M. Tech Project Work Report

On

Technology based Prevention of Cartelization in APMC

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November, 2020

DECLARATION

I hereby declare that the M. Tech Project Work Report entitled **UDAY KUMAR VUSIRIKAPALLY** which is being submitted to the **National Institute of Technology Karnataka, Surathkal** in partial fulfillment of the requirements for the award of the Degree of **Master of Technology** in **Computer Science and Engineering** is a *bonafide report of the work carried out by me.* The material contained in this report has not been submitted to any University or Institution for the award of any degree.

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Guide

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Abstract

Firms in an industry compete with each other and practice methodologies that will eventually end them up in a less profitable situation. In such situations competing firms collude with one another on an agreement to form a cartel. This will benefit the members of the cartel to increase their profit collectively. Cartels are considered to be illegal in most of the countries around the world. Agricultural Produce Market Committee (APMC) is a marketing board in India that regulates the farm to retail price of agricultural produce and ensures farmers are safeguarded from exploitation by large retailers. One of the loopholes of APMC system is cartel. This report tries to address the problem of cartel in APMC through technology based solution. The goal is to design an algorithm that takes APMC data as input, analyses the data and detect cartels in APMC. Two methodologies namely profit based approach and trust points based approach have been explained in this paper. Partial implementation of the profit based approach is implemented and tested on custom data values which gave expected results. Further improvements and set of rules need to be assigned to the approaches and an algorithm should be defined. Implementation of the algorithm should be done and tested on an existing dataset if possible. Results obtained should be shown and conclusions on the objectives achieved to be mentioned.

Keywords: APMC, Cartel, Trust points

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Chapter 1

Introduction

Individual organizations which belong to an industry tend to compete with the other organizations in the same industry. Such organizations are known as competitive organizations of that industry. Competitive organizations that produce the same type of product will follow their own strategies to improve their own sales and individual profits of their respective organization. The competition between two competing firms of the same industry will enable the firms to reduce the cost price of the product in order to increase sales and profits than the other competing organizations. The following is a simple example explaining the situations how a cartel will arise.

Let us consider a scenario where there are to firms A and B manufacturing the same or similar product. Note that the term organization and term firm are used interchangeably in this paper both having the same meaning. Both the firms A and B initially sell their respective products for the same price say Rs.10. Also assume that both the firms are having more or less the same customer support. Hence both the firms make same profits. Let us consider that firm A attracts the customers by decreasing its product value to Rs.9, hence firm A will make profits because all the customers come to firm A as they are attracted by the low price provided by the firm A. At the same time no customers will go to firm B due to more price of the product compared to the firm A hence firm B will end up in loss. Now firm B will also follow the same strategy by reducing the product value to Rs.8. All the customers will buy the product from firm B and firm A will end up in loss now. This process of competition repeats and eventually both the firms end up selling their products for very low profits. This type of situations will encourage both the firms to collude to form a cartel. The situation is explained as follows. If firm A and firm B would have

had an agreement on the price of the product in the market this situation of both the firms ending up in low profits would have never shown up i.e., if firm A and firm B would have had a secret agreement on selling the product for Rs.10 or more and also agree to share the customer support equally the situation of both the firms ending up in least profits wouldn't have shown up.

In scenarios similar to this competing firms collude on an agreement and form a group. This agreement would help them regulate the product price in the market and collectively improve the profits of both the firms. This formation of a group to regulate the price of the product and dominate the market is called cartelization. Such a group is called a Cartel.

A Cartel is a group of independent competitive market participants under the same sphere of business who collude with each other in order to improve their profits and dominate the market. Cartel consists of two or more competitive participants of the same industry. The members of the cartel seek to reduce the competition by controlling the price in agreement to one another. Some of the practices used by the cartel to cut the competition include product output restrictions, price fixing, collusive bidding, market allocation, customer allocation.

