

DATA-DRIVEN DECISION MAKING

Course manual

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Disclaimer: The coordinator reserves the right to make changes during the teaching period to deal with unforeseen circumstances. Any such changes will be clearly communicated to the students.

1 Introduction

1.1 Purpose of the course and place in the curriculum

Data-driven decision making is an introduction to Microeconomics, specifically designed for the BSc program in Business Analytics. The purpose of the course is to help students take the first steps towards thinking like an economist. In particular, we will study the following:

- BASIC QUESTIONS that economists try to answer.
- STANDARD TOOLS that they use in order to answer these questions.

In this sense, the course focuses both on the content and the methodology of economics. Let us briefly describe what we will study in each of these two intertwined parts.

The general question that economists have been trying to answer is how economic agents make choices that have to do with allocating resources under certain restrictions. This question becomes more specific depending on the framework (i.e., the branch of Economics) where we ask it. For instance, in consumer theory, we ask how individual consumers choose to spend their limited budget across different goods. In the theory of the firm, we ask how firms choose the prices they charge given the technology that is available to them and their capacity. But importantly, Economics is not just about decisions related to money. In public economics, we ask how individuals choose how much to pollute using their car, given the time constraints imposed to them by using alternative means of transportation. The common theme in all these cases is that choices made by the different economic agents affect the allocation of scarce resources that everybody wants. It is exactly the fact that economics tries to answer questions from such a wide spectrum of frameworks that makes it so fundamental for several other disciplines, like business, marketing, computer science, just to mention a few. And this is why we study it so early in the curriculum, before we go into more specialized courses.

But of course, asking general questions with far-reaching implications comes at a cost. Namely, it becomes difficult to answer them. So, we need powerful tools and methods. Economics uses a mix of mathematics and data analysis in order to answer these questions. The first step that uses math is to take a problem from the real world (i.e., our question), then translate it into the language of math (i.e., build a model), then keep only the essential parts of it (i.e., make some simplifying assumptions), then do mathematical manipulations (i.e., solve the model), and finally translate everything back to the real world (i.e., make predictions). The second step is to use data in order to test these predictions. This means that we take actual behavior (either directly from the real world or from an experiment that we have designed) and we check whether it is consistent with what the mathematical model predicted. If yes, then we can conclude that we are sufficiently certain that our answer to the research question is good. If not, we have to go back to our model, refine it, and repeat the same process. Of course, you should be aware that *matching elegant mathematical models with messy data is more difficult than it sounds*. But nevertheless, this is the methodological approach that all of science follows, so economics could not have been different. And after all, this is what makes it interesting.

1.2 Structure of the course

Throughout the course, we will follow the first part of the textbook of Acemoglu, Laibson & List, which provides a modern introduction to microeconomics along the lines described above. It is interesting to know that all three authors are leading economists, having contributed in many areas of economics research. The course consists of seven topics, each corresponding to some chapter(s) from the main textbook (see course outline below). Additional material will be provided for certain topics. The topics that we will cover are:

1. **INTRODUCTION TO ECONOMICS:** You will be introduced to the main aims and methods used in economics. The focus will be on the three main principles, which are optimization, equilibrium and empiricism.
2. **DEMAND AND SUPPLY:** This is perhaps the most famous model in economics, analysing and predicting how prices are set and quantities are determined as a result of the demand and supply.
3. **CONSUMER THEORY:** We will take a step back, asking a basic question. Namely, how is demand formed in the first place?
4. **THEORY OF THE FIRM:** We continue asking a second basic question. Namely, how is supply formed in the first place?
5. **PERFECT COMPETITION:** This is one of the benchmark markets that we model in economics. We will discuss the underlying assumptions and study the predictions that this model gives us.
6. **EXTERNALITIES AND PUBLIC GOODS:** We will study different reasons why perfectly competitive markets often fail to lead to socially efficient outcomes.
7. **MONOPOLY AND OLIGOPOLY:** Two more market structures will be studied. Monopoly is the second benchmark case at the opposite end of the spectrum compared to perfect information. Oligopoly can be placed between the two extremes.

