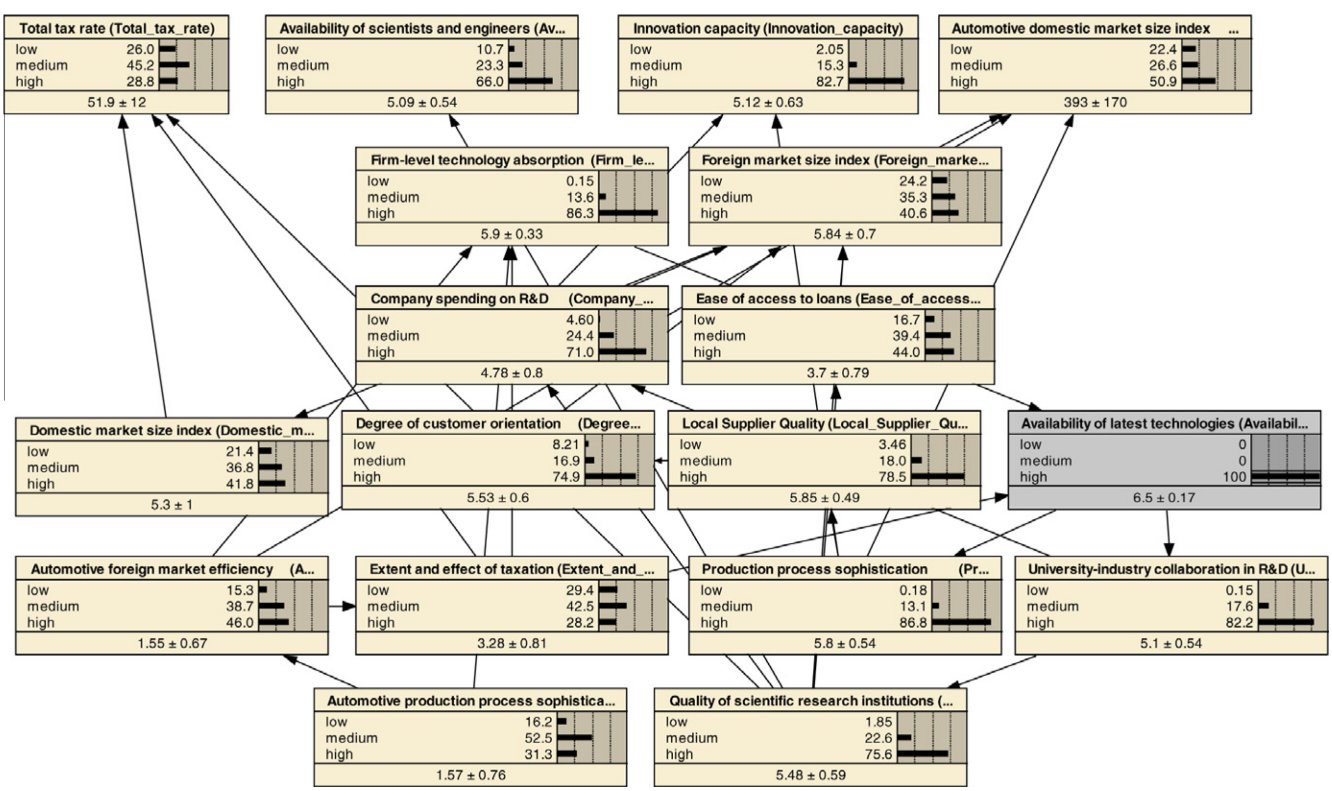


**Fig. 6.** The updated BN when "Availability of latest technologies" is observed as high.

Findings of the model indicate that technological developments in automotive industry can alter the nature of competition in this industry. Competitiveness of businesses in technology-developing countries is comparatively higher than that in countries that buy such technologies. With the proposed method, probability relations between the states of the world have been analyzed. A similar methodology is aimed to be built for different sectors.

