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Applying Bayesian modeling to craft works in urban informal Sector: A Case of silversmithy in silver city of Cuttack in Odisha

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Abstract

A Bayesian Network represents the variables of interest of a problem domain and the causal relationships between them in a graphical form, and inferences can be made from the structure using the theory of Bayesian Probability. In this paper, we model the environment in relation to the socio-economic condition of the craft artisan workers and the owner craftsmen of silver filigree industry in Odisha in the form of a Bayesian Network. From this network, we make important inferences for diagnosis and prognosis so as to explain the present conditions of the silversmiths in silver city of Cuttack and also the ways to improve their existing conditions.

***Keywords*:** Bayesian Networks, Probabilistic Modeling, IT in Society, Urban Informal Sector, Craft Artisans, work culture

1. Introduction.

In the recent past, Bayesian Networks (BN) have been used as a probabilistic model of a wide variety of problem areas in the realm of Artificial Intelligence such as medical diagnosis, reliability modeling, software cost/effort/defect estimation/prediction, and weather forecasting etc. Such a modeling approach is applicable whenever it can be identified that a problem domain has a set of random variables and such variables have a causal relationship between them.

The basic idea of BNs is to produce the most important dependencies and independencies among a set of domain variables in a graphical form, which is easy to understand and interpret. Nodes in a directed acyclic graph represent the variables and the dependencies are expressed as conditional probabilities. Inferences can me made from the network by using theories of Bayesian Probability.

In this paper, we will model the socio-economic environment that surrounds the silver filigree artisans of the Cuttack City in Eastern India. In particular, we will focus on the factors that affect the economic conditions of the owner silversmiths themselves and their relationship with middlemen and workers in craft environment. We derive interesting conclusions. The factors, which determine their present economic condition and suggestions to improve upon their existing conditions, are dealt using theories of Bayesian Probability.

The database of the study comprise primary data collected through interview schedule of structured and quite a few unstructured questions and focus group discussion and secondary data drawn from a variety of sources such as books and journal. The universe of this study covers all the silver filigree artisans of Cuttack city. The sample was purposively random and in all 172 respondents was interviewed, drawn from above said 16 main bazaars.

The organization of the paper is as follows. In Section 2 we introduce Bayesian Networks and how they can be used to model a problem and to make inferences from them. Section 3 describes the case study of this paper and its modeling. In Section 4 we present the various inferences that could be made from the network. Section 5 concludes the paper.

2. Bayesian Networks.

A Bayesian Network (BN) is a directed acyclic graph (DAG) in which each node represents a random variable of a problem domain. A directed edge e = (Xi, Xj) shows a causal relationship between the nodes; i.e. variable Xj is dependent on Xi. Each variable Y has a discrete state space of the form {y1,…,yk}, and for a problem domain it is assumed that the size of the state space is small. Each node has a node probability table (NPT) associated with it. If a node is a root, then it is a marginal probability table; i.e. NPT for Y, assuming that it is a root, is of the form {P(Y=y1, P(Y=y2),…, P (Y=yk)}. Here P(Y=yi) means the probability of Y being in the state yi. If Z is an interior node with parents S, T and U, and their state spaces are as in (Fig. 1), then each entry of the NPT for Z is a conditional probability P

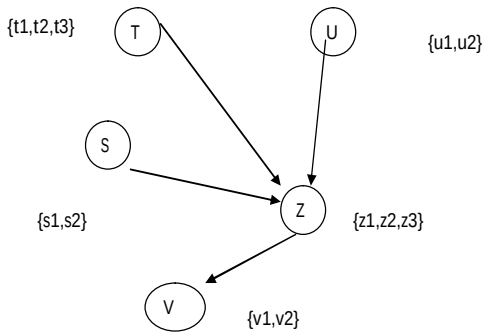

Fig. 1: A Bayesian Network with 5 nodes

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(Z=zi|S=sj,T=tk,U=ul); i.e. the probability of Z being in state zi given that S, T and U are respectively in states sj, tk and ul. We now quote an important theorem from (Neapolitan, 2004).