Our approach will be a mixture of theory and application. In particular, for each topic there will be one theory tutorial (on Monday) during which you will discuss designated questions and problems from the textbook. The aim of these tasks will be to make sure that you have understood the theory well. Then, there will be one project tutorial (on Wednesday) during which you will work on a project. The aim of the project is to understand how we use data to test hypotheses that come from our theories, and eventually provide answers to applied problems. All this is explained in more detail below.

1.3 Expectations

The course is clearly demanding (like most first year courses), as you will be exposed to many new ideas. It is very important to always keep in mind that the whole point is to understand the material, and not to simply memorize it. In order to achieve this goal, it is extremely important that you follow all the designated meetings and that you self-study according to the weekly schedule. Studying hard only before the exam is not enough. The minimum workload of self-study in order to pass the course is estimated at approximately 16 hours per week.

In terms of specific pre-knowledge, you are expected to have a decent understanding of the topics that you covered in your previous courses, and in particular there will be reference to things that you have already learned in Mathematical Analysis (EBC1042) and Statistics (EBC1044).

2 Course content

2.1 Outline of the course

The course consists of 13 tutorial meetings. In particular, each week there are 2 tutorials, except the fourth week in which there is only 1 tutorial (due to career days). Moreover, throughout the course there are 3 online office hours sessions during which you can ask questions (they will be announced on canvas).

WEEK	TOPIC	TUTORIAL	TASK	LITERATURE
1	Introduction to Economics	Theory	Q: 1.3, 1.7, 2.2, 2.3, 2.6, 2.8 P: 1.1, 1.9, 2.7, 3.6	1 – 3
		Project	Returns to education	
2	Demand and Supply	Theory	Q: 4.1, 4.4, 4.5, 4.6, 4.7, 4.9 P: 4.4, 4.9, 4.13	4
		Project	UBER during Covid	
3	Consumer Theory	Theory	Q: 5.3, 5.5, 5.6, 5.8, 5.13 P: 5.1, 5.6, 5.10, 5.13	5
		Project	Demand for UBER	
4	Theory of the Firm	Theory	Q: 6.1, 6.2, 6.6, 6.8, 6.10 P: 6.4, 6.6, 6.8, 6.9	6
		Career days		
5	Perfect Competition	Theory	Q: 7.1, 7.2, 7.3, 7.4, 7.9 P: 7.1, 7.3, 7.10, 7.12	7
		Project	UBER market prices	
6	Externalities and Public Goods	Theory	Q: 9.1, 9.2, 9.4, 9.10, 9.11 P: 9.2, 9.10, 9.11, 9.12	9
		Project	Public good game	
7	Monopoly and Oligopoly	Theory	Q: 12.1,12.3,12.9,14.8,14.11 P: 12.5, 12.7, 12.11	12.1 – 12.5
		Project	Catching a cartel	14.1 – 14.2

2.2 The meetings

Here is some more information on how the tutorials will work:

2.2.1 Theory tutorials

There are 7 theory tutorials, always scheduled on Monday each week. The purpose of these meetings is to make sure that you have a good understanding of the designated literature.

Theory tutorials will be online with the entire tutorial group. For each meeting there will be two discussion leaders who are responsible to jointly initiate the discussion. There will only be some leniency for the first meeting (week 1), during which the tutor will act as discussion leader, but from week 2 onwards you are expected to take over.

The form of instruction will be a modified version of problem-based learning (PBL). There is a list of previously-specified tasks (see your timetable), consisting of Questions (Q) and Problems (P) from your textbook. Before each theory tutorial, you are expected to have carefully read the mandatory

literature (chapters from main textbook), and to have already carefully thought the tasks. Then, during the tutorial you are expected to answer the tasks using arguments from the textbook. You are also allowed to use other sources when you are building your arguments. Remember that PBL is at its best when students come well-prepared, engage actively during the discussions and are open to other opinions that are based on logical arguments. Physical presence alone is not sufficient. *You need to actively contribute to the joint learning effort.* And active contribution means that you need to discuss the questions in depth and even go beyond the questions sometimes: simple two-word answers (just to quickly go through the tasks) is not good practice.

