Dipartimento di Economia e Finanza

Cattedra di Applied Statistics and Econometrics

Collusion in Cournot competition:

An Econometric assessment

Relatore:

Prof. Andrea Pozzi

Candidato:

Luca Sanfelici

Matr. 211461

ANNO ACCADEMICO 2018/2019

INDEX

1. INTRODUCTION

The aim of this study is to assess, through an econometric regression, which conditions or situations enhance collusion inside a market, driven by Cournot competition. First, I considered a basic arbitrary model in which two firms operate: the number of variables are limited and the Demand and Cost functions are symmetric. Then, I changed the Cost function creating an asymmetric model, to see how the Duopoly market reacted when the Marginal Cost is differ from a firm to another.

Through Stata, I implemented my model to see how participants acted in a Monopolistic market, in which marginal costs and prices are generated following a common path and are all slightly different, to study the relationship among variables in an environment with more than two firms. This study has been made through the program Stata, following an Ordinary Least Squares regression.

Further variables have been implemented to study how collusion can affect a market and what are the conditions that make it occur, explaining the effects and relationships and characteristics related to the variables and to the error terms. Afterwards, through the Omitted Variable Bias problem, measurement errors have been reduced and the model gained more consistency that brought to a more precise estimate of the model studied.

2. THE FRAMEWORK

In a Cournot game, two or more firms compete in a market by selling goods at an equilibrium price, given Demand and Cost functions, in order to make profits. By assumption, all participants (both producers and consumers) are fully informed, there are no negative externalities that affect some competitors, outputs are homogeneous and goods are similar (consumers are indifferent). Unlike Bertrand competition, the market Price is very likely to be higher than marginal cost and will get equal to the latter only when the number of firms in the market increases and tends to infinite. In this case the price will shred until P=MC (instead in Bertrand, by backward induction, we can state from the very beginning that even if there are only two firms, P=MC).

Since we are in a competitive Cournot environment but not perfectly competitive (Deadweight loss (DWL) always higher than 0), consumer surplus rises and the producer surplus shorts each time new firms join the market, since Prices will lower and consumers will benefit from this reduction. When the number of firms continues to increase, the result is the perfect competition, in which P=MC. Whenever there is perfect competition, the DWL is always 0, but if for some reasons the Cournot perfect competition turns into a Monopoly or a Collusive outcome, the consumer surplus will reduce and this change will increase the producer surplus and DWL, damaging consumers.

The monopoly won't be taken into account in this study, since the main causes of existence are usually ex ante and can be seen in barriers to entry, absence of competitors, specific product markets or specific concessions lent by governments (like infrastructures).

Instead, an interesting point is to see when a competitive markets with two or more firms turn into a market with a collusive behavior, held by a part or even all the participants. This market does not follow a Grim-trigger strategy since the collusion is not the initial condition but at a certain point it could happen that a firm or more decide to collude and follow a different strategy that shift the equilibrium condition. But if the market has similar goods, perfect information, no negative externalities, and the same cost and demand functions, it would be impossible to deviate from a common strategy: if somebody lowers quantities produced to rise prices, everybody else would rise a little bit outputs and lower prices, making the deviating firm to get cut out from the market. In the case the price gets reduced by a firm, everybody would lower it and thus price will tend to marginal cost.

So what is the point of changing a strategy in a Cournot perfect equilibrium?

The only possible case of success of a collusive outcome happens when in the cost function, the marginal cost (MC) gets reduced, making firms to able to produce more outputs at lower costs. If the market is well regulated by antitrust authorities, this MC reduction is certainly a boost since allows some firms to improve their production cycle, increases competition and thus does not represent a risk for the market competition. Since these firms now hold a higher productivity, they can use their market power to collude and make the market equilibrium shift towards an approach that is more similar to the collusive one. They could for example reduce the quantities of outputs produced by charging higher prices: this would hurt consumers, increase DWL and their surplus.

A good example of change in marginal cost and its relative effects is provided by the paper of Duso, Röller and Seldeslacht that regards collusion in Research and Development market, in which firms have the possibility to spend on R&D while joining Join Ventures (RJVs), with the aim of increasing the technological advances to improve production: by investing in these groups, there is an increase in fixed costs since they firms spend for R&D but by doing this they will be able to reduce their MC (only important variable of cost function that enters into the profit equation). Even if all firms have the same Demand function, the Cost function will be different since those innovative firms will have higher fixed costs in the short period that will lower marginal cost in the long-run rather than normal competitors, creating an asymmetric Cournot that will shift the equilibrium. In perfect competition the DWL is always equal to 0, even if the Cournot now is asymmetric: DWL increases only if these firms that lowered their MCs, use their increased market power (as well as dominant position) to reduce quantities and rise prices, since they are price makers and thus collude to be as close as possible to a monopoly outcome.