1. Output restriction cartel : In product output restriction cartels participants of the cartel will agree upon the quantity one should produce. Based upon the product quantity they produce the participants profits are depended.

2. Price fixing cartel : In price fixing cartels the participants of the cartel will collectively decide a price for the product. This product price fixing decision by the cartel will decide the price of the product in the market. Hence making cartels as a monopoly in the market as they are acting as a key factor in fixing the price of the product.

3. Collusive bidding cartel : Collusive bidding can be taken place in auctions. Participants of the cartel will choose one of the member of the cartel who should win the bid. The chosen member of the cartel will bid for some price which brings him more profit. All the other members of the cartel wantedly bid for a very low price so that the chosen one should be the winner of the auction.

4. Market allocation cartels : In such cartels the members of the cartel will distribute the customers according to geographic area. One cartel member is allowed to sell his goods only in his allocated area.

5. Customer allocation cartels : Customers are equally distributed among the members in the cartel.

Cartels are considered illegal in most parts of the world because they follow anti-competitive practices. Cartels affect consumers by increasing prices in products. It also affects other competing participants by acting as a monopoly and dominating the market.

APMC stands for Agricultural Produce Market Committee. It is a marketing board established by state government in India to ensure farmers are safeguarded from exploitation by large retailers, as well as ensuring the farm to retail price spread does not reach excessively high levels. Before establishing APMC farmers used to sell their farm produce to their money lenders. Money lenders used to buy the farm produce at a price of their choice. Due to this, farmers were in perpetual debt to the money lenders. To overcome this problem government of India has established APMC or Mandi. APMC is also called as Mandi. Mandi is a market area where farmers can bring in their produce and sell them in the market. A farmer can go to any Mandi in India and sell his/her produce in the Mandi. The stake holders of the APMC are farmers, traders, commission agents, laborers, Local bodies and government agencies. Farmers are the producers of the agriculture products. Traders need to take license from the government to take participate in the auctions which will take place in the mandi. Commission agents are the middle men between the farmers and the traders. Labourers are assigned by the mandi for various tasks. Local bodies is nothing but the mandi association. Government agencies is the state government who operate the mandis. Fig 1.1 and Fig 1.2 shows the pictures of a typical mandi. The following paragraph explains about the normal process flow in a Mandi.

Farmers bring their produce into the mandi and consult to a commission agent. Commission agents are assigned by the local body (mandi). Commission agent is responsible for cleaning, sorting and displaying the farmers produce. Then the produce is open for Auction starting from the Minimum support price (MSP) provided by

Figure 1.1: Photograph of a typical mandi.

Figure 1.2: Inbound and outbound logistics in mandi.

the Mandi. Licensed traders put in their bids to buy the farmer's produce. Highest bidder wins the Auction and gets the produce. Produce is bagged and loaded into outbound logistics. The trader who bought the produce has to pay 6 percent tax on the bid he/she has kept. This amount is paid to the commission agent. Commission agent cuts 1 percent as tax for cleaning, sorting and storage from the winner's bid and the rest amount is given to the farmer. This is how the normal process flow works in mandi. The scope of a cartel in a mandi is explained in the following paragraph.

Some of the traders collude with one another to form a cartel and fix their price on bid. They participate in auction with very low and fixed bids. Due to this the farmer may not get a fair price for his produce. Also, people in the cartel act as a monopoly and they buy the produce only if the price is very low. Hence, they act as a monopoly in the mandi.

Chapter 2

Related work

Even though cartels are present in many industries solid solutions through technology and standard rules to identify cartels in collusive bidding are not defined. This problem is raised due to lack of data. Labelled data defining cartels is not available since cartels won't reveal that they are cartels. Even though some members of the cartel reveal that they are cartels, there is very less chance we find all the cartels in the industry. So dataset is a major concern in this area of research. To detect cartels through data analysis one needs to have trader's behavioral data, bidding data. Even though this data is recorded by the agencies who are conducting the auctions, they are not revealed to the outside world. Organization for Economic Cooperation and Development (OECD) is an inter-governmental organization to stimulate economic progress and world trade. Even OECD says not to reveal the bidding data because this data may be used by the competing organizations to form cartels and data may be misused by the existing cartels.