The following rules of conduct should be followed during the tutorials:

- Be on time.
- Turn on your camera.
- Prepare your material (as described above) and avoid free-riding on others' efforts.
- Participate actively in the discussion.
- Take the role of the discussion leader seriously.
- Refrain from hostile behavior, such as derogatory comments towards fellow students or the tutor.
- Do not disturb in any other way.

2.2.2 Project tutorials

There are 6 project tutorials, each corresponding to one project. These tutorials will always take place on Wednesday and they will follow the theory tutorials. The idea is to apply the theory that you have already in scenarios that are close to reality. In particular, each project consists of a series of questions that you are expected to have prepared before your tutorial meeting (see appendix at the end of this course manual). Then, during the tutorial you will discuss these questions one by one, and in quite some depth. Some of the questions are conceptual, while some others are of quantitative nature. For some of these questions, you will need to use a dataset that you will be provided with. Regardless of the type of question, the most important thing is to use arguments that are based on the theory that has preceded the project. And once again, remember that *you need to actively contribute to the joint learning effort.*

2.2.3 Course material

The compulsory textbook for this course is:

- ACEMOGLU, D., LAIBSON, D. & LIST, J. (2018). Microeconomics. 2nd Global Edition, Pearson (ISBN 9781292214504)

Note that the book is sold with and without access to the online platform MyEconLab. In this course, we will only use the textbook, so you do not need to purchase access to MyEconLab.

Short online video lectures will be provided to you each via canvas on a weekly basis. The purpose of these videos is *not to replace your home study, but to supplement it.*

3 Performance assessment

3.1 Calculation of the course grade

In order to pass the course, you **must pass both the following tasks**:

1. **Participation:** For each tutorial meeting, each student will receive a grade on a scale 0 – 3. You will get 0 points if you do not show up; 1 point if you show up and do not participate; 2 points if you show up and you participate actively; 3 points if you show up and you participate actively and your input is of high-quality. This means that in total you can get between 0 and 39 points throughout the course. In order to pass participation, you need to fulfil both the following two requirements:
 - (a) Be present in at least 10 of the 13 tutorials
 - (b) Get at least 21 points in total

You can replace (a) with a course assignment. However, this is not advised unless absolutely necessary. In particular, if you elect to replace (a) with an assignment, you cannot get more than 21 points for participation. Plus the work load in the last weeks of the course will be very intense.

2. **Final exam:** The final exam will be open book and it will contain a mix of conceptual questions and quantitative problems. You will receive more information on the exact structure of the exam once the course has started. The exam will be graded on a scale 0 – 61 points. In order to pass the exam you need at least 34 points.

So overall, if you pass both parts, your final grade will be the total number of points from parts 1 and 2, divided by 10 and rounded to the nearest half. For example, if you score 30 points for participation and 37 points in the exam, your total number of points will be 67, and your grade will be 6.5. For the students who fail the exam, there will be a resit exam. The students who take the resit carry with them the participation grade. If you fail to collect 21 participation points, you fail the course and you need to repeat it. Note that partial grades obtained in this course remain valid for a period of three years, i.e., the academic year in which the grades were obtained plus two subsequent academic years.

3.2 Fraud and plagiarism

In order to protect the reputation of our degrees and the integrity of our school, instances of fraud or plagiarism are treated very seriously. Fraud is understood as a student's act or failure to act that makes it partially or fully impossible to correctly assess his/her knowledge, insight or skills. An example of fraud is cheating during an exam. Plagiarism is understood as the presentation of someone else's ideas or words as your own without proper reference to the source. An example of plagiarism is copying from someone else's paper, or copying from a textbook or an online source without explicitly mentioning where this was taken from.

If the board of examiners concludes that any offense related to plagiarism or fraud has been committed, they will initiate the procedures for imposing sanctions in accordance to the school's policies.

4 Contact information

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A Returns to education

An economist working for the Dutch Ministry of Education is asked the following question:

Should the government subsidize university education?

Q1: Is this question relevant for an economist?

Q2: What do you think one should do in order to answer it?