Theorem 1: Let G be a DAG in which each node stands for a random variable. The discrete conditional probability distribution (DCPD) of each node given values of its parents has been given. Then the product of these conditional distributions yield a joint probability distribution P of the variables and (G, P) satisfies Markov condition. (Markov condition here means: a node variable of the DAG is conditionally independent of the set of its non--descendants given the set of its parents).

If X1,…,Xn are the random variables then the joint probability distribution is given by

$$P(x1,\ldots,xn) = \prod^{i} P(Xi=xi \mid parents(xi))$$

In relation to Figure 1, we have:

$$P(v1,z1,s1,t1,u1) = P(v1 \mid z1) .$$
$$P(z1 \mid s1,t1.u1) . P(s1) . P(t1) . P(u1)$$

Here P(v1,z1,s1,t1,u1) stands for P(V=v1,Z=z1,S=s1,T=t1,U=u1). P(v1|z1) stands for P(V=v1 | Z=z1).

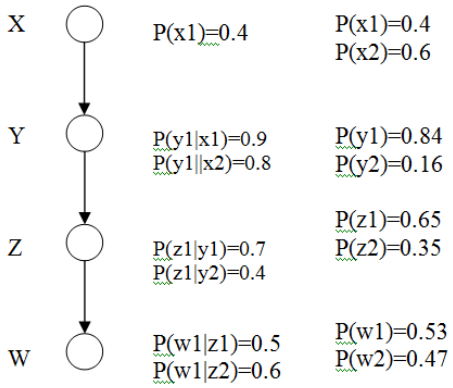

Fig. 2: A Bayesian Network in the form of a chain

The following example has been taken from (Neapolitan, 2004). The BN of (Fig. 2) has four nodes in the form of a chain. Each NPT describes the node conditional probabilities. It is assumed that each node has two states, and therefore, the probability of one state has been given for each node. According to Theorem 1, a node probability only depends on it parents and they can be computed as follows.

P(x1) = 0.4 and P(x2) = 1 – 0.4 = 0.6
P(y1) = P(y1|x1)(P(x1) + P(y1|x2) P(x2) = 0.84 ; P(y2) = 1 – P(y1) = 0.16

Similarly other probabilities can be calculated and they have been shown in the figure. The given probabilities are termed as default or the prior probabilities. We will now demonstrate the inference in presence of evidence. Let us assume that we know for certain that variable X is in state x1; i.e. P(x1) = 1 and P(x2) = 0. This network satisfies Markov condition; therefore, this new evidence will have impact on the prior probabilities of the variables in the following way.

P(y1|x1) = 0.9
P(z1|x1) = P(z1|y1,x1)P(y1|x1) + P(z1|y2,x1).P(y2|x1)
= P(z1|y1)P(y1|x1)+ P(z1|y2)P(y2|x1)
= 0.67

Other values can be recomputed in a similar manner. These are called the posterior conditional probabilities and from which we can obtain the individual node probabilities. It is worth noting that evidence can be incorporated into any node in this network. If we are certain that W is in state w1, then with this new evidence we can alter the prior probabilities of X, Y and Z. For instance,

P(z1|w1) = P(w1|z1)P(z1) / P(w1)
= 0.61 (Bayes' Theorem)

Thus the impact of evidence can propagate either in downward direction or in upward direction. In the present case the BN is in the form of a chain. However, when it is a DAG, sophisticated algorithms do exist (Lauritzen and Spiegelhalter, 1988) and Jensen et al. [1990]) which can compute the posterior probability values of the nodes. Many tools use such algorithms to perform inference over BNs where the random variables have discrete states.

3. The Case Data on Silversmithy in Silver City

The artisan silversmiths produce silver filigree items, made of silver drawn into fine wires and foils, which are artistically joined together in a framework of delicate designs. Filigree work is the inherited traditional art, created by the genius of silversmiths, for which they are locally called "RoupyaKaras" or "Rupabanias". The silver filigree is distinguished from other ornaments and jewellery by its exquisite finish, dexterous foils, fine texture and snow gloss. Cuttack city is popularly known as the 'silvercity', named after the occupation of silversmithy. The term 'tarakashi', the local name of silver filigree is believed to be a Persian term. Ancient Hindu traders of Odisha, engaged in trade with Ceylon, Persia and other Middle East countries, are said to have imported the term 'Tarakashi' from Persia in course of their trade and have continued to use it since then (Table 1).