OECD [2013] is the document that compromises proceedings of a roundtable by OECD on cartel Investigation and the use of screens to detect cartels. The document consists of discussion and the contributions of 25 countries towards the detection of cartel using screens. OECD [2013] majorly classifies detection of cartels into two types namely pro-active and reactive methods. Fig 2.1 shows the classification.

Reactive detection methods are based on information or evidence brought before the competition agency by third parties. Reactive methods include complaints, external information and leniency programs. Leniency or amnesty programs are considered the most effective reactive detection measure, especially because they provide the competition agency with direct evidence of a cartel. This in turn facili-

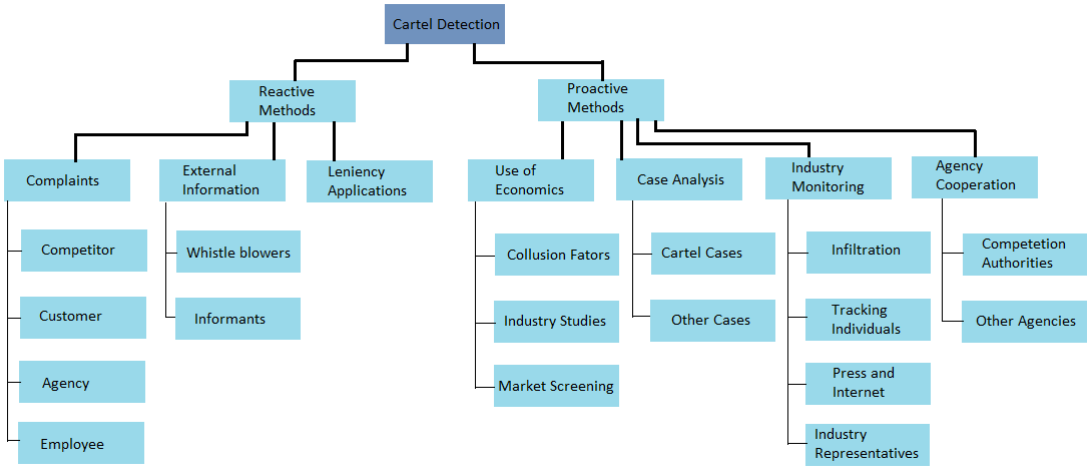

Figure 2.1: Pro-active and Reactive methods to detect cartels

tates the investigation of the illegal conduct and the subsequent punishment of the perpetrators.Pro-active methods include use of economics, case analysis, industry monitoring and agency cooperation. In contrast to reactive, pro-active detection occurs when competition agencies engage in cartel detection on their own initiative, i.e. pro-active methods of cartel detection are initiated from within the agency and do not rely on an external triggering event. India as its contribution provided screening methods among which one point is related to one of the methodology proposed in this paper. The point is, Rotation of competing vendors as the award winner over a series of tender awards. Similar approach is proposed as a method in this paper. South korea has been following a cartel detection mechanism which is similar to another approach that is proposed in this paper. They call it Bid Rigging Indicator Analysis System (BRIAS). The system monitors behavior of the traders taking part in each auction and gives an individual score to each trader. This score is helpful in detecting the cartels and differentiate between bad traders from the good traders. The traders score is calculated by an algorithm that runs in the background and analyses every transaction in the auctions. It also analyses the historical auction data which it has been analyzing from the start. Based upon the actions by the traders his/her score is increased or decreased. If the trader falls below a specific threshold then he/she is considered to be part of some cartel.