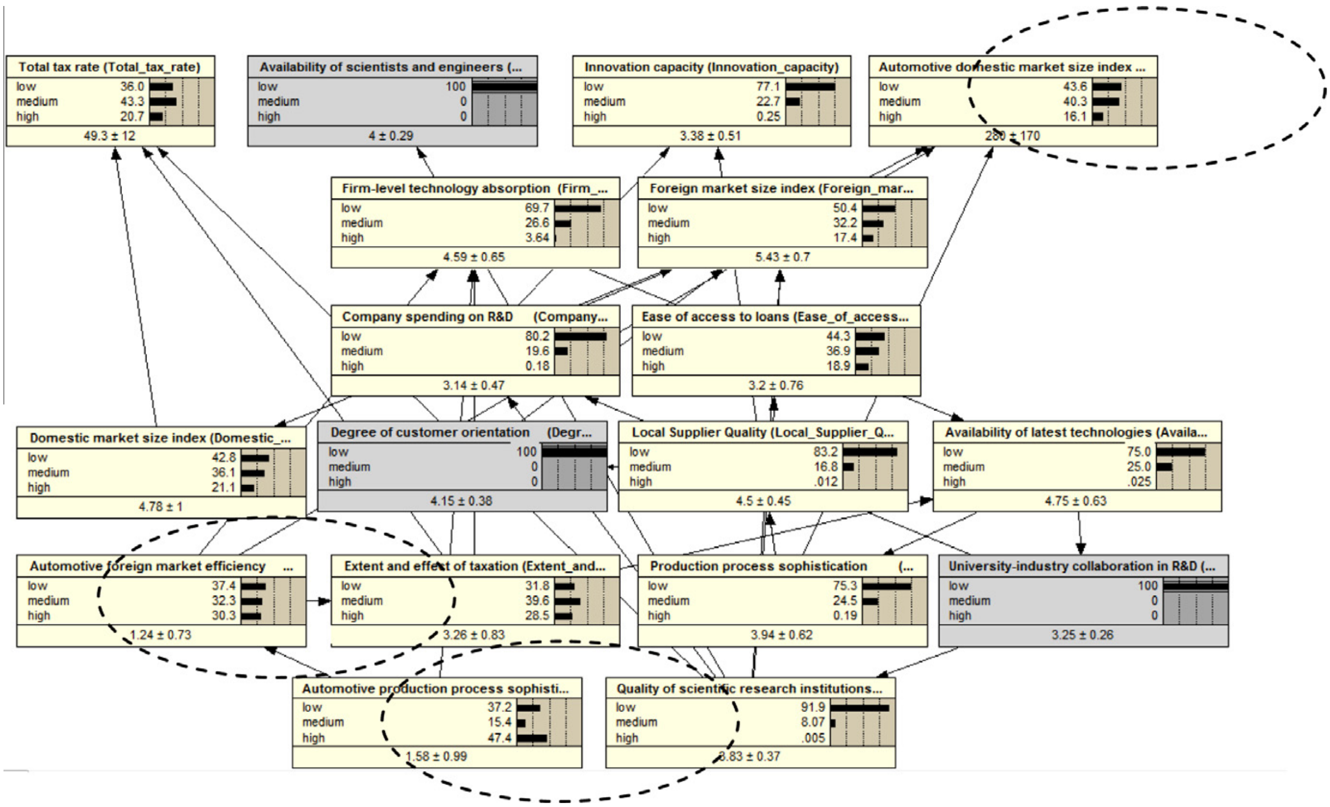


**Fig. 7.** The updated BN when "Availability of scientists and engineers" = low, "Degree of Customer Orientation" = low, "University industry collaboration in R&D" = low.