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The artisans are of two type's owner craftsmen who are Self-employed family businessmen (102) and paid workers-65. Owner craftsmen are those entrepreneurs from a given family, owning the capital, having their own organization, running the risk of incurring losses and employing paid-workers from outside the family on necessity. They run the business as a

Table.1: Problem Dimensions, Solution Measures and Policy

Indicators	Problem Dimension	Solution Measures/Policy
luctive Resources	1.(a) Shortage of funds	1.(a) Banks to provide concessional finance and procedures for availing finance must be easy.
	1.(b) Inadequate infrastructure	1. (b) Institutional finance to be supported by consumption loans, working capital loans be provided
	1.© Low investment	1. (c) Revitalization of co-operatives to finance and provision for raw material
	1.(d) Impossibility of profit	1.(d) Monthly quota of silver filigree materials be provided by informal sector raw-material banks.
	1. (e) High cost of raw materials	1.(e) Market Survey
	1.(f) Impurity of products	1.(f) Standardization of finished products
2. Income & socio-economic status	2.(a) Insufficiency of income	2.(a) Employment and product expansion
	2.(b) No savings	2.(b) Minimise the expenditure
	2.(c) Degradation of standard of living and deterioration of socio economic status	2.(c) Giving due official recognization, detailed census and genealogical study by independent research team.
	2.(d) poverty	2.(d) Productive activity and appropriate utilization of time.
3. Marketing	3.(a) Middlemen's exploitation	3.(a) Governmental intervention.
	3.(b) Clandestine competition	3.(b) Apt market network
	3.© Lack of export promotion	3.(c) quality control mechanism
	3.(d) Refusal of Govt. orders due to delay in payment	3.(d) establishment of Govt run factories
		3.(e) Market survey and export promotion
	3.(e) Want of advertisement and publicity	3.(f) Due publicity and advertisement to build up customer's faith
		3.(g) Common production programme
		3.(h) Ministry of labour and industry to set up home working units.
4. Credit	4.(a) Lack of access to or non-availability of credit facility	4.(a) Identification of 'need' through base line research
	4.(b) Informal borrowing and high interest rates	4.(b) credit facilities through banks and co-operative societies
	4.© Indebtedness	4.© Registration and identification of beneficiaries.
		4.(d) A comprehensive committee with concerned authorities. 4. (e) Role of NGOs, voluntary organizations and professional social workers.
5. Organization and cooperatives	5.(a) Poor organization	5.(a) Artisans interests to be protected
	5.(b) Co-operatives defunct	5.(b) to organise the artisans on common interests
	5.(c) Powerlessness	5.(c) to encourage organization of home workers.
		5.(d) Role of NGOs, voluntary organizations, political parties and professional workers.
		5.(e) Unionization, participation
		5.(f) Revitalization of co-operatives
6. Motivation	6.(a) Lack of motivation	6(a) to provide motivational help
	6.(b) Sucidal tendency	6(b) Employment and product expansion.
		6(c) Insurance and social security provisions
		6(d) Govt. to sponsor detailed study
		6(e) NGOs and voluntary organizations help

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		6(f) Legal protection
7. Education and skill	7.(a) Low education and lack of development of proper skill	7.(a) Educational development and training of new skills and to upgrade existing skills.
	7(b) Low awareness	7(b) Younger generations to be encouraged.
		7(c) Creating awareness among them about governmental opportunities through artisans meetings.
		7(d) Free education for children or provision for scholarship.
		7(e) Apprenticeship at Govt. institutions free of cost.
8. Technology	8(a) Simple instruments	8(a) upgradation of technology and modernization
	8(b) Primitive technology	8(b) Introduction of new varieties and designs
	8(c)Lack of innovation	8(c) Need for innovative tendency.
9. Wage and facilities	9(a) Low wage	9(a) Extension of minimum wage legislation, enforcement and monitoring.
	9(b) Longer hours of work	9(b) To establish and inspectorate
	9(c) Absence of social security benefits	9(c) Provision for governmental benefits, social security, etc.
		9(d) Written contracts between employers and employees.
		9(e) Fixation of working hours.
10. Health and hygiene	10(a) Eye sight problems	10(a) Modernization of drainage system through Govt. of India
	10(b) Health problems	10(b) Eradication of mosquito through specific schemes
	10(c) Insanitation and unhygienic conditions	10(c) Opening of special eye hospitals
	10(d) Mosquito prone area	10(d) free health care.