Bence Toth and istvan janos toth. [2015] provides a toolkit for detecting collusive bidding in public procurement.. The paper discusses about various approaches in

detecting collusion, robust elementary indicators and analytical tools for adapting them to local contexts. The paper delivers a conceptual definition and theoretical discussion for each indicator as well as a complex empirical assessment using data on over 75,000 contract awards in Hungary.

Pesendorfer [2000] has done a study on bidding for school milk contracts in florida and texas. Pesendorfer [2000] observed two types of cartels: one cartel divides the market among members and the other cartel uses side payments to compensate members for refraining from bidding.

Porter and Zona [1993] examines cartels in state highway construction contracts and says that detection of collusion is possible because of limited participation in the collusive scheme. They also say that collusion did not take the form of a bid rotation scheme. Instead, several ring members bid on most jobs. One was a serious bidder, and the others submitted phony higher bids.

Morselli and Ouellet [2018] focuses on collusion bidding patterns in Quebec's construction industry. Used Jaccard index to detect similarities in firm's interactions.

Conley and Decarolis [2016] present statistical tests to detect coordinated entry and bidding choices. The tests perform well in a validation dataset where a court case makes coordination observable. They used the tests to detect coordination in a larger dataset where it is suspected, but not known.

Wachs and Kertesz [2019] tries to detect cartels using a network-based approach. The author allocates one node to each trader who is participating in the auctions. If two traders are participating in an auction then the weight of the edge between the two traders is increased. This increment is done because if two traders are from a cartel there is very less chance of participating in the same auction. So, if two traders are participating in the same auction then we can sense that they may not be belonging to a cartel. Then we identify the groups of traders who bid for the same type of products using an overlapping community detection algorithm. Then calculate the topological features defined by the author. They are coherence and exclusivity. Coherence is the ratio of geometric mean to arithmetic mean of the weight of the edges in a group. Exclusivity is the ratio of strength within the group to the total strength of nodes in the group (including edges leaving the group). As features of groups of firms, coherence captures the consistency and intensity of interactions among firms in

the group, while exclusivity quantifies the extent to which group interactions happen in isolation from the rest of the firms in the broader market. The author says that the collusion is more likely to emerge among high coherence and exclusivity groups because they offer the ideal conditions for firms to learn to cooperate and trust one another. With this method they worked on a dataset of school milk contracts with a known cartel, a dataset of virtually all contracts awarded in the Republic of Georgia over several years, and in a simulation model of contracting markets with spatial correlations.

They plotted the distribution of groups in coherence-exclusivity space and with the help of their group detection algorithm they identified cartels for each year. They observed that groups in network that has been developed from the data exhibit high coherence and exclusivity than the model the network they simulated providing random bids.

Chapter 3

Proposed Methodology

Farmers bring their agricultural produce to the APMC for selling them through auctions. There will be auctions held separately for different products. Traders will participate in the auction by placing their individual bids. The highest bidder in the auction is considered to be won and the product in the auction will be given to that bidder. Traders form a cartel well before the auction takes place. They fix the value of the bid and agree upon a winner. All the other members of the cartel either doesn't participate in the cartel or bids for a very small amount compared to the chosen winner. Our Aim is to detect such cartels in APMC. The following are two methods that help in detecting a cartel.

1. Method based on profit share in cartel : We know that traders who form a cartel collude for collective profit i.e. the members of the cartel should get equal or approximately equal profits. Also, the members of the cartel would take turns to win the auctions. We use the profit factor along with the winning pattern of the traders to detect the cartel. APMC will be storing the data about the auctions. The following table represents some of the column names from the data stored by APMC.