In this paper the outcome is that whenever there is a market share reduction for firms that have been able to innovate, it is a very likely that the cause is a collusive behavior held by those firms that reduced their Marginal Costs. There is then a close link to MC and Collusion, in the sense that through an increase in production, is easier to collude and set higher Prices and lower Quantities to rise the profit of the firm, in an anticompetitive way that hurts competitors that do not have the technological advances to innovate and thus have to stick to their profit function.

I will now consider a Cournot Model of two firms that will be extended afterwards to a Monopolistic market of 100 firms, to see how the notion of Marginal Cost changes whenever the possibility to collude increases.

3 EMPIRICAL STUDY FOR TWO FIRMS

The study has been made in a Competitive market, in which the goods are homogeneous, consumers are well informed and rational, each producer is a price taker and follow the same demand and cost functions of the type: $P(x_i)=\alpha_0+\alpha_1 x_1+\alpha_2 x_2$ for Demand and $C(x_i)=\beta_0+\beta_1 x_i$ for Costs. Since all firms are price takers, the aim is to produce certain quantities of outputs Q equal to the market Q*(market equilibrium) at a given price P that is found indirectly by all market participants: the more there are, the higher Q* will be and the lower P* will be. If the number of firms increases tending to infinite, then P=MC.

3.1 Marginal Cost reduction

Research joint ventures(RJVs) have been a rising phenomenon, since they are ventures made by firms whose aim is to reduce their MC. They are a clear example (explained in the paper of Duso, Röller and Seldeslacht) of how marginal cost can influence firm behavior and decision inside a market by rising the possibility of collusion. Firms take part in these ventures by investing a lot in research and development, by rising short-run fixed cost to become efficient: by spending on R&D, firms reduce their future marginal costs through new technologies, allowing them to gain in the long-run and even cover the short-run fixed costs coming from R&D expenses. These RJVs are usually of two types: Horizontal or Vertical.

In both cases firms seek MC reduction but with the only difference that Vertical RJVs are populated by firms that are not direct competitors of the same relevant market, while in the Horizontal ones, firm meet directly with its rivals. This difference is crucial and will make me focus only on the second type since in these ventures, the possibility of colluding would be more easy and effective rather than take accords with firms that are not even in the same relevant market. Firms can meet directly, collude better and also share the same market, research inputs and higher dominant position rather than competitors that are part of the same market but don't join research ventures.

RJVs are a clear example that shows how the market structure can be asymmetric, due to a change in MC, that shifts the market Cournot duopoly equilibrium and also the market equilibrium even when there are more than two firms. I will be taking into account three scenarios, in which firms behavior change depending on their aims: when RJVs don't exist in the market, when they are joined just for innovation purposes to lower MC or if the purpose is to collude due to the dominant position held before in the first period in the RJV(where Q is lower).

3.2 Empirical model

I will consider an exogenous model in which variables like Prices, Quantities and Costs represent a market of two firms, in which Cournot holds. The numbers of firms in the markets is actually higher than 2, but since I am assuming that all firms that join RJVs have the same characteristics, aims and production (same reasoning holds for firms that do not join them), I will consider as there are only two firms: Insider firm (sum of production of all firms inside RJVs) and Outsider firm (every firm that do not take part in RJVs). Then I will make further considerations when the number of firms increases: in the market there are in fact n=100 firms, of which 50 are insiders and the other half are outsiders.

- $Demand\ function: P(X) = 60 - 3(q_1 + q_2)$
- $Cost\ function: C(Xi) = f + 12 * Qi$

i) NO RJV=Constant MC

In this first scenario no firms decide to join RJVs, thus there is no effort to seek efficiency and to reduce marginal cost: every firm is equal to the others. The market quantities and prices can be found either by using Cournot formulas for symmetric games or by solving the profit formula in a system of equations.

$$Profits: \Pi_1 = (P - MC)Q = \big(60 - 3(q_1 + q_2) - 12\big) * Q; leading\ to\ first\ order\ conditions:$$

$$q_1 = q_2 = \frac{a-c}{(n+1)b} \Longleftrightarrow FOC: \begin{cases} Firm\ 1: \dfrac{\partial \Pi}{\partial q_1} = 48 - 6q_1 - 3q_2 = 0 \\ Firm\ 2: \dfrac{\partial \Pi}{\partial q_2} = 48 - 6q_2 - 3q_1 = 0 \end{cases}$$

In this case I could have proceeded in two ways: by doing the system of equations of the specular First Order Conditions or by using the formula $\frac{a-c}{(n+1)b}$: I will only use it in this particular case, since there is no MC reduction or increase and the Demand function keeps constant. In fact this is the formula for symmetric Cournot, in which *a*, *b* and *c* are constants of the equation and *n* is the number of firms in the market.