family co-operative employing workers largely from inside and occasionally from outside the family and drawing the capital resources from the family. Household is a place of work. 85 percent cases of the workshops that the researcher investigated are located at the main entry room of the artisan's houses (Mohanty, 1993). These were only production and repairing units with occasional sales operations. The system runs on one principle, i.e. "each one's responsibility is everybody's responsibility". The paid workers are those who sell their labour (without having capital of their own) to a wage-paying employer, who are self-employed family businessmen.

Again although the owner craftsmen occupy the position of owners, small-scale operations and the meagreness of resources mean their ownership limited by their dependence on the petty traders (merchants or middlemen who are locally called 'Bhatias'). Thus the owner artisans represent a nebulous category. They are neither employed nor do these traders strictly occupy the position of employers, but the major part of their income part takes the nature of wages. The artisans to whom these traders supply raw materials and money and who deliver products in return in lieu of making charges are not strictly the wage earners. They retain their individual workshop and most important asset in the craft, which is "skill." The middlemen monopolize the very initiative and enterprise in addition to the trading of wares. Further the position seems to be rather anomalous - the artisan is neither an enterprising craftsman nor a pure and simple wage earner. Nor do the traders who bank on the products made by the artisans have the workshops where the artisans would merely work in lieu of the wages for the labour put in.

The unregistered character is evident in case of silver smithy (169 cases) of Cuttack. Small size itself makes it necessary and possible to run an organization without a structured division of labour and management hierarchy. The owner artisans and non-owning casual labour invariably engage themselves in production activities. A large majority of the artisans follow "no fixity" in regard to the hours of work in the workshop. During the months of festivity and marriage, the artisans get heavier orders and are found working up to midnight. Perhaps one of the very few fields, which have been little influenced by today’s technological breakthrough, is the craft of filigree. Except for wire drawing and plate making which may be done mechanically, filigree craft is purely hand made. In some cases the middlemen provide acids.

In regard to the place of sale, the choice of the artisans is very limited. Since these artisans are petty producers, except a few, many don't deal with the customers directly. Ordinary customers are the major consumers of the filigree items; however, they

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directly go to the show rooms for purchases; at times they approach the owners and buy items directly from them. Show rooms also receive orders to export filigree items to outside of the country. Although co-operative society in the name of Odisha Filigree Workers Co-operative Society exists, because of its hard terms and conditions, the artisans have preferred middlemen to the co-operative society. Even Central Co-operative Bank located adjacent to this society at Nimichouri does not advance loan to it because of its uncertain future. At present there are four parallel workers filigree cooperative societies in Cuttack city found name sake with signboards hanging and doors locked from outside viz. 1) Odisha Filigree Workers Co-operative Society 2) Jaganath Workers Filigree Co- operative Society 3) Sriram Filigree Workers Society and 4) Maa Chandi Filigree Workers Co-operative Society. There was a move to merge all the four filigree workers co-operative societies into one. i.e. Central Filigree Workers Co-operative Society, but that was not possible because of lack of unanimity and infighting among them. Therefore marketing through the State Co-operative Handicraft Corporation becomes difficult. Thus since most of the producers do not have sale outlets and required raw materials of their own, the artisans depend on the middlemen for the sale of their products.

The middlemen not only monopolize the organization of manufacture but also the trade of products. This is suggestive of the defunct character of the filigree co-operative society and the utter helplessness of the artisans. The export of silver filigree products has been halted after Government's ban on silver export since 1974. After that neither the artisans have taken any interest nor has there been any initiative on the part of the Directorate of Export Promotion Marketing to streamline the exports.

There is unanimity of opinion amongst the artisans that they are getting a very poor return indeed for their work (Mohanty, 1993). The income of owner craftsmen depend on the availability of orders and the number of family members engaged. Amongst the family businessmen, the highest level of income does not exceed Rs.7000/- per month. The entrepreneur's income accrues from their own investment and the cost of production inclusive of the wages realized from the middlemen. Besides, while supplying materials, the middlemen allow wastage of 10 percent and the entrepreneurs try hard to keep the wastage at the minimum so that the saved material adds to their income. The artisan entrepreneurs also steal a portion of the material supplied to them by the middlemen and add further alloys. Similarly the interest of consumer is what is discounted the most in this craft. The artisans are seen making silver from the dust and refuse of their own workshops.

