Chapter 7 Economic impact of the automotive sector in the eastern region of the state of Tlaxcala

Capítulo 7 Impacto económico del sector automotriz en la región oriente del estado de Tlaxcala

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Abstract

The installation of the automotive assembly plant AUDI in 2016 and the companies that are integrated into this supply chain in the eastern region of the state of Tlaxcala, generate an economic impact, directly benefiting seven Tlaxcala municipalities. The innovative aspect of the study is the generation of a model using Bayesian networks, which allows visualizing the growth and development of the different sectors in the eastern area of Tlaxcala, taking into account the analysis of the variables: economic units, employed personnel, remunerations, investment, income and total gross product, which they infer in the economic branches of twelve sectors of commerce and services that develop activities in the municipalities of interest. This investigation allowed to know the opportune and profitable economic turns for its growth based on the determined needs.

Automotive, Economic Growth, Prediction, Bayesian Networks

1. Introduction

The economic growth of a region is linked to various factors ranging from its geographical location to the ethnic origin of its population. One of them, which depends directly on the governmental instances, is the diffusion of the industrial activity in the regions that present social and economic backwardness. In the last three decades the government of the state of Tlaxcala has adopted promotion strategies that allowed an intense process of industrialization. According to the Secretarìa de Economìa (SE, 2015), in 2014 Mexico ranked as the seventh producer of vehicles at the international level and the first place in Latin America. The production and export of light and heavy vehicles set a new historical record in the country at the end of that year. The automotive sector in Mexico is driven by the presence of vehicle assembly companies such as: BMW, Chrysler, Ford, General Motors, Honda, Mercedes-Benz, Nissan, Toyota, Volkswagen and Volvo; In total there are 24 productive complexes in the country in 14 states, in which activities ranging from assembly and armoring to the casting and stamping of components for vehicles and engines. Currently, Mexico produces more than 40 models of cars and light trucks. Most of the assembly companies in Mexico have auto parts companies that are located around their vehicle plants to meet the requirements of supply and delivery times.

At the beginning of 2012, the automotive and auto parts industry announced its plans to expand in Mexico. The government of the state of Tlaxcala considered that the establishment of this type of companies benefits the entity and forces to create poles of development in diverse sectors to cover the needs that are generated (González, 2013). The objective of the present investigation was to project the economic growth of the eastern area of the state of Tlaxcala, through analysis through Bayesian networks of the variables: economic units, employed personnel, remunerations, investment, income and total gross product, which infer in the economic branches of twelve sectors of commerce and services that develop activities in the eastern area of Tlaxcala.

The study carried out has a quantitative and correlational approach because the relationships between the variables of interest were analyzed to describe the phenomenon, the methodology is made up of eight steps: definition of the domain of the problem, identification of the variables of interest, collection and pre-processing of data, definition of the state of the variables, design of pilot networks, proposal of the network for the eastern region, validation and evaluation of the network and propagation of evidence in the network. The results of this research can be considered as a statistical basis for the elaboration of a regional development plan. The statistical data generated could also be used by investors interested in the area, to know the economic branches with the greatest potential due to the increase in the demand for services. It should be mentioned that the data was projected using the Bayes algorithm, which was trained with previous economic information from the states of Aguascalientes and Puebla, where similar automotive companies have been established.

Twelve economic branches of commercial sectors and services with greater potential in the region of study were identified, which could offer to the original settlers, profitable business options, to provoke the economic growth of the region, driven by investment capital of local origin. With the Bayes-trained algorithm, the projections of the six variables were obtained: economic units, employed personnel, remunerations, investment, income and total gross product, which are inferred in each of the sectors in the municipalities of interest.

2. Theoretical review

This section provides a vision of where the proposed approach lies within the field of knowledge in which the research is developed, exposing the concepts and theoretical applications related to economic growth, economic sectors and Bayesian networks.

Growth and economic development

Man has always been faced with satisfying his needs, which is why he discovered fire, agriculture and other forms of using the elements of nature and transforming them into the elements he requires; when living in society it became necessary to look for general models to ensure the satisfaction of their needs as well as the conditions of their coexistence (Marx & Engels, 1979). López (1967) refers that the word economy etymologically comes from the Greek and is composed of oikos that means house and nomos that means law. Which, according to the author, can be interpreted as the order and rules that are observed in the income and expenses of a household. Later economy meant the order in which things are managed.

According to Fuentes and Martínez (2001), economics is the science of choice. Study the way in which individuals decide to use scarce or limited productive resources to produce various goods and distribute them among different members of society for consumption. Taking the above definitions it can be said that the Economy is in charge of studying the allocation of scarce resources among different activities in order to obtain goods and services that are distributed among individuals for the satisfaction of their needs. The various theories of economic growth use simplifications of reality, called economic growth models, to explain their causes. These models do not refer to any particular economy. However, most of the conclusions are that the economy grows because workers have more and more instruments for their work, that workers with more knowledge are more productive and that the economy grows by the technological process; Many authors explain the economic growth with these three variables in the models that pose (Miller & Gómez, 2013).

Another determining factor is the increase of the population to know if the product or per capita income increases or not. Development is a complex phenomenon that includes improvements or economic, political, social and human changes; affecting economic structures and political and social institutions. Development can manifest itself at the economic level with the increase in GDP per capita, consumption, investment, exports, among others and social by showing a more equitable distribution of income, poverty reduction, decrease in inequality between regions, races, sex, among others. According to Heath (2012), in Mexico there is a large amount of statistics and economic indicators generated by various institutions. Some are considered first level or importance, referring to the impacts on financial markets, such as the foreign exchange market, the Stock Exchange or the money market. Others are second level, because they complement the first and can refer to indirect impacts. Finally, there are third level indicators that are of analytical and academic interest, but whose immediate impact is practically null. Most of these economic indicators come from surveys, censuses or administrative records, generally expressed in units corresponding to their value in pesos, or referred to their volume.