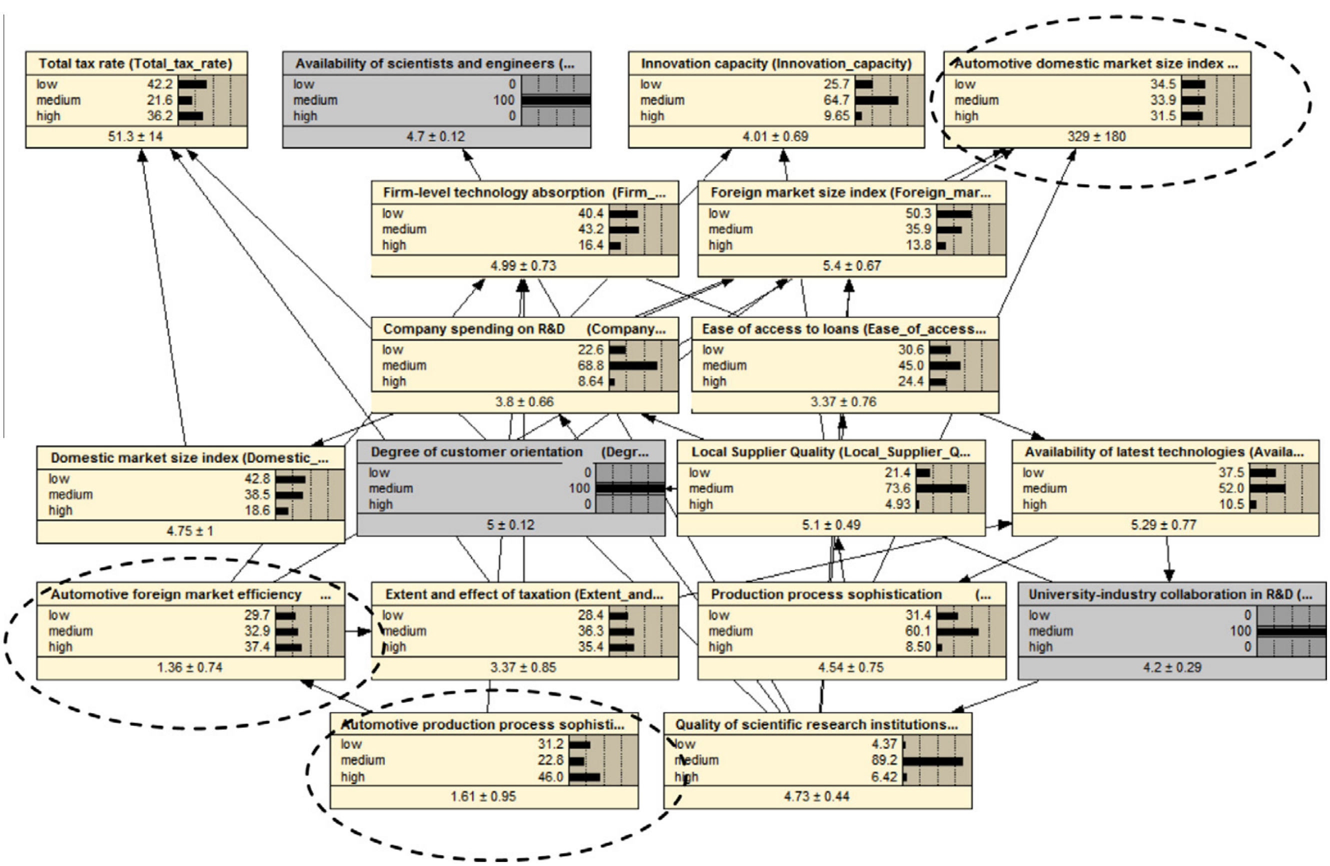


**Fig. 8.** The updated BN when "Availability of scientists and engineers" = medium, "Degree of Customer Orientation" = medium, "University industry collaboration in R&D" = medium.

## 4. Conclusion and recommendations

The world has entered a very significant period of change. Importance of economic, political, technological, socio-cultural, ecological and demographic changes has been growing, and the success of any industry in a country is no longer possible through that industry's own means and has grown more closely associated with that country's global competitiveness.

The model in this study has been constructed in order to determine to what extent the factors of global competition would affect the automotive industry's competitiveness in particular.

Automotive industry is extremely significant and strategic with its high value added, high employment, competitive nature, many technologies that it employs and its multiplier effect on the technological development of the country. Therefore, special attention must be given to the automotive industry.

The results of the study focus on building a road map for automotive sector competitiveness through scenario analysis. To achieve this, several analyses can be conducted similar to the ones that have been done in the previous section. Besides, the model helps us to analyze the model not only in terms of single variables but as a whole. That is, the effect of several variables can be analyzed also.

According to results, the efficiency of automotive sector in a country depends basically on the levels of local supplier quality, availability of latest technologies and firm–level technology absorption in that country. As can also be seen in the analysis conducted in the previous section, although the availability of latest technologies, for example, has an indirect effect on automotive related variables, it plays a basic role in increasing the level of efficiency of the sector.

This proposed model is expected to reduce the uncertainty about the relation between national competitive advantage and the establishment of competitive superiority in automotive industry. The decision makers, as a result of a detailed analysis, will be able to analyze very easily the impact of any policy that they are planning to adopt over the automotive sector.

As a further suggestion, this analysis should be repeated each year in order to see the results of the policies as well as the changes in the perceptions of experts. Additionally, this analysis should be expanded to other important sectors in order to provide a guide on how to increase their comparative advantage.

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