The employers pay wages to the casual labourers who are the non-kin paid workers. While labour productivity is significantly high, the wages paid to them are substantially low. A few of the experienced workers (only 6 out of 65 workers) who insist on working on piece rate receive better wages, but a majority of them are not paid what they deserve for their labour. Their income oscillates around the subsistence level. Some of the workers were found sympathizing with the owner artisans saying that payment to them depends on the type of payment they receive from "Bhatias" (middlemen). Casual workers who work for wages under employers do not receive more than Rupees 2000 a month. Their income is never sufficient to meet their expenses. A mere total of 4 percent of the total respondents leaving aside 96 percent say that their income is sufficient. Insufficiency of income and growing indebtedness are not only found among the casual labourers but also among the owner craftsmen. Labour productivity is substantially lower than the average size of the family, which stands out to be an additional burden on them. The main reason for incurring debts is to meet the day-to-day expenses. While borrowing money for the raw materials, they divert a part of their loan to meet the day-to-day household expenses.

The artisans are fully trapped in the exploitative relations of production. Artistic skill and proficient craftsmanship do not count as the most important element in the silversmithy of Cuttack as it might be expected in a craft like this. These middlemen procure silver, copper, and zinc from the wholesale market in large quantities and in suitable shapes. Almost all of them affect the admixture at some place with the help of a few trusted artisans and deliver the alloy to the artisans for manufacturing. The artisans deliver the products in return for making charges. The artisans sell their ornaments mostly to the middlemen. The delivery of the products to the middlemen is concomitant with supply of the raw materials and the artisans say that they depend on the middlemen for finance. The artisans do not name the middlemen for fear of being exploited and being looked down upon by others. The single most important source of exploitation of the petty entrepreneurs lies in the cunning impression management of the middlemen (Mohanty, 2003). The escalation of the price of raw materials and the artificial dearth of raw materials are generally the reasons shown by these traders to deprive the artisans of getting the work in time or on the other hand to compel them to pay higher rates for raw materials.

Middlemen provide the raw materials and take the finished products at a lower rate and promote sale at a high price in organized show rooms. The exploitation of the casual workers by the owners is attributed to the type of exploitative situation to which producers are drawn by the middlemen. One of the entrepreneurs said: “The 'Bhatias' (middlemen) have sucked our blood. Our payment of wages to the workers depends on the type of payment we receive from 'Bhatias' “. When asked, "Why do you not deal with organized show rooms directly?" One of the entrepreneurs said: “We do not have that much of capital to cater to the large scale contracts of the organized show rooms. Where from shall we get those raw materials and money?” Exploitation by middlemen has not only changed the very character of filigree industry but also has seriously affected the conditions of the workmen (Mohanty, 2009). The middlemen exploit the petty producers and the casual workers are doubly exploited directly by the entrepreneurs and indirectly by the middlemen. Not only in this industry are the workers doubly exploited but also the middlemen

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are doubly profited. The source of double profit lies in the fact that the middlemen supply the raw materials at a high price, thus taking the finished products at a low price from the petty producers and selling them at a higher rate than the standard price.Employer-employee relationships in the silver filigree industry are not only contractual but also superficially cordial. Only an oral contract exists between employer and employees. The employers seem to be interested in getting their work done and the workers are supposed to have no other interest than to work for them. It is quite noteworthy that although the artisans are dissatisfied, they want to continue with their present job. During the field work one of the entrepreneurs said: "I am at a big loss. May be I choose some other occupation. But it is too late for me as well as my children because I have not been able to give adequate education to my children for a non-traditional occupation". When the artisans are inclined to change the job, they have permanency of job and better wages in mind.

4. Bayesian Modeling

We have identified the following nine random variables of interest from this problem domain; in the brackets we also indicate the cardinality of the state space of each of the variables after discretization. For instance, the variable Worker's Economic Condition (Worker_cond in Fig. 4) has been discretized into 4 states: *minimum, low-medium, high-medium and high*. The state space of all other variables should be obvious from Fig. 4.