Economic indicators are useful for the government sector, businessmen, and even for citizens in general, because by understanding, relating and interpreting them, it is possible to forecast the economic future and anticipate changes. Since 2011, the INEGI is responsible for the calculations and dissemination of the main economic indicators of Mexico. Although you can still find all the information on the Banco de México website, INEGI publishes all the indicators in detail. The Board of Economic Indicators of INEGI provides an overview of the evolution of fundamental variables that interact in the Mexican economy, as well as other external variables that influence it. This table includes variables from the real sector and the labor market, financial variables and the so-called opinion or feeling indicators.

Sectors of economic activity

The identification and classification of different types of sectors is fundamental in the economy, since once a key sector is detected, specific policies can be used that enhance it and benefit the rest of the economy. For analytical purposes economists classify the economic activity of production into three sectors, each refers to a part of the economic activity whose elements have common characteristics, keep a unit and differ from other groups. Its division is made according to the production processes that occur within each of them.

The primary or agricultural sector is the one that obtains the product of its activities directly from nature, without any process of transformation. Within this sector are agriculture, livestock, forestry, hunting and fishing. Mining and oil extraction, which are considered part of the industrial sector, are not included in this sector.

On the other hand, the secondary or industrial sector includes all economic activities related to the industrial transformation of food and other types of goods or merchandise, which are used as a basis for the manufacture of new products. This sector can sub divided in two: industrial extractive and industrial transformation. Finally, the tertiary or service sector includes all those activities that do not produce a commodity per se, but are necessary for the functioning of the economy and contribute to the formation of national income and the national product of a country. This sector is dedicated to providing services to people and companies, so that they can devote more time to their central work, without having to take care of other tasks.

Given its close relationship with productive activity, the development of services to production must be analyzed in relation to the evolution of the organization of contemporary production, and more specifically to the growing internationalization and the development of new information technologies.

According to Hernández (2013), it is possible to affirm that the services sector is more closely related to the aggregate economy than the secondary sector, not only because of its relative contribution to GDP, but also because of the magnitude of the long-term elasticity it exhibits. In that sense, it can also be said that the activities of trade, real estate services and transportation are at least as relevant to the economy as manufacturing and construction.

The North American Industrial Classification System (NAICS) is a regional classifier because it is essential that in a free trade zone there are truly compatible economic classifiers, this implies that both its construction and its updating are done in coordination with the United States and Canada. The versions published since 1997 respond to the trilateral five-year update agreement of the SCIAN taken by the national statistical agencies of Mexico, the United States and Canada to prevent the classifier from becoming obsolete, adapting it to the changing circumstances of constantly changing economies.

SCIAN is composed of twenty activity sectors; five sectors are essentially producers of goods and fifteen are fully service providers. The hierarchical structure of the SCIAN is made up of five levels of aggregation: sector (the most aggregated level), subsector, branch, sub-branch and activity class (the most disaggregated level). The first four levels constitute the trinational classifier, which is common among the three countries, and the last level, that of the activity class, was reserved so that each country could make a greater breakdown according to its national statistical requirements.

Bayesian networks

A Bayesian network is a directed acyclic graph in which each node represents a random variable that has a conditional probability function associated with it. The structure of the Bayesian network provides information on the relations of dependency and conditional independence existing between the variables. Bayesian networks (also known as probabilistic causal networks, causal networks, Bayesian expert systems, belief networks, probabilistic expert systems or influence diagrams) are statistical tools that represent a set of associated uncertainties based on conditional independence relationships that they are established between them (Santiesteban, 2012).

One of the most important advantages of Bayesian networks is that the structure of the associated graph determines the dependence and independence relationships between the variables, so that it is possible to discover, without the need for numerical calculations, which variables are relevant for another variable of interest.

Sometimes, Bayesian networks are called causal networks when the arcs that connect the nodes can be interpreted as the representation of direct causal relationships. Experts are often able to relate causes and effects in a way that reveals inherent conditional independencies that are representable through a Bayesian network (Nilsson, 2001).

A Bayesian network is used to model a domain that contains uncertainty in some way. This uncertainty may be due to an imperfect understanding of the domain, an incomplete knowledge of the state of the domain at the moment in which a determined task must be carried out, a randomness in the mechanisms that govern the behavior of the domain or a combination of these. These models can have diverse applications, for classification, prediction, diagnosis, among others; and they are widely used in fields such as medicine, education, marketing and social sciences. According to Sucar (2015), Bayesian networks are a graphical representation of dependencies for probabilistic reasoning, in which the nodes represent random variables and the arcs represent direct dependency relations between the variables.

For Huete (1998) Bayesian networks constitute one of the most powerful tools in the design of probabilistic expert systems. From a graphic point of view, a Bayesian network is an Acyclical Directed Graph, where the nodes represent the variables of a problem and which allows to represent knowledge from two points of view:

- Qualitative: expressing the relationships of dependence and independence between the variables. Graphically, they are represented by the presence of connections or paths between the variables.

- Quantitative: expressing the strength of relationships of relevance or dependence. Allows you to represent the uncertainty that you have about the occurrence of events.

Bayesian networks represent an acyclic structure of dependence between random variables for probabilistic reasoning. Each variable is characterized by its corresponding states, which can be defined by numerical values, intervals, qualitative estimates or Boolean functions. The relationships between variables are established in terms of probabilistic dependence. To each variable corresponds a table of conditioned probability, which presents the probability distribution of said variable in each of its states, given the states of its parent variables. The conditional probability information can be obtained from different sources: direct measurements, mathematical models and expert opinion (Koski, 2009) . To make predictions with a Bayesian network, it is required to build a model. A model can be learned from the data, manually constructed or a mixture of both. Prediction is the process of calculating a probability distribution on one or more variables whose values you want to know, given the information (evidence) that you have about some other variables. These can be:

- Discrete variables. For a discrete variable D with 3 states {Low, Medium, High} a prediction will be of the form [0.1, 0.3, 0.6]. That is to say. The probability of belonging to each state. The task of predicting a discrete variable is often referred to as Classification in line with other approaches.