Let us start by building a model consisting of two parts, a cost and a benefit. Our model will be based on the following hypotheses:

- (a) Each additional 1k Euros of subsidy, increases the number of enrolments by 2000.
- (b) Having a university degree, increases the annual salary by 20% on average, from 30k to 36K Euros per year.

Q3: According to our hypothesis, what is the total cost for the government as a function of the amount that the government subsidizes per student?

Q4: Assume that the income tax rate is flat 30%. Then, according to our hypothesis, what is the total benefit per year as a function of the amount that the government subsidizes per student (assuming that all students who enrol also graduate)?

Q5: Assume that the government wants to maximize its net benefit the first year after the students graduate. Then, by how much should each student be subsidized?

Everything up to this point is a theoretical exercise. Usually, introductory economics courses stop here. Let us go a step further and now look at the data. We now want to test our hypotheses. We will use two datasets that we have access to:

- (a) One dataset (EBC1046_1.xlsx) with the annual salaries and the university education of 107 randomly drawn employees.
- (b) One dataset (EBC1046_2.xlsx) with subsidy levels and university enrolment numbers during the past 30 years.

Q6: Using linear regressions, estimate the effect of the subsidy on enrolments and the effect of having a university degree on the annual salary?

Q7: What can you tell about our hypotheses qualitatively? How about quantitatively?

Q8: Revisit Q5. Has your conclusion about recommended subsidy changed after you have seen the data?

Q9: Identify some of the assumptions that we have made.

Q10: How could we make our analysis more realistic?

Q11: Our conclusion in Q8 implicitly suggests that there is a causal effect between subsidy and university enrolment. Does our dataset allow us to draw this conclusion?

Q12: What additional information would you need in order to test whether this relation is causal or not?

B UBER during Covid

The management of UBER wants to understand the effect of the lockdown due to the pandemic in the Amsterdam area. In particular, the first question is:

How does the lockdown affect the market for UBER services?

The hypothesis is that the lockdown has shifted the market demand curve to the left.

Q1: Which are the factors that could have led to such a decrease in demand?

Q2: Do you think that the market supply curve has also shifted due to the pandemic?

Q3: If your answer to the previous question is positive, which are the factors that could have led to such a change?

The UBER management has asked the UBER research department to test these hypotheses. As a response, UBER research has access to data before and after the lockdown (EBC1046_3.xlsx). In particular, UBER research regularly runs field experiments in order to estimate demand and supply. How is this done?

First, UBER varies its standard price, and then observes how many rides will be requested via the app (per hour). This will allow us to estimate the demand curve. Second, it also observes how many UBER drivers go to work. This will allow us to estimate the supply curve. Such data is available from the period before the first lockdown.

Q4: Using linear regression, estimate the demand and supply curve before the lockdown.

Hint: in order to express demanded and supplied quantity in the same units, we use an estimated of maximum 2 rides per driver per hour.

Q5: Which are the estimated market equilibrium price and market equilibrium quantity?

Now, UBER research collects such data during the lockdown.

Q6: Using linear regression, estimate the demand and supply curve during the lockdown.

Remark: Here we estimated separate equations before and after the lockdown. We could have pooled all our data together and run one regression with two variables, i.e., price and a dummy lockdown variable. This would have been the same.

Q7: What can you tell about our hypotheses? Has market demand decreased? How about market supply?

Q8: If we want to identify the true factors that actually led to this decrease in demand, what additional data do you think we should have access to?

Q9: How have the estimated market equilibrium price and market equilibrium quantity changed due to the lockdown?

Q10: Suppose that before the lockdown, UBER had set its price to the estimated equilibrium price. What would the effect be in case UBER did not adjust its price during the lockdown?

C Demand for UBER

We continue the study of the UBER project from last time. Now we focus on regular times (before the lockdown). The UBER management wants to know the following, in order to design an optimal pricing strategy:

How sensitive is demand for UBER to price changes?

The hypothesis is of course that higher prices will lead to lower demanded quantity, but the question is by how much. The data before the lockdown are summarized in EBC1046_4.xlsx.

Q1: Using linear regression, estimate again the demand curve.

Q2: Which is the elasticity of demand? What does this tell us regarding our earlier hypothesis?