- Worker's Economic Condition (4)
- Owner's Health (Economic Condition) (4)
- Show Room Status (2)
- Ordinary Customer Support (to Owners) (2)
- Government help (3)
- Co-operative Society Health (3)
- EPM Department Effort (3)
- Export Order (2)
- Middleman Control (4)

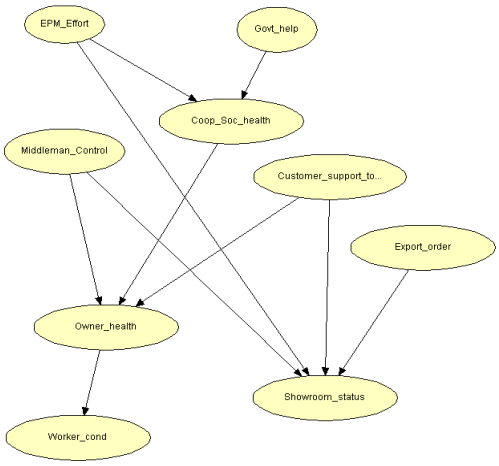

Fig. 3: A Bayesian network model of the Case

We have formed a BN with the above nine variables as node variables. The causal relationships between the variables have been derived from expert knowledge and domain analysis; this has also been corroborated by the qualitative data which we obtained after interviewing the various parties involved in the craft environment. The most important aspect of the model was in forming the node probability tables. We have incorporated the conditional probabilities into network by mostly consulting the experts (Senior and experienced artisans, Assistant Director of the Directorate the Bureau of Statistics and Economics (Bhubaneswar), Assistant Director of the Directorate of Export Promotion and Marketing, the Deputy Registrar, Industrial Cooperatives (Cuttack) and his section office and some office bearers of the defunct co-operative societies), and from available literature. The resulting BN has been shown in (Fig. 3).

5. Inference using the BN

Figure 4 shows the default probabilities of the nine nodes in the BN. Next, we will make inferences from the network by entering evidences. The qualitative and quantitative data showed that the middlemen have absolute control over the whole of the filigree industry. In addition, it has been seen that the condition of the co-operative societies are very poor indeed.

If we incorporate these two evidences to the BN; i.e. we assign P (middleman_control=very_high) = 1and (cooperative_Soc_health = bad) = 1 then we get the network of (Fig. 5).

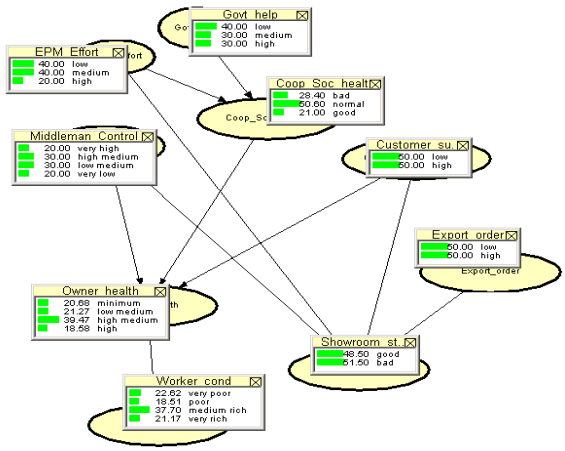

Fig. 4: BN with default node probabilities

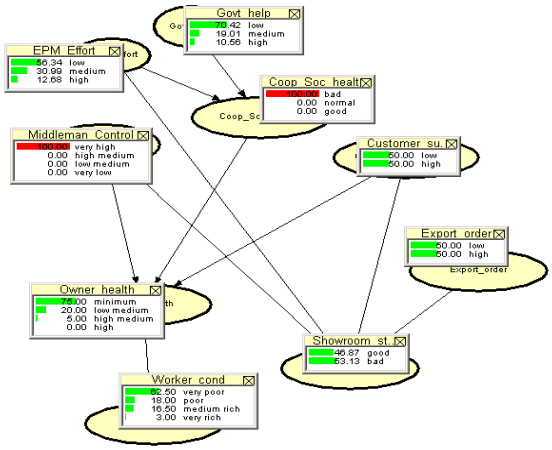

Fig.5: Inference from evidence (a)