- Continuous variables. For a continuous variable C, a prediction will contain both a Mean and a Variance. The task of predicting a continuous variable is often referred to as linear regression with other statistical approaches.

- Input and output variables. The variables to be predicted are known as output variables, while the variables whose information is used to make the predictions are known as input variables.

In Statistics, input variables are often referred to as predictor, explanatory, or independent variables, while output variables are often referred to as response variables or dependents. Bayesian networks deal strictly with inputs and outputs. This is because any variable in the graph can be an entry or exit or even both. You can even predict the joint probability of an exit and a lack of entry. However, describing the variables in terms of their functions as inputs or outputs remains a useful concept.

BayesN tool

The BayesN tool is designed with two main parts, one of them is a graphical interface where the user can enter the database to be processed, generate and modify the network, and generate complete conditional probability tables, adding arcs (relationships) between the variables under study and is based on techniques known as knowledge discovery in databases. Which is designed with two main parts: The graphic interface where the user can enter the database to be processed, generate and modify the network, and complete the conditional probability tables.

The other is an inference engine that performs the calculations and obtains the conclusions from the information provided in the database. For this uncertainty is propagated, with which its conclusions will be conditioned to such propagation. BayesN was developed by Jiménez (2003) which is based on the previous work of Cruz (1997) both from the Universidad Veracruzana.

3. Methodology

This research has a quantitative approach, during its execution a data collection was carried out to determine the variables of interest that characterize the phenomenon to be observed, and based on the numerical measurement and the statistical analysis, patterns of behavior of the study variables were established. In addition, it is correlated and applied, that is, the relationships between the variables of interest were analyzed to describe a phenomenon. It is non-experimental because the variables were not manipulated; descriptive because it seeks to specify the properties, characteristics and profiles of the observed phenomenon; and synchronous because it was carried out in a given period of time.

4. Development

The eight steps that make up the methodological proposal of this research are: define the domain of the problem, identification of variables, collection and pre-processing of data, definition of the state of the variables, design of pilot networks, validation and evaluation of the network, construction of the network for prediction and propagation of evidence in the network.

1. The domain of the problem

It is important to study the domain to have the maximum degree of knowledge and understanding about the problem to model. This will require having experts in the area, who should be sufficiently interested and motivated for the collaboration to have good results. This will require having experts in the area, who should be sufficiently interested and motivated for the collaboration to have good results.

2. Identification of the variables of interest

In this stage, each of the variables (see table 7.1) that will be used in the network, its role in the network and its origin are defined. It is also necessary to define what variables will be called objective and what variables will be called of intervention. It is important to focus only on those variables that are of interest in the current problem. For this, it helps to ask questions of the type:

- What is the situation that arises?
- What possible causes can explain this situation?
- What other factors can make the situation happen, or prevent it from happening?
- What evidence is available to support these causes, situations and factors?

There are variables that can be grouped into classes. If the problem is addressed with these classes in mind, the modeling process is easier.

Table 7.1 Types of variables according to their role in the network

Type of variable	Short description
Objective	They model objects of interest. Not directly observable.
Observations	They model the way to measure objective variables. They can be observed directly.
Factor	They model phenomena that affect other variables of the model.
Promoter	The affected variable is more likely when they are present.
Inhibitor	The affected variable is less likely when they are present.
Required	If it does not take action, the affected variable does not occur.
Preventive	If it goes into action, the affected variable does not occur.
Auxiliaries	Used for convenience (to simplify the model)

Source: Millán (2005)

There were two classes of economic and population variables. The economic variables are: sector, total gross production (PBT), economic units (EU), employed personnel (personnel), remunerations (remuneration), total investment (investment), income from the supply of goods and services (income), investment in manufacture of the automotive industry (inv_auto).

In the opinion of experts in Economics, these variables can describe the economic dynamics that develop within the region under study in the twelve sectors of economic activity of trade and services. The population variables are: population density (Density) and Occupation.

3. Data collection and pre-processing

In this phase, we first explored several options of computer tools, such as Hugin Lite software, Weka, the BayesN algorithm, Bayes Server, where the latter two were the ones with the most previous knowledge (training phase of the network), and then use them to obtain the projections of the statistical data of each study variable with reference to the various economic sectors established. For the design of the pilot networks, the economic and population variables were determined and trained with data from the Ministry of Economy (SE) and the National Institute of Statistics and Geography (INEGI) for the years 2004, 2009 and 2014, of the states of Aguascalientes, Puebla and Tlaxcala, these entities were considered because they have in common established companies of the automotive sector.

For the classification of economic units INEGI makes use of the Industrial Classification System of North America, Mexico 2013 (SCIAN), a classifier that offers the double possibility of forming and grouping the data according to the characteristics of the Mexican economy, and at the same time compare it with statistics from Canada and the United States of America, countries that also use this classifier.

For the purposes of this research, only data from 12 service and commerce sectors were used. Namely: 43 Wholesale trade, 46 Retail trade, 48-49 Transport, mail and storage, 51 Information in mass media, 53 Real estate and rental services of movable and intangible assets, 54 Professional, scientific and technical services, 56 Business support services and waste management, and remediation services, 61 Educational services, 62 Health and social work services, 71 Cultural and sports entertainment services, and other recreational services, 72 Temporary accommodation services and food and beverage preparation, 81 Other services except government activities.

Another important source of information were the experts in economics, whose opinions were gathered through personal interviews, with an official of the Tlaxcala Delegation of the Ministry of Economy, with an INEGI official and with a teacher-researcher from the School of Tlaxcala. In order to contrast the statistical results of the analysis with the reality perceived by the inhabitants of the region, surveys were also conducted to owners or employees of the economic units of the twelve sectors of commerce and services in the municipalities of interest.