Furthermore, UBER manages to get access to data on taxi rides this same period.

Q3: Is the number of taxi rides a good measure of demanded quantity for taxi?

Q4: Are taxi services a perfect or a close substitute of UBER? In other words, are the two exactly the same good?

In any case, we have to test the hypothesis that taxi and UBER are substitutes.

Q5: Compute the cross-price elasticity of demand.

Q6: What does this tell us regarding our earlier hypothesis.

Q7: Using the market equilibrium price that you computed last week, compute the consumer surplus from UBER. With the data that we have available, can we also compute the consumer surplus from taxi?

Suppose that UBER gets access (in a legal way) to some personal data of its users. Often tech companies get such data through data brokers, and in particular by matching profiles from different online platforms (e.g., by matching UBER and Facebook profiles). Suppose for instance that UBER gets access to information about each user's profession, and manages to classify users into low-income people (with annual income below 20k) and high-income people (with annual income above 20k).

Q8: Is this enough in order to calculate the income elasticity of demand?

Q9: What type of data would UBER need in order to estimate the income elasticity?

Q10: How can UBER use the available data (on its users' income)?

Extra Question: What is price discrimination? How do you think it would work in this case?

D UBER market prices

We continue further the study of the UBER project from last time. We still focus on regular times (without lockdown). We first begin with following question:

How sensitive is supply of UBER drivers to price changes?

The hypothesis is of course that higher prices will lead to higher supplied quantity, but the question is by how much.

Q1: Using linear regression, estimate again the supply curve.

(Hint: once again, in order to express demanded and supplied quantity in the same units, we use an estimated of maximum 2 rides per driver per hour)

Q2: Which is the elasticity of supply? What does this tell us regarding our earlier hypothesis?

Q3: Using the market equilibrium price that you computed in week 2, compute the producer's surplus from UBER.

Q4: Putting this together with your previous analysis, estimate the total market surplus.

Suppose that UBER decides to set the price 0.10 Euros above the equilibrium price.

Q5: What will the effect be on the estimated consumer's surplus and on the producer's surplus? How much is the estimated deadweight loss going to be?

Now, suppose that UBER sets the price 0.10 Euros above the equilibrium price. However, this extra amount is not paid to the drivers, but rather it is collected by UBER itself.

Q6: What will the effect be on the estimated consumer's surplus and on the driver's surplus? How much is the estimated deadweight loss going to be? How do things differ compared to the previous question?

Now, suppose that UBER sets the equilibrium price. However, it collects 0.10 Euros from the amount that is paid to the drivers.

Q7: What will the effect be on the estimated consumer's surplus and on the driver's surplus? How much is the estimated deadweight loss going to be? How do things differ compared to the previous two questions?

Demand often fluctuates. This does not occur only due to unforeseen major events (like the lockdown), but it could even happen during the same day, often in predictable ways. Suppose that UBER management wants to answer the following question:

How should the price be adjusted throughout a usual week day?

The hypothesis here is that during peak hours (i.e., at 8:00-10:00 and 16:00-18:00) there is higher demand than the rest of the day. Hence, the price should be adjusted to remain in equilibrium.

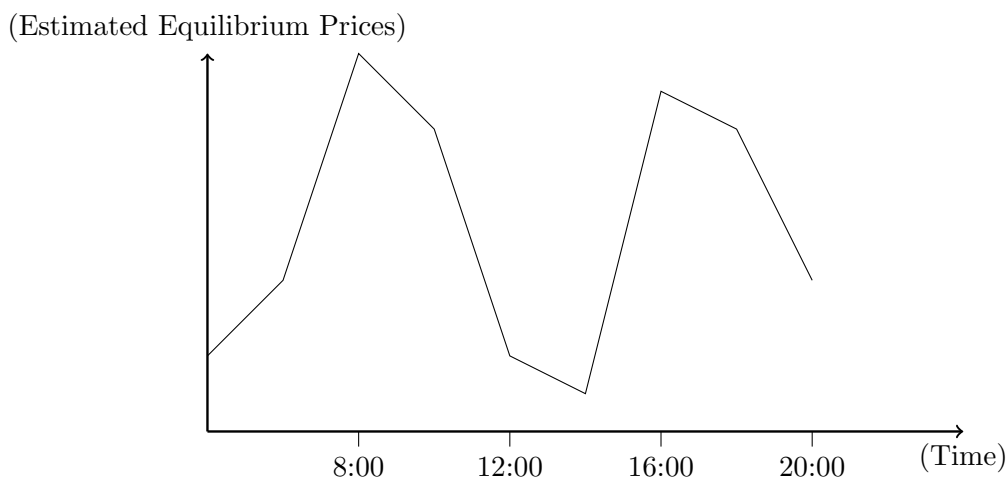
Q8: Read the passage “Evidence-based Economics: do companies like UBER make use of the invisible hand” in Chapter 7 of your textbook, and then answer the following question: Why is it important to adjust prices (as a response to demand changes) so that we remain in equilibrium?