Concluding, in this symmetric Cournot:

$$q_1 = q_2 = 5{,}3$$

$$P(Q) = 60 - 3(5{,}3 + 5{,}3) = 28{,}2$$

$$\Pi_1 = \Pi_2 = (P - MC)Q_i = (28.2 - 12) * 5{,}3 = 85{,}86$$

No firms have any incentives to deviate from the market equilibrium (5,3;5,3) set by both firms and the same reasoning hold if the number of firms>2.

ii) RJV FOR REASEARCH= Decreasing MC

In this case, firms decide to invest more in the short period to gain afterwards the technological improvements and this can be seen in a marginal cost reduction. The demand function keeps constant but this time firm 1 will rise its fixed costs and will decrease its marginal ones, becoming more productive, efficient and competitive.

- $Demand\ function: P(Q) = 60 - 3(q_1 + q_2)$
- $Old\ firm\ 2\ cost\ function: C(q_2) = 5 + 12q_2$
- $New\ firm\ 1\ cost\ function: C(q_1) = 7 + 10q_1$

This time I will not use $\frac{a-c}{(n+1)b}$ formula since this time the market is asymmetric: market equilibrium will shift since cost asymmetry and this formula is useless whenever $q_1 \neq q_2$.

By solving the new system of FOC:

$$New\ FOC: \begin{cases} Firm\ 1: \dfrac{\partial \Pi}{\partial q_1} = 50 - 6q_1 - 3q_2 = 0 \\ Firm\ 2: \dfrac{\partial \Pi}{\partial q_2} = 48 - 6q_2 - 3q_1 = 0 \end{cases}$$

Solving the system, there is an expected asymmetric result:

$$q_1 = 5.8$$

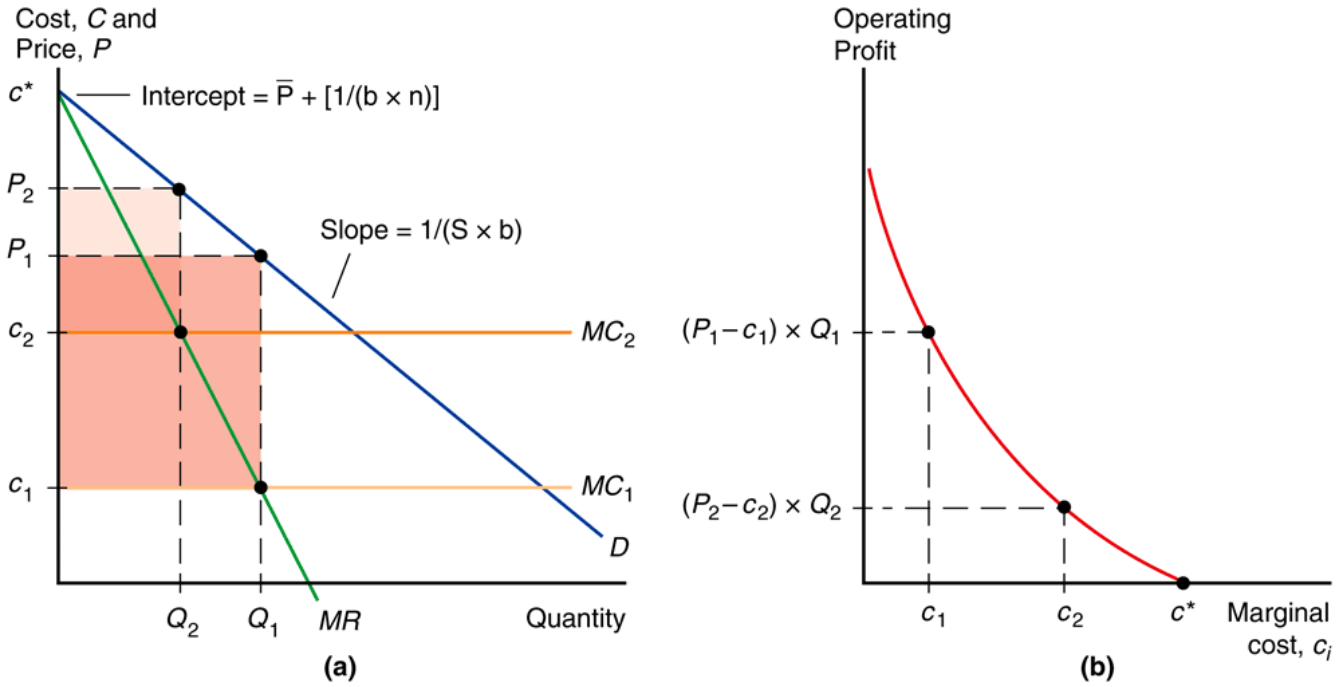
$$q_2 = 5.1$$

$$P(Q) = 60 - 3(5{,}8 + 5.1) = 27.3$$

$$\Pi_1 = (P - MC_1)q_1 = (27.3 - 10) * 5.8 = 100.34$$

$$\Pi_2 = (P - MC_2)q_2 = (27.3 - 12) * 5.1 = 78.03$$

Firm 1 through MC reduction, is able to produce more outputs at a lower cost of production, its profits rise and consumers benefit from this market situation, since the price level reduced, due to an increase in the overall quantities present in the market.



iii)RJV COLLUSIVE=Decreasing MC

The situation in still the one of the previous example, in which some firms are able to become more efficient and lower MC; the only thing that change (along with the outcomes) are the scopes. Again, firms decide to spend in the first period to increase their efficiency and become more profitable in the future periods. This makes them hold a significantly stronger position in the market over their competitors and this, for antitrust authorities, is not a problem at all, since in some markets stronger positions must hold for the good functioning of a certain environment.