The database of the INEGI page was obtained in an Excel file format, the data was pre-processed to adapt them to TXT files, which are the extensions that BayesN can interpret, which is an algorithm programmed in Java tests of conditional independence adding arcs (relations) between the variables under study and is based on techniques known as discovery of knowledge in databases. In order to compare the behavior of the variables of interest in regions where the Automotive Industry is in a degree of maturity, data were obtained from three municipalities of Aguascalientes, six municipalities of Puebla and seven from the Oriente Region of Tlaxcala: Atltzayanca, Cuapiaxtla, El Carmen Tequexquitla, Huamantla, Ixtenco, Terrenate and Ziltlaltepec.

The database of the research is formed by 1833 (see table 7.2) records that cover the economic and population data of sixteen municipalities and twelve economic activity sectors of the three states of the Mexican Republic that were chosen, said states were considered because they installed automotive plants and there were already economic growth results which could be compared with the projections.

Table 7.2 Records by year and state

	2004	2009	2014	Total
Aguascalientes	170	177	186	533
Puebla	265	316	351	932
Tlaxcala	107	122	139	368
Total	542	615	676	1833

Source: self made (2016)

4. Definition of the state of the variables

Each variable will have different states (see table 7.3) that can be represented as intervals, absolute values, categories or binaries. The BayesNAIVE algorithm, which consists in the generation of Bayesian networks based on the training of the Bayesian network with existing data for the prediction of future scenarios based on the Bayes algorithm, was chosen because other researchers had already made successful projections with this software it uses discrete variables and the INEGI databases have numerical attributes, so it was necessary to transform them into qualitative attributes.

A normalization technique was used that transforms the range of values to a certain interval (normally [0,1]). This technique is useful because distance-based learning algorithms will be applied so that all the attributes are in the same range.

Table 7.3 States of the variables

Variable	States
Sector	Trade: Retail sector M commerce: wholesale trade sector Services: twelve service sectors
Occupation	Low: less than or equal to 15% Medium: less than or equal to 30% High: greater than or equal to 31%
Density	Low Medium High
Inv_Auto	Very low: less than or equal to 0.15 Low: less than or equal to 0.30 Medium: less than or equal to 0.65 Height: less than or equal to 0.80 Very high: greater than or equal to 0.81
EU	
Personal	
Remunerate	
Investment	
Income	
PBT	

Source: Self Made (2016)

5. Design of pilot networks

Defined the set of variables and their states, the records were used to generate 9 networks that describe the relationships between the variables for the three states: Aguascalientes, Puebla and Tlaxcala in three different moments of time corresponding to the last three Economic Censuses published by INEGI in 2004, 2009 and 2014. Table 7.4 summarizes the 55 relationships that the algorithm found in the different data groups that were used to form the nine networks that describe economic activity in the twelve sectors of commerce and services chosen for this research in the sixteen municipalities of the states of Aguascalientes, Puebla and Tlaxcala that were used as reference for the manufacturing activity of the Automotive Industry.

Table 7.4 Summary of the relationships found in the networks

Arcos detectados	Aguascalientes			Puebla			Tlaxcala			Total
	2004	2009	2014	2004	2009	2014	2004	2009	2014	
EU - Staff		X	X		X	X	X	X	X	7
Remunerate - PBT		X	X	X	X	X		X	X	7
Sector - Density	X			X		X			X	4
Inv_Auto - Occupation		X	X		X	X				4
Personal - Remuneration		X	X	X		X				4
Sector - Occupation						X		X	X	3
Occupation - Density						X		X	X	3
Occupation - Sector		X	X		X					3
Personal - Income					X			X	X	3
Sector - Revenue			X			X				2
Inversion - Revenue	X	X								2
Income - Investment				X	X					2
Income - Remuneration								X	X	2
Density - Income						X				1
Density - Occupation					X					1
Density - EU			X							1
Density - Sector					X					1
Personal - Investment	X									1
Remunerate - Staff	X									1
Investment - Staff				X						1
Inversion - Remunera					X					1
Income - PBT	X									1
Total	5	6	7	5	9	9	1	6	7	55

Source: Self Made (2016)

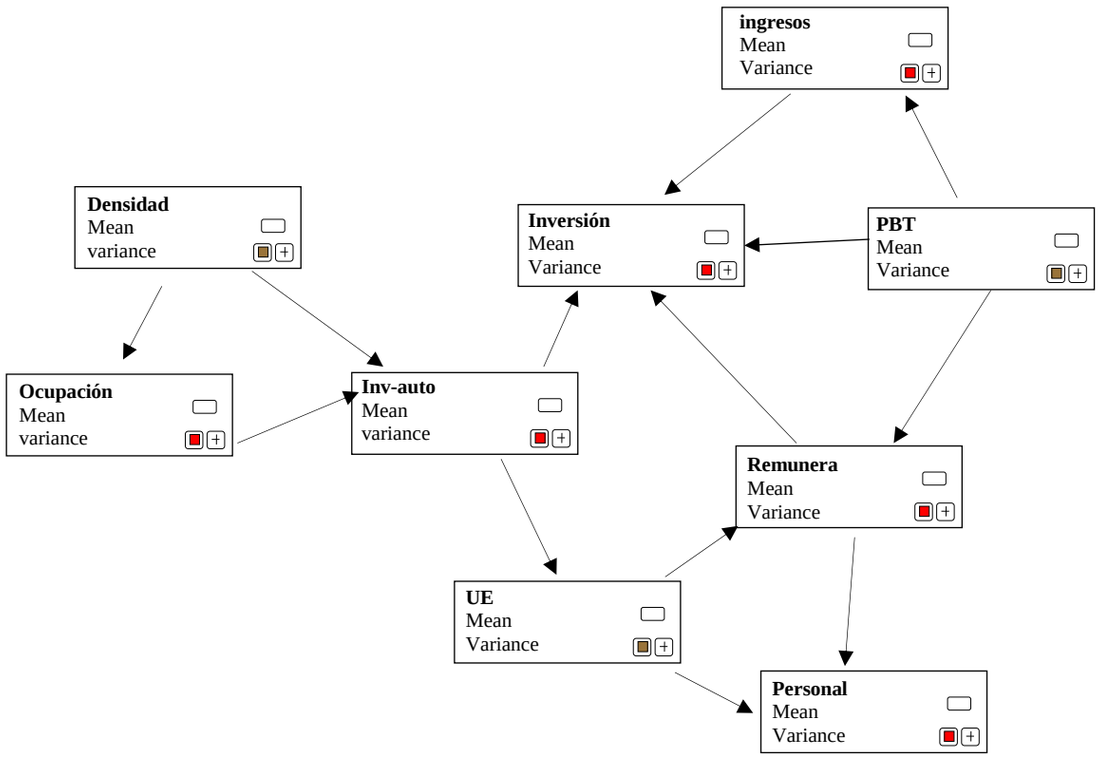
The behavior of the networks increased the relationships and the information is more sensitive to the number of records as they were accumulated from one census to another. The two most repeated relationships are: UE - Personal and Remunerations - PBT, for which they were considered in the construction of the network for the prediction of the variables of interest.