Suppose now that UBER has collected more detailed data, that provides information not just of the requested rides, and the price, but also of whether it is peak time or not. This data is summarized in EBC1046_5.xlsx.

Q9: Using linear regression twice estimate the demand function, once on peak hours and once off peak hours. What can we say about the earlier hypothesis.

Q10: Now using the supply function that you estimated in Q1, find the estimated equilibrium prices on peak hours and the estimated equilibrium prices off peak hours.

Q11: The following figure shows UBER’s estimated equilibrium prices throughout an average week day. Explain what you see. What kind of data do you think UBER has used to get to this figure? How is this data different compared the ones in EBC1046_5.xlsx?



Q12: Do you think it is easier for the market to clear when UBER has access to the data that led to the previous figure or to the data from EBC1046_5.xlsx? Explain.

E Public good game

Economists observe that the free-rider's problem appears consistently across different economic environments where provision of public goods is private.

Q1: Can you think of such environments?

So, economists ask the following question?

Is it possible to escape the free-rider's problem?

The hypothesis is that it is very hard to avoid this problem. So, we would like first to test this hypothesis, then to understand the common underlying mechanism of the free-riding problem, and finally to think if there are solutions that would circumvent the problem.

Q2: But first of all, why do we think free riding is an actual problem? And moreover, is this question relevant for economists?

Economists seek general and abstract understanding of the incentives. Thus, they often remove context and other specific factors, and they design dry economic lab experiments. In the case of public good provision, they have come up with the following game (called the public good game; abbreviated to PG game). This game is also discussed in your textbook in Chapter 9.4:

There is a group of 4 individuals (called the subjects), each of them originally endowed with 10 Euros. In line with most economic experiments, subjects do not know each other's identity. They simultaneously choose how much money of their 10 Euros to put into a common account, and the remaining they will keep it in a private account. The private account does not have any interest (i.e., you get back exactly the amount that you put in that account). The common account has 100% interest rate (i.e., the total amount that goes into the common account is multiplied by 2 and then distributed equally across the 4 subjects). The decision of each subject is how much money to put in the common account. The decisions made by the 4 different subjects result into a monetary payoff for each of them. The game will be repeated 10 times.

Question regarding the experimental methodology: Why do you think we run these experiments anonymously?

Q3: Explain the free-rider's problem in this abstract game. How does this game relate to the examples from Q1?

Q4: Play this game for 10 rounds in your tutorial group (no need to maintain anonymity, but you should not communicate with each other during the experiment). Instead of Euros, the currency will be lottery tickets. So, in the end of the experiment, each of you will have collected a number of lottery tickets. We will then take the number of lottery tickets that each of you has won, put them all in a pot and randomly draw a winner. The prize that the winner will receive is a small advantage in the final exam.

Question regarding the experimental methodology: Do you think it is important to incentivize subjects in economic experiments?

Now, let us turn to some experimental data (EBC1046_6.xlsx). There were 10 groups, and in each column you see the total contribution of the corresponding group to the common account over the 10 periods.

Q5: Find the average contribution per period (together with the standard errors). Plot in a bar chart (on the horizontal axis you should have the periods, and on the vertical axis the contributions). What do you observe?

Q6: From the previous graph what can you tell regarding our earlier hypothesis?