Auction ID	Product type	Trader ID	Bid	Quantity	Retail price

Table 3.1: Auction Data Schema

APMC has multiple auctions for different products. Auction ID will be unique for every auction taking place in the APMC. Product type tells which type

of product is sold in the auction. Trader ID stores the ID of the trader who won that particular auction. Bid tells the price of the product sold in that particular auction. Quantity tells the amount of product in the auction. Retail price tells the price of the product available to end users on that date. In order to maintain equal profits between the members of the cartel they will choose an order in which the members of the cartel should take turn in winning the auctions. An algorithm is run that monitors the data in the above table and lists out trader ID's who are making nearly equal profits on a periodic basis. After that the algorithm takes the above list of traders and observe if the traders follow any winning pattern in the previous auctions. If the winning pattern is repeated more than a defined threshold then we can say the list of traders are maintaining equal profits on a periodic basis and they are taking turns in winning the auction hence the traders in that list are found to be in a cartel.

For example, Say there are 5 traders with trader ID's from 1 to 5. Assume that traders 1, 2 and 3 are having equal profits on a periodic basis. Now we search for a winning pattern of the traders 1, 2 and 3 in the list which contains the trader ID's who won the auctions of apple which are listed according to time. Say the list trader ID's who won the auctions for apples from a point of time in the past is 4,1,5,2,3,1,2,3,5,1,4,2,3. Here it is observed in the list that the pattern 1, 2, 3 is repeated 3 times. Note that the pattern 1,2,3 might contain other trader ID's in between i.e, trader 2 wins the auction after trader 1 has won the auction but 2 winning after 1 may not be immediate. Similarly trader 3 wins the auction after trader 2 has won the auction. This analysis tells us that traders 1, 2 and 3 are having close profit margin and they repeatedly follow a pattern in choosing the cartel member to win the auction. Based on this two factors we can say that the traders who satisfy both the above two conditions have a very high chance of being in a cartel.

2. Method based on trust points: The idea is not to detect a cartel but to identify if a trader is part of some cartel or not based upon his/her actions. We do behavioural analysis of the trader and give each trader a score or trust point. We design an algorithm that takes various data as input including the data of