6. Proposal of the network for the Oriente Region

Given the analysis of the projections of the previously applied networks, we proceeded to consult the valuable opinion of the human experts, who validated them and proposed a network that was able to predict the behavior of each of the variables of interest. The network was built on the Bayes Server software, which is a tool for modeling Bayesian networks. This software is from an English company that specializes in the development of intelligent systems based on artificial intelligence, machine learning and data science.

The main window of Bayes Server is that it has the six menus that allow the user to manage files, build a network, make queries, load data, analyze the data and manage the views of the windows, which accepts continuous variables, so that the data of the records were loaded with the original values of the information source in an Excel file. To construct the Network for the Oriente Region, nine nodes were created with the names of the variables that were analyzed. The next step was to add the arcs between the nodes through the algorithm for structural learning that uses conditional independence tests to determine the structure of the network; for this learning, the records of Aguascalientes and Puebla were loaded into the network. For the 2014 census, nodes were added and deleted with the information in the summary table, taking into account the validation of the human experts from where the necessary variables were determined. The result was the network shown in Figure 7.1 (it should be mentioned that this figure is automatically generated by the Bayes Server software).

Figure 7.1 Proposal: Network for the Oriente Region



Source: Bayes Server (2016)

Then, the parametric learning is executed, that is to say, that each node is assigned statistical parameters with the help of an algorithm of trees. Since the data is continuous instead of calculating probability tables, each node is adjusted to a Normal Distribution function. This learning was done in Bayes Server loading the data to Tlaxcala in the 2014 census.

7. Validation and evaluation of the network

In this stage, the results obtained are verified, which must be reviewed and contrasted, since there may be discrepancies that require a modification of the network to adjust it to the analyzed case of study. It is convenient that the validation and the evaluation are carried out with the experts in the subject for congruence of the results. The information was validated with data from the 2004, 2009 and 2014 censuses, which coincide with the results obtained by the Bayes Server software, this instrument being valid for future projections.

8. Propagation of evidence in the network

Once the network was built and trained, a consultation was made for each year to be projected taking as available evidence the Density of Population (Density), the Investment in Automotive Manufacturing (Inv_Auto) and the Percentage of Occupation by Sector of Economic Activity (Occupation). Values were determined from the experts' considerations and the natural growth of the populations and the economy.

This process is known as propagation, a probability propagation algorithm uses the independence relations implicit in the Bayesian network structure to calculate the probabilities of each of the nodes given the available evidence. Thus, taking into account the values of those variables determined by the previous networks and the propagation of them, these were determined for the projection of the following three economic censuses: 2019, 2024 and 2029; the evidence to propagate in a network is shown in the following table.

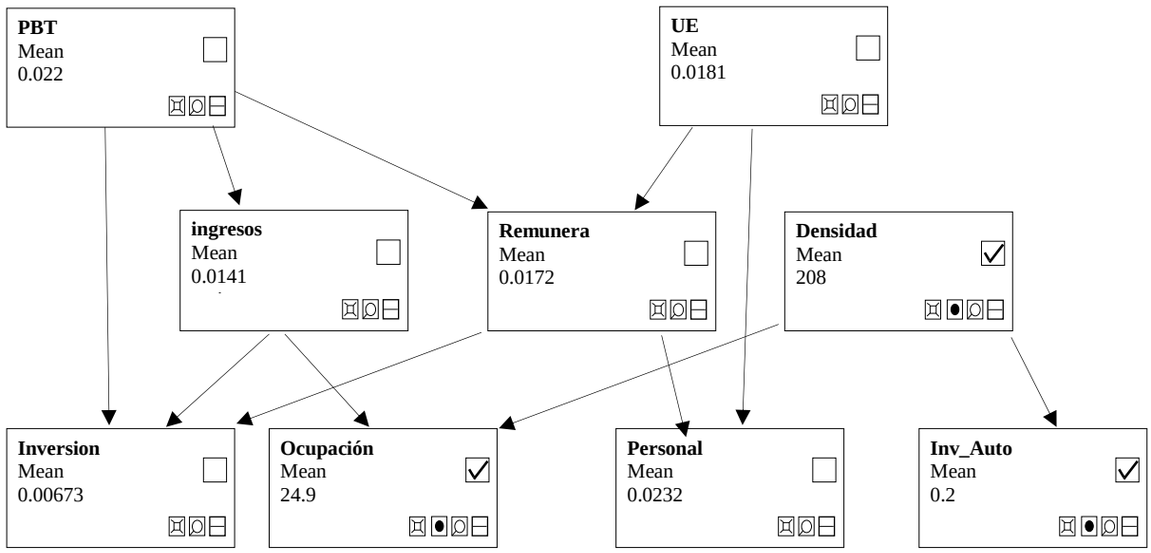
Table 7.5 Evidence to spread the network

Year	Occupation (%)	Commerce Services (%)	Density of population (inhabitants)	Investment in automotive industry (%)
2014	11.88	22.55	175.84	0.01
2019	13.46	24.86	207.52	0.20
2024	15.98	27.35	249.02	0.30
2029	17.53	30.96	288.87	0.35

Source: Self Made (2016)

The steps in the tool to carry out the propagation of the evidence are presented with the following figures that were taken from the screens of the application. Figure 7.2 shows the load of evidence in the network, generated by the Bayes Server software.