Q7: Which do you think is the mechanism that drives the behavior we observe in the data? In order to answer this question, it will be helpful to look at individual behavior (per group). For instance, compare the observed contributions in groups 1,2,9 with the contributions in the other groups. What do you make out of this?

Now let us, take a second variant of this game, called public good game with punishment.

The game proceeds in exactly the same way, with only one difference. After the subjects play public good game in each period, they are given the chance to subtract money from other individuals. However, this comes at a cost of 3 Euros for each Euro that you subtract. For instance, assume that A contributed 2, B contributed 4, C contributed 6, and D contributed 8, meaning that 20 Euros were contributed in total to the common account, which became 40 Euros (after multiplying by 2). So, each of them receives 10 back from the common account, and the total payoffs are $8 + 10 = 18$ for A, $6 + 10 = 16$ for B, $4 + 10 = 14$ for C, and $2 + 10 = 12$ Euros for D. Now, they are given the chance to subtract money from other, and assume that C wants to subtract 2 from A, and D wants to subtract 1 from A and 1 from B. Then, the total payoffs will be: $18 - 2 - 1 = 15$ for A, $16 - 1 = 15$ for B, $14 - 3 \cdot 2 = 8$ for C, and $12 - 3 \cdot 1 - 3 \cdot 1 = 6$ for D. The game will be again repeated 10 times.

The question that we are trying answer is the following:

Does the existence of punishment mechanisms solve the free riding problem?

Such punishment mechanisms often exist in the form of institutions, whose aim is to improve contributions to public goods.

Q8: Following your answer to Q1, can you think of environments where such institutions are present?

The hypothesis is that the presence of punishment mechanisms will solve (at least to some degree) the free riding problem.

Q9: Do you think that this will indeed be the case?

F Catching a cartel

On the island of Sicily all gas stations are owned by two families, the Corleones and the Tattaglias (see “The Godfather” for further reference on the two families ☺). The European Commission suspects that the two families are operating a cartel, and has therefore launched an investigation on the issue. The following question is asked first:

Is it possible to prove that a cartel has been formed?

Given that everyone is innocent until proven guilty, the Commission needs strong evidence in order to prosecute the two families.

Q1: How do you think we can test the hypothesis that the two families have formed a cartel?

First, we will try to understand what type of market we have.

Q2: Is this a perfectly competitive market or an oligopoly? Is the good homogeneous? Do you think that both families face the same cost function? Explain your answers.

Q3: So, what sort of evidence would the Commission need in order to claim that there is a cartel?

The Commission has access to the following data from roughly the first three months of 2019 (EBC1046.7.xlsx). First, the commission knows the price at which each of the two families buys oil from BP. This appears on the first column. It is estimated that the MC is equal to twice this price (factoring in all other operation costs). Both families charge the same per litter price, which appears on the second column. The quantities that they sell appear on the third and fourth columns respectively. On the last column you can see the total quantity (sum of the previous two). Observations are daily and all quantities are measured in thousands of litters.

Q4: Estimate both the individual demand functions and the market demand function.

Q5: Do the individual demand functions differ from each other? How do you explain daily differences in demanded quantities between the two families?

From our data it becomes obvious that the marginal costs vary over time.

Q6: For each level of oil price that we observe, find the estimated monopoly price and the estimated oligopoly price.

Q7: Do you think that the two families have formed a cartel? Justify your answer.

Q8: Assume that the fine has to be equal to the total welfare loss (for the period that we have data, assuming that each week one data point was collected). How much should the families be fined?

When the two families were called to testify, they argue that the marginal costs were underestimated because only the oil prices are directly observable. In particular, they argued that when oil prices increase, so do transportation costs (especially since their business is located on an island), and therefore their marginal cost does not increase linearly but quadratically (with respect to the oil prices).

Q9: Explain their argument. Do they have a point?

In general, it is quite difficult to prove cartel formation, which is why the Commission often does not rely exclusively on economic data, but instead these are combined with additional evidence. For instance, leniency is offered to the party that will testify against the cartel.

Q10: Have you heard of any such real case? Have a look online and provide an example.