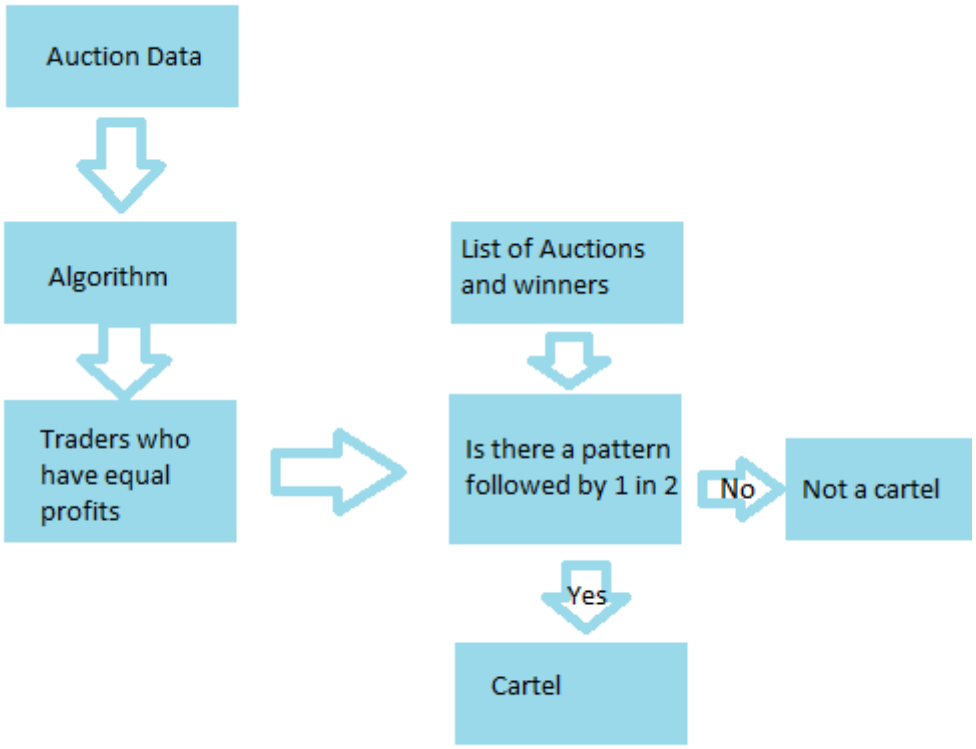

Figure 3.1: Flow chart

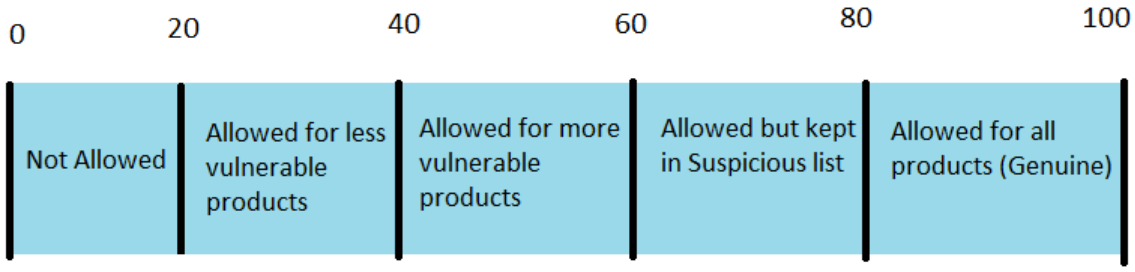

Figure 3.2: Trust points scale

each auction. This algorithm runs for each auction taking place in APMC and increases or decreases the trust point of traders based on some factors. If the trust point of a trader falls below a given threshold then we can say that he/she is part of some cartel. If the trust point of a trader falls below some other threshold we can say he/she is not eligible to participate in auction's of some of the products. Fig 3.2 shows the model of a trust point scale.

We categorize the products in APMC into more vulnerable to cartels and less vulnerable to cartels. If the trust point of a trader is in the range 80 and 100 we consider him as a genuine trader and the trader is allowed to participate in auctions of all the products in the APMC. If the trust point are in the range 60 to 80 we list the trader under suspicious traders and the trader is allowed to participate in all the auctions of all the products. If trust point is in range 40 to 60 we list the trader under a concentrated list and the trader is allowed to participate in limited number of auctions per day of all the products . If the trust point falls below 40 and is more than 20 then the trader is not allowed to participate in auctions of more vulnerable products but the trader is allowed in participating auctions of less vulnerable products. If the trust point of the trader falls below 20 then the trader is not allowed to participate in any of the auction.

We can consider coherence and exclusivity as discussed in chapter 2 as a parameter that alters the trust points of the trader. We can also consider the winning patterns discussed in method based on profit share in cartel to alter the trust points of the trader.

Chapter 4

Results and Anlysis

It is hard to find a real time dataset of APMC from online sources. We cannot easily spot any other auction datasets from online sources. Even OECD (Organization for Economic Co-operation and Development) says that the auction data should not be made public as it may be useful for the cartel groups. Even if we find an auction dataset there is very less probability that the data is labelled with respect to cartel or not. Finding datasets in this domain is a difficult task otherwise one has to develop his/her own dataset.

Working of APMC, cartel system, types of cartels and cartels in APMC are studied and explained in the previous sections. Proposed two methodologies as a starting point in detecting the cartels. One method is based on the profit share between the members of the cartel. This method finds out the traders who are having equal or nearly equal profits and checks if they are following any winning pattern in the previously held auctions of that particular product. If the pattern is found more than a fixed threshold then that set of traders are considered to be part of a cartel. The other method to detect cartel members is based on trust points. This method does not exclusively find a cartel and all its members but, it tells us how good is a particular trader by giving him a score. This score is calculated by the analyzing the behavior of the trader on various factors.