Figure 7.2 Loading of evidence on the Net for the Oriente Region



Source: Results generated through Bayes Server software (2016)

After the load, a query is made so that the tool calculates the projected values for each dependent variable. Table 7.6 shows an example of one of the eleven queries of each of the study variables: economic units, employed personnel, salaries, investment, income and total gross product.

Table 7.6 Result of the consultation to the network

	A	B	C	D	E	F	G
	Case_ID	Predict(UE)	Predict(Personal)	Predict(Remunera)	Predict(Ingresos)	Predict(Inversion)	Predict(PBT)
1	1	0	0.008727	0.026272	0.022568	0.010501	0.008364
2	2	0	0.008727	0.026272	0.022568	0.010501	0.008771
3	3	0.056288	0.05753	0.013704	0.022568	0.012599	0.017002
4	4	0	0.008727	0.026272	0.022568	0.010501	0.007172
5	5	0.007916	0.01559	0.024505	0.022568	0.010796	0.007904
6	6	0.003518	0.011777	0.025486	0.022568	0.010632	0.007252
7	7	0	0.008727	0.026272	0.022568	0.010501	0.007458
8	8	0.002639	0.011015	0.025683	0.022568	0.010599	0.007817
9	9	0.003518	0.011777	0.025486	0.022568	0.010632	0.007402
10	10	0.001759	0.010252	0.025879	0.022568	0.010567	0.007173
11	11	0.001759	0.010252	0.025879	0.022568	0.010567	0.007541

Source: Bayes Server (2016)

5. Results

The results obtained by the network that was generated are presented in numerical and percentage tabular form for each of the six study variables, where the economic impact of each sector in the eastern region of the state of Tlaxcala can be observed when companies are established of the automotive sector.

Current situation of the Oriente Region

Based on data from the 2014 Economic Census in the seven Tlaxcala municipalities of Atltzayanca, Cuapiaxtla, El Carmen Tequexquitla, Huamantla, Ixtenco, Terrenate and Zitlaltepec, which make up the Oriente Region of Tlaxcala there are 4546 economic units that carry out their activities in the twelve tertiary sectors that were chosen to be analyzed. As can be seen in Table 7.7, the largest percentage share refers to Retail Trade, which represents about 2/3 of Economic Units (EU) and Employed Personnel; in Investment and Revenue represents 3/4 parts; finally in Remuneration and Total Gross Production (PBT) a little more than half. The behavior of this sector in the region under study is similar to that of the state of Tlaxcala, where the Retail Trade EU represents 53% and the national where it is 50% of the total EU.

Table 7.7 Variables by Sector of economic activity, Oriente Region 2014.

Economic sector	% UE	% Personal Occupied	% Remuneration	% Investment	% Incomes	% PBT
Retail trade	65.4	61.4	52.2	77.6	71.8	56.4
Accommodation, food and beverages	8.9	9.6	5.8	3.3	3.7	11.6
Other services	14.7	12.6	9.0	6.8	3.2	10.4
Wholesale	0.9	1.9	8.8	0.3	16.9	7.6
Educational services	0.7	4.3	12.2	0.9	1.4	4.6
Health and social assistance services	2.5	3.7	6.3	5.7	1.3	4.2
services professionals, scientists and technicals	0.9	1.4	3.0	0.6	0.7	2.2
Support for business	2.7	2.2	1.1	1.9	0.4	1.2
Recreational, cultural and sporting services	1.5	1.2	0.8	2.0	0.3	0.9
Real estate services	1.5	1.4	0.2	0.9	0.1	0.3
Information in mass media	0.2	0.2	0.2	0.0	0.1	0.3
Transportation, mail and storage	0.1	0.1	0.3	0.0	0.0	0.1
Total	4.54	9.413	98.753	27.430	86.98	74.44

Source: Self Made based on Economic Census 2014 (2017)

Economic Units (EU). The number of UEs established by sector in the Eastern Region of the state of Tlaxcala will have growths (against previous census, see table 7.8) of 8.8% in 2019, 10.8% in 2024 and 6.9% in 2029. What in the most positive scenario would lead to to an accumulated growth of 90.8% based on 2004 and of 28.8% on 2014, date of the last census publication.

Table 7.8 Economic Units by sector, base year 2014.

	Historical					Projection			
Sector	2004	2009	2014	2019	%	2024	%	2029	%
Retail trade	2,220	2,714	2,972	3,212	8.1	3,554	19.6	3,813	28.3
Other services	427	547	667	730	9.4	800	19.9	837	25.5
Accommodation, food and beverages	178	324	404	447	10.6	510	26.2	552	36.6
Support for business	36	110	121	132	9.1	145	19.8	158	30.6
Health and social assistance services	57	66	114	133	16.7	145	27.2	148	29.8
Wholesale	28	65	41	45	9.8	50	22.0	55	34.1
Recreation, cultural and sports	3	55	69	78	13.0	87	26.1	94	36.2
Real estate services	15	39	70	74	5.7	84	20.0	90	28.6
Services professionals, scientists and technicals	33	41	41	48	17.1	53	29.3	56	36.6
Educational services	27	25	34	38	11.8	42	23.5	45	32.4
Transportation, mail and storage	71		40	40	0.0	43	7.5	45	12.5
Information in mass media			11	11	0.0	12	9.1	12	9.1
Total	3,095	3,986	4,584	4,988	8.8	5,525	20.5	5,905	28.8

Source: Self Made (2017)

Busy Staff This variable includes all the people who worked during the reference period, depending contractually or not on the economic unit, subject to their direction and control.