Problems rise when these positions facilitate certain unlawful behaviors that can hurt competition, markets and especially consumers. Collusion is one of these, since holding a dominant market position enables to have more freedom in the tactics to use in a market and if these are decided with other competitors, the market is very likely to be very exposed to the moves of a block of few strong firms rather than the big majority of price takers competitors.

Increases in DWL, prices and producer surplus are a direct effect of collusion and to prevent them ex ante, a good method is study the changes in Market Shares.

This time firm 1 uses his enhanced position to set its quantities on the market without following the equilibrium:

- $q_1\ reduces$: 5.8 ⟶ 4.5

As a consequence, by plugging the new q_1 into q_2 reaction function, we find:

$$FOC = 48 - 6 * q_2 - 3 * 4.5$$

$$\Rightarrow q_2 = 5.75$$

$$P(Q) = 60 - 3(5.75 + 4.5) = 29.25$$

Price increased, hurting consumers, increasing DWL. As a result, collusive firms will increase their profits, also hurting competitors; by plugging in the profit functions:

$$\Pi_1 = (P - MC_1)q_1 = (29.25 - 10) * 4.5 = 86.62$$

$$\Pi_2 = (P - MC_2)q_2 = (29.25 - 12) * 5.75 = 99.19$$

3.3 Empirical observations

	Firm 1				Firm 2		
DATA	MC constant	MC decrease	MC collusive decrease	DATA	MC constant	MC decrease	MC collusive decrease
Marginal cost	12	10	10	Marginal cost	12	12	12
Price	28,2	27,3	29,25	Price	28,2	27,3	29,25
Quantity	5,3	5,8	4,5	Quantity	5,3	5,1	5,75
Tot quantity	10,6	10,9	10,25	Tot quantity	10,6	10,9	10,25
Profits	85,86	100,34	86,62	Profits	85,86	78,03	99,19
Market share	50%	53%	44%	Market share	50%	47%	56%

The table above sums up the results obtained in the previous empirical study.

First scenario: everything is constant and the market follows its basic demand and cost functions.

Second scenario: an innovative firm reduces its MC and is able to invest in the short-run rising its fixed costs, to decrease in the long-run its Marginal Cost becoming more efficient. It becomes able to produce 5,8 outputs instead of 5,3 and Research and Development expenses reduced MC from 12 to 10 that is equivalent to a 16% decrease, causing an increase in quantities for the innovative firm by 10%.

This increase in quantities by a competitor caused a decrease in the output for the other firm of 4%, from 5,3 to 5,1. The market benefited from this scenario enhancing competition since output rose from 10,6 to 10,9 that is a significant increase of 3%, while prices decreased from 28,2 to 27,3, so by 3%. This is a huge benefit for consumers, since are able to buy at lower prices and also dispone of a wider range of outputs. The profit of the first innovative firm increases as well as its market shares. The other firm instead is affected by the strategy of the competitor and becomes "dominated", losing part of its profits and market shares/power.

Third scenario: the innovative firm, once gained a higher market power, becomes a price maker and decides to hold an anticompetitive behavior, that is to decrease its outputs, hurting the market. Now this firm by producing 4,5 outputs instead of 5,8 was able to set the market price to 29,25 instead of the previous 27,3. This anticompetitive move allowed the firm to obtain the same profits it had when it could not innovate to reduce the MC, that is the first case. Quantities reduced by 22% for the first firm while the second firms gained from this by rising them to 5,75 from 5,1 (10%), yielding a profit increase of 27%. Market price increased by 7%, hurting consumers and reducing their buying power. In this case the demand becomes more elastic since the decrease in quantities from 10,9 to 10,25 by 6% was lower than the market price increase of 7%.

Concluding, there is empirical evidence that in a Cournot Duopoly if a firm reduces its marginal cost, increases its profits by producing more. The other competitor will have opposite effects and the market will decrease its price and elasticity. Instead if a company uses its enhanced market power to set lower quantities, it will increase prices, elasticity and the competitor profits, hurting itself and consumers.

Marginal Cost is a condition that can enhance the profits of a firm when it has already gained a dominant position in the market, by letting reduce outputs, produce less and with low efforts, to just gain the most from the Price rising, affected by the market power.