Part of the proposed methodology using profit share in cartel is implemented. Used java to implement the said approach. This is achieved through coding the approach into a java program. The program is written in Eclipse IDE. The program takes list (L1) of trader ids who won the auctions of a particular product and the list (L2) of trader ids who get equal profits on a periodic basis as inputs. The program computes

all possible permutations of L2 because with the current set of traders in L2 they can follow any order that may appear in L1. So the program generates every permutation of L2 and checks if the sequence L2 is followed in L1. If the pattern appears in the L1, there is no proof that the traders are forming a cartel. To improve the probability the programs counts the number of such occurrences and compares it with a threshold value. If the count of such occurrences is greater than or equal to the defined threshold then the program comes to a conclusion that that particular permutation of L2 forms a cartel because that permutation sequence of L2 is repeatedly occurring in L1 more than the given threshold. Custom inputs are given to the program and tested only to produce the expected results. Fig 4.1 shows the screenshot of the program and its output.

There are two lists given as input in the program.

List 1 : 4 1 5 2 3 1 2 3 5 1 4 2 1 3 5 2

List 2 : 1,2,3,5

Subsets of list 2 starting from size 3 are considered one by one the starting being 1,2,3. The program generates all the permutations of the the subset I.e,

1,2,3,1,3,2,2,1,3,2,3,1,3,1,2,3,2,1

Each permutation is checked if such a pattern is present in list 1. The first permutation generated in the example problem is 1,2,3. Since this pattern is present more than three (threshold) times in the list 1, hence they are marked as a cartel. Similarly, subset 1,5,2 is found three times in the input string list 1. so it is also a cartel.