Table 7.9 shows the expected figures for the twelve sectors of economic activity, these figures are expressed in number of people, and in percentage form, where the other services sector is the one with the highest projected growth with 36.3%.

Table 7.9 Employed Person by sector, base year 2014.

	Historical					Projection			
Sector	2004	2009	2014	2019	%	2024	%	2029	%
Retail trade	3,551	5,736	5,780	6,537	5.6	7,199	17.9	7,740	24.2
Other services	582	1,153	1,188	1,281	12.3	1,442	27.9	1,518	36.3
Accommodation, food and beverages	359	858	905	956	12.6	1,067	23.0	1,124	26.7
Support for business	231	328	404	448	7.8	519	21.4	545	27.8
Health and social assistance services	92	155	352	385	10.9	447	28.5	471	34.9
Wholesale	150	262	179	201	13.1	229	24.6	244	33.9
Recreation, cultural and sports	56	209	208	231	9.4	266	27.0	271	33.8
Real estate services	71	126	129	143	6.4	153	16.4	156	25.5
Services professionals, scientists and technicals	22	108	135	152	11.1	166	27.9	171	30.3
Educational services	3	91	110	117	10.9	128	18.6	138	20.9
Transportation, mail and storage	134		5	5	5.6	5	11.1	5	16.7
Information in mass media			18	19	0.0	20	0.0	21	0.0
Total	5,251	9,026	9,413	10,475	11.3	11,641	23.7	12,404	31.8

Source: Self Made (2017)

Remuneration to the personnel. Are all payments and normal and extraordinary contributions, in cash and kind, before any deduction, to compensate the work of personnel dependent on the company name, in the form of wages and salaries, social benefits and utilities distributed to staff. Includes: employer contributions to social security schemes, payment made to licensed personnel and temporary permission. Excludes payments for liquidations or indemnities, payments to third parties for the supply of employed personnel; payments exclusively for commissions for those personnel who did not receive a base salary; fee payments for professional services contracted infrequently. The expected behavior of this variable is represented in thousands of annual pesos (table 7.10), where the transport, mail and storage sector has a projected higher growth of 44.5% with respect to the rest.

Table 7.10 Remuneration by sector, base year 2014.

	Historical					Projection			
Sector	2004	2009	2014	2019	%	2024	%	2029	%
Retail trade	31,780	40,491	51,559	58,223	12.9	64,887	25.9	69,033	33.9
Other services	6,699	1,366	12,030	13,341	10.9	15,076	25.3	15,844	31.7
Accommodation, food and beverages	5,450	6,141	8,726	9,686	11.0	10,596	21.4	10,946	25.4
Support for business	1,926	5,071	8,893	10,067	13.2	11,282	26.9	12,205	37.2
Health and social assistance services	2,145	4,941	5,758	6,138	6.6	6,801	18.1	6,917	20.1
Wholesale	1,126	2,725	6,258	6,802	8.7	7,632	22.0	8,220	31.4
Recreation, cultural and sports	603	1,809	2,978	3,279	10.1	3,505	17.7	3,736	25.5
Real estate services	1,977	-	306	353	15.2	408	33.2	442	44.5
Services professionals, scientists and technicals	152	805	1,101	1,204	9.4	1,383	25.6	1,423	29.2
Educational services	52	915	155	168	8.5	192	24.0	207	33.4
Transportation, mail and storage	18	174	776	845	8.9	925	19.2	980	26.3
Information in mass media	-	-	213	238	11.7	256	20.4	282	32.5
Total	51,928	74,438	98,753	110,345		122,944		130,235	

Source: Self Made (2017)

Income from the supply of goods and services. It is the amount obtained by the economic unit during the reference period, for all those activities of production of goods, commercialization of goods and provision of services. Includes: the value of the goods and services transferred to other economic units of the same company, plus all expenditures or taxes charged to the buyer. Excludes: financial income, subsidies, fees, contributions and sale of fixed assets. Table 7.11 shows the expected figures in thousands of pesos per year and the sector with the greatest projection is information in mass media, with 39.9%.

Table 7.11 Income projection by sector, base year 2014

	Historical					Projection			
Sector	2004	2009	2014	2019	%	2024	%	2029	%
Retail trade	769,353	1,074,037	1,342,335	1,526,790	13.7	1,685,941	25.6	1,806,837	34.6
Wholesale	88,080	184,609	316,813	333,921	5.4	376,329	18.8	388,748	22.7
Accommodation, food and beverages	25,294	57,855	69,081	79,029	14.4	90,725	31.3	95,261	37.9
Other services	23,786	44,226	60,330	66,016	9.4	73,020	21.0	75,909	25.8
Educational services	14,689	21,871	26,562	30,653	15.4	32,982	24.2	35,456	33.5
Health and social assistance services	6,551	10,157	24,225	26,744	10.4	30,756	27.0	31,187	28.7
Professionals, scientists and technicians	5,068	5,669	12,746	14,594	14.5	16,973	33.2	17,329	36.0
Support for business	2,353	8,510	7,178	8,047	12.1	8,795	22.5	9,630	34.2
Postal transport and storage	15,946	-	783	856	9.3	921	17.6	951	21.5
Real estate services	1,078	5,426	2,658	2,958	11.3	3,381	27.2	3,507	31.9
Cultural and sports entertainment	134	2,295	5,516	6,200	12.4	6,820	23.6	7,502	36.0
Information in mass media	-	-	1,753	1,934	10.3	2,251	28.4	2,453	39.9
Total	952,332	1,414,655	1,869,980	2,097,741	12.2	2,328,893	24.5	2,474,770	32.3

Source: Self Made (2017)

Investment. It is the increase in assets, inputs and products that the economic units experienced during the reference year. It is obtained by adding to the Gross Formation of Fixed Capital the variation of Stocks, table 7.12 shows the expected figures for this variable, where the sectors Wholesale trade projects a greater growth of 43.1% with respect to the others, and the one of Postal and storage transports, begins to have economic movement with the projections from the year 2019.