4 ECONOMETRIC MODEL WITH MORE FIRMS

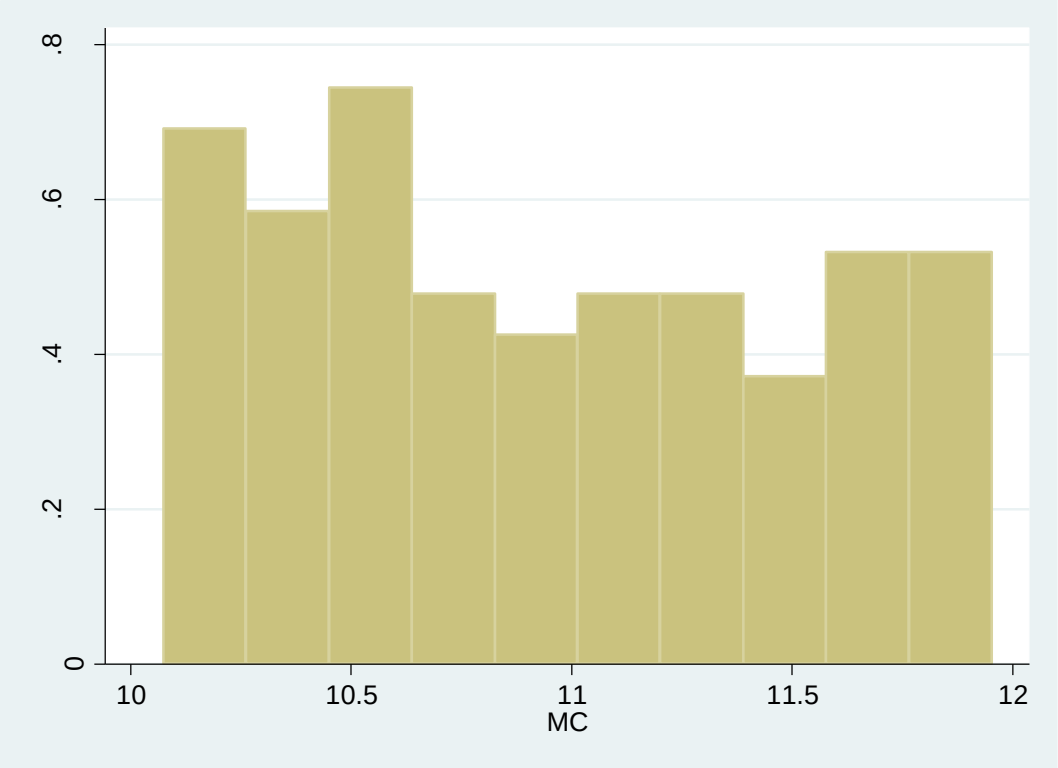
When the number of firms increases, we pass from a competitive Cournot Duopoly with just two firms to a Monopolistic competition. I assumed that the market increased reaching 100 firms but in this case I have consider the demand and cost functions as proper of the single fragmented functions of a specific "i_{th}" firm:

- $Demand\ function: P(X) = 60 - 3(Qi)$
- $Cost\ function: C(Xi) = f + MC * Qi$

Now I will have more than two firms, precisely 100. My sample enlarged and since new entrants joined the market, I will expect the overall quantity in the market to increase while price go down. This market is similar to a real world one: in the real economy is very difficult to find a unique price and quantity at equilibrium, since there are usually negative market externalities, slight differences between homogeneous products, consumers preferences and willingness to pay and lots of other market and behavioral conditions. Since it is very difficult to make a system of 100 first derivatives to find each single firm quantity, I generated the Marginal Cost variable by giving it random generation commands in a range of values in which I am sure that the market will hold. Perfect Cournot Duopoly and the Monopolistic market are the extremes of a generated function, in which the outcome will represent a real world market for 100 firms.

$$10 < MC < 12$$

With this condition, I will proceed on Stata in order to compute my regression by generating 100 different random Marginal Costs between 10 and 12 for every single firm. I have chosen the uniform distribution, rather than the normal one, since firms in the same industry have similar characteristics and are produce following the same cost function. This does not mean that all MCs have to be the exact same (in the real world a perfect competitive market does not exist), but they still have to follow a similar path. Even though normal distribution gives a close and reliable approximation of the actual "mean", is not a good way to represent reality. In the real economy, those firms that take place in the tails of the "bell shaped" distribution, produce a quantity output that in the long-run is not sustainable. Skewed firms will in fact shrink their quantities at an increasing rate: little Q means high Prices, hurting consumers that will buy at a smaller price those goods that take place at the center of the normal curve. The graph and the table below represents the information and the uniform distribution of the marginal costs faced by each firm; the variable taken into account will be now indicated with MC.



The sample was 100 that is large and gives the idea that for this market structure, the uniform distribution performed well, since the mean 10,95 would have been very close to the one of a normally distributed model with the same number of observations and ranges.