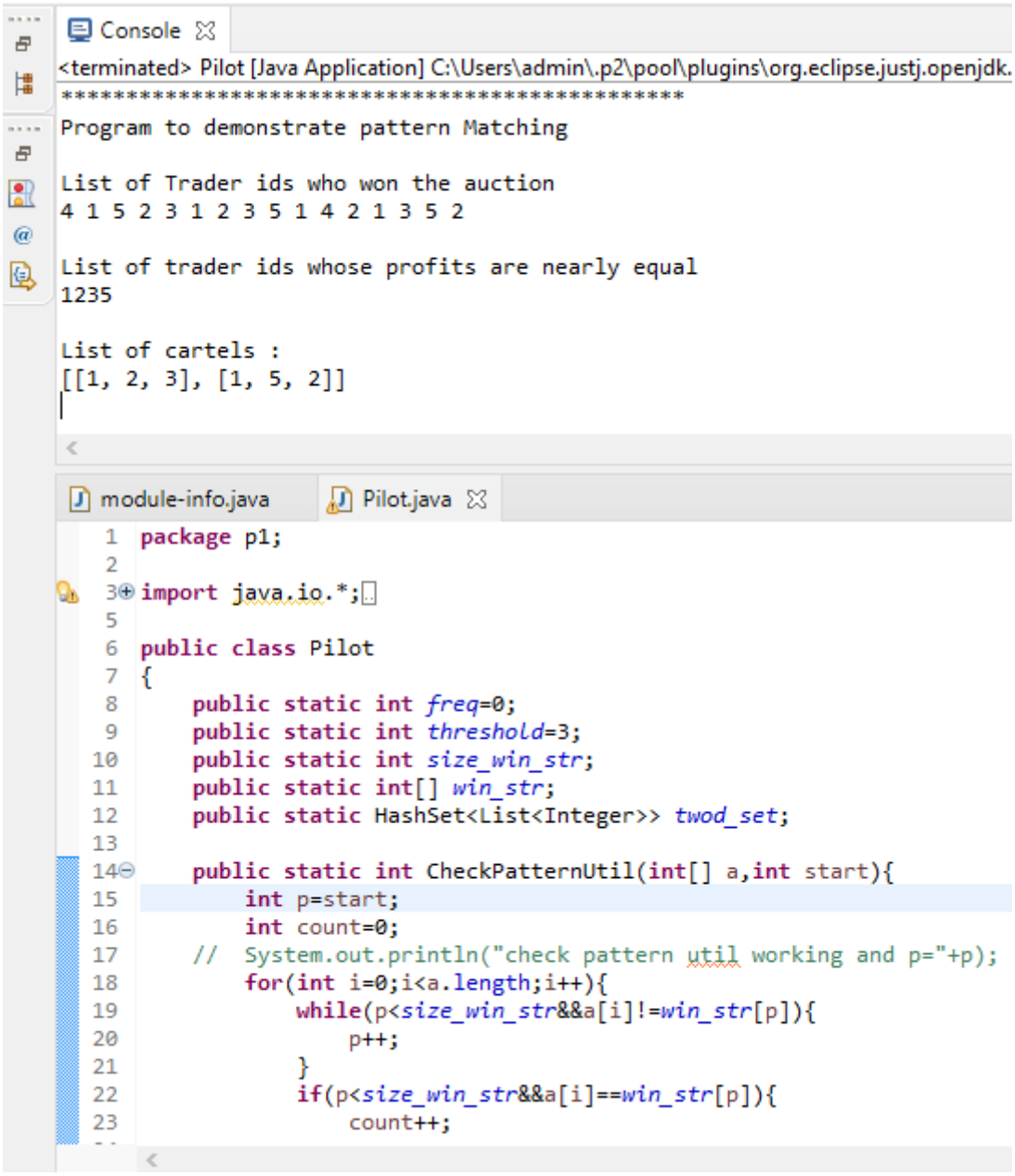

Figure 4.1: Screenshot of the program showing outut.

Chapter 5

Conclusions and Future Work

A thorough study is made on APMC. Studied why APMC are required and who regulates the APMC. Studied the workflow in APMC. Studied what is a cartel. Studied various types of cartels in the market. Studied cartel in APMC. Identified inputs that can be considered in detecting a cartel. Proposed two methodologies in identifying a cartel. One is based on profit share in cartel and the other is based on trust points given to the traders. Partial implementation of the first method is done by coding the method into a java program. Program is tested on custom inputs only to produce the desired results. Outline of the second methodology is proposed. Further objectives and future work are mentioned in the following paragraph.

To define standard factors that should be considered in altering the trust points of the second approach explained in this paper. Provide solid reasons why those factors are chosen. Develop an algorithm that incorporates all the above defined factors and implement it. Test the proposed algorithm and debug. Develop a demo web application to simulate the work done.

Bibliography

Agnes Czibik Bence Toth, Mihaly Fazekas and istvan janos toth. Toolkit for detecting collusive bidding in public procurement. 2015.

Timothy G. Conley and Francesco Decarolis. Detecting bidders groups in collusive auctions. *American Economic Journal: Microeconomics*, 8(2):1–38, May 2016. doi: 10.1257/mic.20130254. URL `https://www.aeaweb.org/articles?id=10.1257/mic.20130254`.

Carlo Morselli and Marie Ouellet. Network similarity and collusion. *Social Networks*, 55:21 – 30, 2018. ISSN 0378-8733. doi: https://doi.org/10.1016/j.socnet.2018.04.002. URL `http://www.sciencedirect.com/science/article/pii/S0378873317303751`.

OECD. Ex officio cartel investigations and the use of screens to detect cartels. 2013.

Martin Pesendorfer. A Study of Collusion in First-Price Auctions. *The Review of Economic Studies*, 67(3):381–411, 07 2000. ISSN 0034-6527. doi: 10.1111/1467-937X.00136. URL `https://doi.org/10.1111/1467-937X.00136`.

Robert H. Porter and J. Douglas Zona. Detection of bid rigging in procurement auctions. *Journal of Political Economy*, 101(3):518–538, 1993. doi: 10.1086/261885. URL `https://doi.org/10.1086/261885`.

Johannes Wachs and Janos Kertesz. A network approach to cartel detection in public auction markets. *Sci rep 9, www.nature.com/articles/s41598-019-47198-1.pdf*, 2019.