Table 7.12 Investment projection by sector, base year 2014

	Historical					Projection			
Sector	2004	2009	2014	2019	%	2024	%	2029	%
Retail trade	17,985	32,935	21,273	23,477	10.4	26,018	22.3	28,155	32.4
Wholesale	3,336	287	911	1,034	13.5	1,168	28.3	1,199	31.6
Accommodation, food and beverages	541	647	1,861	2,087	12.1	2,399	28.9	2,491	33.8
Other services	621	1,844	78	90	15.8	105	34.8	112	43.1
Educational services	233	222	1,573	1,809	15.0	2,046	30.1	2,199	39.8
Health and social assistance services	494	630	530	561	5.8	652	23.0	708	33.6
Professionals, scientists and technicians	554	37	245	278	13.6	313	27.7	324	32.4
Support for business	182	310	260	288	10.8	336	29.1	357	37.5
Postal transport and storage	5	142	540	621	15.0	699	29.5	711	31.7
Real estate services	277	130	153	173	12.9	194	26.8	205	34.3
Cultural and sports entertainment	55	-	-	30		31		41	
Information in mass media	-	-	6	7	9.6	8	25.6	8	33.8
Total	24,283	37,184	27,430	30,425	11.0	33,938	23.8	36,470	33.1

Source: Self Made (2017)

Total Gross Production. It is the value of all goods and services produced or marketed by the economic unit as a result of the exercise of its activities, including the value of the products produced; the gross margin of commercialization; the executed works; income from the provision of services, as well as the rental of machinery and equipment, and other movable and immovable property; the value of fixed assets produced for own use, among others. Includes: the variation of inventories of products in process. Goods and services are valued at the producer's price.

The Total Gross Production variable will behave like the data displayed in table 7.13 and where the sector with the greatest economic projection is Cultural and Sports Recreation, with 48.2%.

Table 7.13 Total Gross Production by sector, base year 2014

	Histórico					Proyección			
Sector	2004	2009	2014	2019	%	2024	%	2029	%
Retail trade	189,844	280,291	323,726	360,630	11.4	392,004	21.1	410,036	26.7
Wholesale	25,004	56,641	66,791	79,548	19.1	88,377	32.3	90,498	35.5
Accommodation, food and beverages	23,403	42,184	59,673	66,416	11.3	75,116	25.9	79,097	32.6
Other services	42,585	29,671	43,644	49,274	12.9	54,595	25.1	56,887	30.3
Educational services	14,694	21,871	26,562	28,979	9.1	32,456	22.2	34,435	29.6
Health and social assistance services	6,627	10,155	24,168	28,518	18.0	31,426	30.0	32,305	33.7
Professionals, scientists and technicians	5,000	5,663	12,411	14,260	14.9	16,042	29.3	17,453	40.6
Support for business	2,236	8,218	7,127	8,160	14.5	9,384	31.7	9,637	35.2
Postal transport and storage	15,928	-	783	843	7.7	900	14.9	987	26.1
Real estate services	1,086	5,412	2,654	3,105	17.0	3,514	32.4	3,812	43.6
Cultural and sports entertainment	134	2,178	5,155	6,160	19.5	7,188	39.4	7,640	48.2
Information in mass media	-	-	1,748	1,924	10.1	2,151	23.1	2,312	32.3
Total	326,541	462,284	574,442	647,817	12.8	713,153	24.1	745,099	29.7

Source: Self Made (2017)

Conclusions

The purpose of the investigation was to project economic growth in the Eastern Region of the state of Tlaxcala, due to the installation of an automotive assembly plant, through the generation of Bayesian networks, allowing to identify the economic branches with the greatest growth potential. Having tested the projections of the Bayes Server Software with the real data in the States where companies of the automotive industry had already been installed and compare that the growth was similar, the instrument could be validated and trained with data from the State of Tlaxcala. For the development of the research, the behavior of six variables (Economic Units, Employed Personnel, Remuneration, Investment, Income and Total Gross Product) of the economic branches of twelve sectors of commerce and services that carry out activities in the seven municipalities of interest.

It should be noted that the figures presented in the Economic Survey Report are estimates made based on data from the original electronic sources of INEGI, and were calculated by statistical methods for research purposes, so they should not be considered as information from the original source. In the period of the investigation, there was no commercial and service infrastructure in the Oriente region of Tlaxcala that would support the demand caused by the increase in the flow of people involved in the installation of an automotive assembly plant, but by capitalizing on the opportunity for the inhabitants of the surrounding municipalities, this physical and economic infrastructure could provide the population that Sedatu is projecting in almost 200 thousand inhabitants by the year 2030.

The economic growth of the Eastern Region of the state of Tlaxcala was projected, using the Bayes Theorem tool and statistical inference to determine the dependence between them. The economic branches that have ample growth potential in the years 2019, 2014 and 2029, derived from the data processing of the Bayesian Network, were presented in the various tables corresponding to each study variable. As a summary of this information, table 7.14 is presented, where this information is presented.

Table 7.14 Economic sectors with greater projection for the year 2029

Economic sector	Variable	% Projected for 2029
Accommodation, food and drink	Economic Units (EU)	36.6
Services professionals, scientists and technicals	Economic Units (EU)	36.6
Other services	Busy Staff	36.3
Transportation, mail and storage	Remuneration	44.5
Wholesale	Investment	43.1
Information in mass media	Income	39.9
Recreation, cultural and sports	Total Gross Production (PBT)	48.2

Source: Self Made (2017) based on the projection of the Bayesian network

We can observe in the projection for the year 2029 the variables such as economic units, employed personnel, remuneration, investment, income and total gross production show significant growth. If we analyze the growth of the other states that served as a guide for the analysis where automotive companies had settled, we can highlight that there was also an important growth of the companies related to the automotive industry, in this way we can conclude that in the State of Tlaxcala it is inferred that there will also be an economic development.

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