Variable	Obs	Mean	Std. Dev.	Min	Max
MC	100	10.94616	.5663632	10.07385	11.95273

The environment of the new model is the one of monopolistic competition, in which every firm follows a competitive market and every producer is a price maker. Due to product differentiation, different consumer tastes and differences in efficiency/production, these firms can produce different amount of goods at different prices. In reality a perfect competitive environment does not exist, but it is also true that within the same relevant market, firms almost follow the same production path/cycle. To recreate this environment, I arbitrarily chose a common demand function, in which every variable comes from the selection of the marginal cost. Marginal cost was randomly generated following a uniform distribution: this allowed all 100 firms to have a marginal cost ranging from 10 to 12. From this, I assumed that all firms wanted to keep a common mark-up for their profits: $(P - MC) * Q = 0.6 * P * Q$, with the following relationship: $MC = 0.4 * P$. This also allows the firm to have a randomly chosen price, that is still consistent with their mark-up ideal value . Since I now know the single price that a firm charges, I will also find out the quantity that it produces, since the demand function is $P = 60 - 3Q$.
This demand function represents the single demand function per firm, since in a monopolistic market prices and quantities are all different, even though they follow a competitive market structure.

Another variable to be taken into account is the price that single firms face in their production function. Since all firms in a Monopolistic market are considered as price makes, even if they stick to a competitive environment, they have the possibility to charge their own prices. Prices are randomly determined again following the normal distribution but this time they follow a common path: the mark-up. In this market I assumed that the mark-up (Price-Marginal Cost) is kept constant between each firm, and in the specific:

$$\Pi_i = (P - MC_i)q_i = (0.6 * P) * q_i; \text{ meaning that } MC = 0.4 * P; so\ P = \frac{MC}{0.4}$$

Variable	Obs	Mean	Std. Dev.	Min	Max
P	100	27.36539	1.415908	25.18464	29.88184

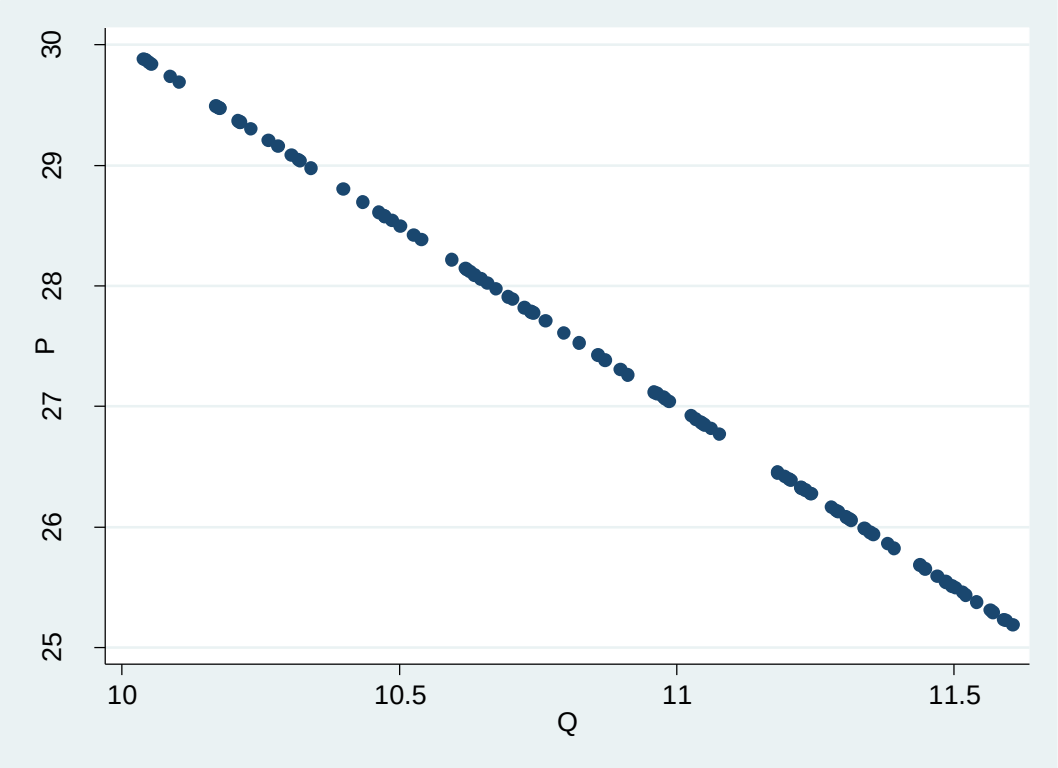
Now, by plugging the new variable P into my demand function, I will find the market quantities produced by each single firm.

Variable	Obs	Mean	Std. Dev.	Min	Max
Q	100	10.8782	.4719694	10.03939	11.60512

In this case quantities have even a smaller Standard Deviation than the ones of Prices and Marginal Costs, probably meaning that the production functions are very similar but the productivities and the characteristics of goods produced are different, due to the bigger entity of the differences in Prices and marginal costs.

Now I can represent the function that relates Prices and Quantities that are affected by the marginal productivity of each single firm, that is Marginal Cost.

My demand function is downward sloping and decreasing: new entrants means more quantities that lead to a decrease in prices, if the cost function keeps constant for every firm, the Price will not go below MC, but it will reach it when firms tend to infinite.