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The new network shows:
P(worker_cond = very_poor) = 62% and P(owner_health = bad) = 75%

This means, the owners and the workers would both remain extremely poor. Thus the BN of Figure 5 truly represents the present economic conditions of the workers and the owners. Now the question arises: assuming that the middleman's control remains very high, what could be done to improve the economic conditions of the workers and the owners. To answer this question, we introduce the evidence:

P (middleman's control = very high) = 1 and P (owener's health = high medium) = 1

Fig. 6 shows the resulting BN. What it says that in order to raise the owner's condition to high medium, the functioning of the

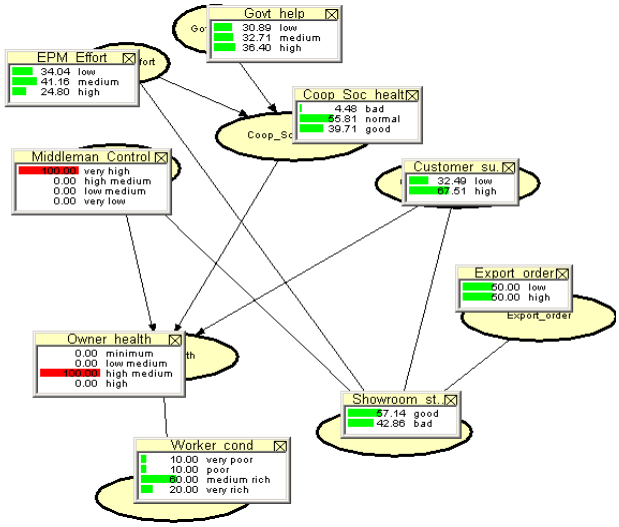

Fig. 6: Inference from evidence (c)

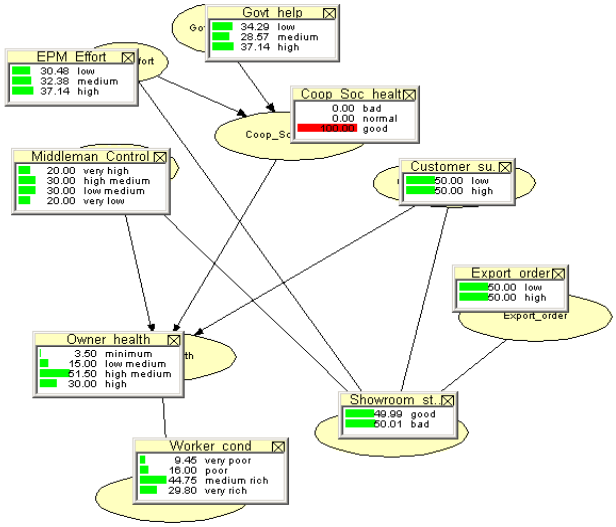

Fig. 7: Inference from evidence (b)

co-operative society should be at normal level, and in addition, they should receive adequate support from the members themselves to attract Government help and the ordinary customers.

If we incorporate the evidence
P (co-operative_Soc_health= very_good) = 1, then the Fig. 7 shows the resulting BN. What it shows is that making the functioning of the co-operative societies good itself would reduce the control of the middlemen.

6. Summary and Conclusions

Identification of problem dimensions and corresponding solution measures or control of policies with reference to each indicator may be schematically represented in the form of the following Table. However, the problem dimensions and solution measures do not represent any order of importance or ranking nor is there any one tone correspondence between specific dimensions and specific measures. Looking back to the issue raised in the beginning, a Bayesian Network has been constructed to model the socio-economic environment surrounding the employers and the workers of the silver filigree industry in the Cuttack City of Odisha. The Inferences that we obtain from the network not only reveals in a quantitative manner the present economic conditions of the workers and the employers but it also suggests what could be done to improve upon the existing conditions. Unless otherwise the support base and financial strength of the artisan owners is improved, survival of the dying craft shall be difficult and workers economic condition shall further deteriorate. Middleman's control can be brought to the minimum if the Co-operative Society Health improves under Government monitoring and assistance and the owners become self-reliant. Efforts need to be directed towards publicity, appropriate market network and greater customer care.

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