.

The negative relationship between P and Q can also be seen through an OLS regression:

Source	SS	df	MS
Model	198.47479	1	198.47479
Residual	5.8138e-11	98	5.9324e-13
Total	198.47479	99	2.00479586

Number of obs	= 100
F(1, 98)	= .
Prob > F	= 0.0000
R-squared	= 1.0000
Adj R-squared	= 1.0000
Root MSE	= 7.7e-07

P	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Q	-3	1.64e-07	-1.8e+07	0.000	-3	-3
_cons	60	1.79e-06	3.4e+07	0.000	60	60

The regression above shows consistency between Q and P: the marginal increase in Q accounts for a decrease in P for 3 and this holds with the assumption made before that when new firms join the market, there is an increase in the overall level of outputs that leads to a decrease in prices. The test hypothesis is accepted at 95% with a big margin so my coefficient is statistically different from 0, that would have been the case in which an increase in quantity didn't affect a change in price, that is the scenario in which Perfect Competition is reached, and no firms have incentives to enter, deviate or exit the market.

The RMSE (root mean standard error) is an overall measure of the multiple single errors that can be found in the regression of the dataset and that are "aggregated" in a single measure to explain the entity of the error term and its effects in the model. The more is low, the more the model is accurate with the given data. RMSE states that the data generated fit well in the model. Finally my coefficient -3 represents the negative slope of the Demand function while 60 is the intercept with the y axis.

Model:

$$P = 60 - 3 \cdot Q + \varepsilon, \;\; with\, \alpha = 60\, and\, \beta_1 = -3$$

The regression between Prices and Marginal Costs shows instead the inverse relationship between these two variables:

Source	SS	df	MS
Model	198.47479	1	198.47479
Residual	3.1357e-11	98	3.1997e-13
Total	198.47479	99	2.00479586

Number of obs	100
F(1, 98)	.
Prob > F	0.0000
R-squared	1.0000
Adj R-squared	1.0000
Root MSE	5.7e-07

P	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
MC	2.5	1.00e-07	2.5e+07	0.000	2.5	2.5
_cons	-2.81e-07	1.10e-06	-0.26	0.799	-2.46e-06	1.90e-06

5 OMITTED VARIABLE BIAS

Until now, the OLS regression explained the relationships between variables in a competitive scenario of a Monopolist market. This section now, questions the possibility that in the market, firms may not chose to act in a competitive way but decide instead to hold a collusive behaviour. When a firm for example, is able to reduce its marginal cost, the Price should move in the same direction, since firm's productivity increases and the firm is able to lower its costs per marginal output. As a consequence should be able to lower Prices as well, condition enjoyed by consumers that can buy more goods with same level of income.

But what if the positive relationship between prices and marginal cost becomes positive?

If prices go up every time the marginal cost decreases, it means that firms are holding a collusive behaviour that negatively relates prices and marginal costs.

How to prove it? Through Omitted Variable Bias.

Omitted Variable Bias (OVB) is a very important topic that has always to be taken into account before a regression. In a basic model like: $Y = \alpha + \beta_1 X_1 + \varepsilon$, the error term ε is a coefficient that contains all other characteristics and information that could be related to the dependent variable (Y). Following the OLS assumptions, this "other stuff" are not related to the independent variable (X) but they could be to Y: in fact when all of these information are contained in ε, my model gives me an estimate that is not the most precise one. If for example I forgot to consider another variable or I just want to implement the model, surely the result will change since now Y will depend on another or more variables and as a consequence it will become more precise, tending to the real value that my estimates are trying to replicate. Since now I have to consider another variable, my error term will be split: $\varepsilon = \beta_2 X_2 + \gamma$, such that now I will have a new error γ that has "less mass" than ε.

My model is now more accurate: $Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \gamma$

5.1 New Model

The previous OLS model just explained how prices, quantities and marginal costs were related if every firm acted lawfully in a monopolistic market. In the previous regression I could not see if market players decided to deviate their strategies by imposing collusive increases in Prices.

When firms are able to lower their MCs, it means that they have been able to increase their productivity, allowing them to either produce more at the same overall costs, either produce the same amount of output with a lower cost. Since MC and Prices have a positive relationship, when Marginal Cost decreases, the same movement affects Prices, such that a firm will keep a certain margin of profits, but by lowering marginal costs and prices this will enhance competition within producers in the market. The aim of this thesis is to explain possible causes of a collusive behaviour that would hurt competition: in fact what if for some reasons the decrease of MC actually makes prices rise and quantities decrease, hurting consumers?

This can either be explained by economic shocks, a change in market or consumer tastes but mostly likely due to collusion. In fact a decrease in MC allows firms to be more productive, but if Prices rise and quantities diminish, this is a exactly the opposite of how competition works. There must be something that inversely relates Marginal Cost and Prices. Something that allows prices to rise even if marginal costs decreased along with technological innovations that allow firm to rise productivity.

Normally in a competitive environment when prices decrease, consumer welfare increases and DWL decreases (if the market is not perfect competitive) but in this case an unusual increase in prices even due to a decrease in MC increases DWL, producer surplus and reduces consumer one.

First I set demand function: P=60-3Q, then I set MC, such that all firms have a 10<MC<12.

Then I set a mark-up to (that allows me to find single firms prices) but allows firms to have a proportional price in order to keep constant a certain level of profits. So MC=0.4P, and thus P=MC/0.4 and profits mark-up: P-MC=P-0.4P=0.6P.

Finally is possible to find quantities through the inverse demand function: Q=(60-P)/3

The demand is still affected by choices of other players (P and Q are not that different between firms) but still they can chose their production functions without taking into account best responses decisions based on the other players decisions. These functions are considered as proper of little monopolies in which every output actually depends on the marginal cost. When marginal cost decreases in a competitive environment prices decrease while Q increases since productivity rose.

I will now introduce a new variable called COLL that allows me to explain when a decrease in marginal cost can still have a positive relationship with prices, but a negative one with the new variable. Now collusion is taken into account and COLL=$\frac{Q_i}{MC}$ is the variable that explain it.

COLL is basically the amount of outputs per Marginal Costs that are added every time in the market demand per firm. If this ratio increases, then this means that firm are becoming more productive since either quantities are rising for a fixed Marginal Cost or with a fixed level of outputs, firms can reduce their MC.

If this COLL variable decreases, then is a synonym of collusive behaviour, since it is like withdrawing quantities per level of marginal costs from the market. I have already said that if MC decreases, Prices reduce and Quantities increase. In this case even if Marginal Costs are decreasing, Prices are now relatively related with COLL and thus even if a decrease of Marginal Costs decrease production costs, the Price rise because of the inverse relation of COLL. In fact if collusion increases, that is new quantities are withdrawn from the market, prices increase and as quantities will fall.

By running an OLS regression with the omitted variable I found that:

Source	SS	df	MS	Number of obs =	100
				F(2, 97) =	.
Model	198.47479	2	99.237395	Prob > F =	0.0000
Residual	3.1303e-11	97	3.2271e-13	R-squared =	1.0000
				Adj R-squared =	1.0000
Total	198.47479	99	2.00479586	Root MSE =	5.7e-07

P	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
MC	2.499999	2.27e-06	1.1e+06	0.000	2.499995	2.500004
COLL	-5.57e-06	.0000137	-0.41	0.685	-.0000327	.0000216
_cons	.0000154	.0000385	0.40	0.690	-.000061	.0000918

Now Price is again positively related to Marginal Cost but negatively correlated to Collusion. This means that in the formula COLL=$\frac{Q_i}{MC}$; when Marginal Cost decreases, collusive possibility rise: firms decide to increase their Prices to exploit the productivity increases and as a consequence quantities will decrease. In every case the test hypothesis doesn't get rejected, meaning that the market welcome investments to reduce the marginal costs.

New model:

$$P = \alpha - \beta_1 \cdot MC - \beta_2 \cdot COLL + \gamma, \ \ with\, \alpha = 0.000015;\ \beta_1 = 2.5;\ \beta_2 = -0.014$$

6. CONCLUSION

Concluding, I noticed that in both Cournot Duopoly with two firms and in Monopolistic market with 100 firms, Marginal Cost has always a positive correlation with Prices: whenever Marginal Costs reduce with the technological and productivity improvements, Prices decrease as well and as a consequence quantities rise, enhancing competition:

$$MC \downarrow \xrightarrow{+} PRICE \downarrow \xrightarrow{-} QUANTITY \uparrow$$

When instead, firms that already hold a dominant position for having been able to reduce their Marginal Costs, decide to lower their production to exploit their comparative advantage in productivity with low efforts, a new variable is added into the regression model that is COLL: the more Marginal Cost reduces, the more a firm is willing to hold a collusive behaviour, that affects the relationship between Prices and MC, that now becomes negative:

$$MC \downarrow \xrightarrow{-} COLLUSION \uparrow \xrightarrow{+} PRICE \uparrow \xrightarrow{-} QUANTITY \downarrow$$

If a market is not strictly regulated, firms hold a dominant position and are able to set prices without considering other players' best responses, it can be inferred that Marginal Cost reductions can be seen as the primary link to a possible market collusion, held by all market participant, against competition and consumers.

7. REFERENCES

- Collusion through Joint R&D: an empirical assessment – Tomaso Duso, Lars-Hendrik Röller, Jo Seldeslachts, The Review of Economics and Statistics (May 2014)

- Interfirm rivalry in a repeated game: an empirical test of tacit collusion – Margaret E.Slade, The Journal of Industrial Economics (June 1987)

- Introduction to Econometrics – James H.Stock, Mark W.Watson (Third edition)

- Industrial Organization: A Strategic Approach – Jeffrey Church, Roger Ware, McGraw Hill (2000)