Cartel creation in an oligopolistic market

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Abstract

With my NetLogo model, drawing inspiration from Bos, Harrington (2010) I want to reproduce a simple collusion mechanism among some firms in a market. Firms have the same cost function and each of them has a certain production capacity, the goods are homogenous while the consumers have different reservation prices and they search within a certain radius. When the cartel is created is decided by the user through a button; only firms with a certain production capacity with respect to the total one can join the cartel. All the parameters of the cost function, the number of firms and of consumers, the radius within consumers search for goods, the threshold for being part of the cartel and the cartel surcharge can be modified by the users through sliders. In my experiments I have tried to see the effects of different radii within which consumers look for sellers, the impact of different number of firms operating in the market, the impact of different minimum threshold to be part of the cartel and the effects of different surcharge levels applied by the cartel.

One of the main findings of this model is that a low radius not necessarily implies high cartel profits and that cartel profits heavily depend on the demand dynamic. In particular only a demand growth or at least a constant demand can assure positive cartel profits.

Another finding is that the number of firms operating in the market is significant in determining cartel profits only with respect to the number of non-cartel firms left after the creation of the cartel. The same reasoning is applied also the the capacity threshold in order to be part of the cartel, since it indirectly determines the number of cartel/non-cartel firms. Therefore, generally speaking, the less firms are operating in the market the higher and more stable are the cartel profits.

The last finding is that the greediness of the cartel can be source of negative or zero profits. It is anyway interesting to notice that a greater degree of greediness can be better than an average one. In the latter case there is some potential demand for the cartel firms which is anyway captured by the non-cartel firms, whereas in the first case, since there is no potential demand for the cartel, cartel firms exit the market.

Contents

1 The theoretical model

As in the paper previously mentioned, there are different firms (in a fixed number) with different production capacities, with the same quadratic cost function

$$TotalCost = a * quantity^2 + b * quantity + c \tag{1}$$

. The firms produce only one homogenous good, therefore there is no product diversification among firms and consumers choose only by looking at prices. There are consumers, in a fixed number, each of them willing to buy different quantity of the good with different decreasing reservation price (randomly determined) for each subsequent purchase. An important different between my NetLogo model and Bos, Harrington (2010) is that consumers do not compare all the different prices made by every firm, as in Bos, Harrington (2010), but they compare the firms prices within a certain range in which they look for. Setting up this sort of limitations to consumers is equivalent as setting transportation cost or research costs which makes an extensive research unattractive for consumers. Those research costs can be modified by the users in order to be able to experiment different settings. Another important difference is that in my work I have assumed that the firms in the market deeply know how the demand is structured. In particular, since there is no demand curve, but only a set of consumers with their own reservation prices, I have assumed that the firms can observe the reservation prices of the period before for each consumers within their range. That could seem absurd, but if we consider that we are in an oligopolistic market with a very little number of firms with a deep knowledge of the demand itself it is no more absurd than assume that firms know the demand curve of their market (actually it is the same assumption). The firms knowledge of the demand is not complete since it is affected by the changes happening at the demand in each period. This is the third main difference with respect to Bos, Harrington (2010): demand evolves over time in a unpredictable way for firms which is decided by the user. That feature has two important consequences on the model. Firstly, the demand is not perfectly forecastable by firms not only because consumers move around the NetLogo world (and therefore the consumers within each firm range change every period), but also because the reservation prices changes over time. This adds more uncertainty to the outcome of the firms price and quantity decisions yielding a higher grade of reality. This higher uncertainty is reflected in the mechanism with which firms decide the quantity and the price of their goods under competition. Since we have homogenous goods and the demand evolves over time each firm can only observe the variations among their profits and it takes its decisions upon that (i.e. there is no profit function to be maximized). The price is determined by profits: from a random change in price each firm will observe how their profits will react to increases/decreases in price and it will act consequentially. If, after increasing (decreasing) the price, profit will increase then the price will be increased (decreased) again and vice versa. Whereas the quantity is given by the number of observed consumers with a reservation price lower than the price fixed (i.e. the quantity is given by the consumers within the radius willing to buy at the fixed price). The fourth difference is about the cartel formation. In my model the cartel formation is not based upon having at least a certain production capacity with respect to the industry production capacity. This assumption is made to overcome a main difficulty in using the standard short run gains and long run

losses approach: the fact that in our model profits cannot be assumed constant over time and they can vary a lot form period to period. Again it is the uncertainty linked to the demand which plays a key role in shaping firms decision of being or not being part of the cartel. Firms decide to create a cartel only if the counterparts of the cartel are big enough to play, as a whole, a significant role in the market controlling in a better way the volatility of demand. If a firm is part of the cartel it will fix the price fixed by the cartel, whereas the quantity will be fixed according, as previously written for competing firms, to the number of consumers within the firm range having a reservation price which is less than the fixed price.

2 The code

The model is composed basically by three procedures: the "setup" procedure which creates my NetLogo world and defines my agents and their attributes, the "go" procedure which contains several other procedures which most of them will be deeply analysed further and the "create_cartel" procedure which creates the cartels. All the above mentioned procedures are activated through buttons in the interface by the user. Now I will focus on the most interesting part of the code:

- The "run_consumers" procedure;
- The "correct_price" procedure;
- The "ex_post_correct_price" procedure;
- The "create_cartel" procedure,
- The "create_demand" procedure.

2.1 The "run_consumers" procedure

```
to run_consumers
  ask consumers[
      let counter 0
      while [counter < purchases]
      [set heading random 360
        fd random 2
        set counter counter + 1
        let counterparts (firms in-radius consumer_radius) with [quantity_left > 0
        let counterparts1 counterparts with-min [price]
        let counterpart one-of counterparts1
        if counterpart != nobody[
          if [price] of counterpart <= item (counter - 1) price_list [
            ask counterpart [
              set quantity_left quantity_left - 1
              set quantity_sold quantity_sold + 1
             ]
            ]
        ]
     ]
     ]
end
```

Figure 1: The code lines for the run_consumer procedure

This procedure describes the behavior of the consumers (i.e. it describes the demand side of my model). Consumers are asked to go around the world randomly and look and buy a good for a number of times equal to the number of purchases they want. In order to do this a counter is needed to be set equal to zero and added up by one each repetition of the while cycle which is repeated for each consumers the number of consumer's purchases. In each cycle each consumer looks for firms with non-zero quantities of goods within his/her range

of research, which is fixed by the user through a slider, (*"let counterparts (firms in-radius consumer_radius) with [quantity_left > 0]"*) and among these he/she selects the one with the minimum price (*"let counterparts1 counterparts with-min [price]" "let counterpart one-of counterparts1"*). If there is at least one firm with a positive quantity of goods (*"if counterpart != nobody"*) then the firm and the consumer may exchange. The necessary and sufficient condition in order the exchange to take place is that the price fixed by the firm is less or equal to the reservation price of the consumer (*"if [price] of counterpart <= item (counter - 1) price_list"*). if this is the case then the firm will decrease their goods stock by one (*"set quantity_left quantity_left - 1"*) and will increase the quantity of sold goods (*"set quantity_sold quantity_sold + 1"*)

2.2 The "correct_price" procedure

```
to correct_price
   ask firms with [cartel? = false] [
     set best_profits 0
     let j 0
     while  [j < firms_number][
       let p1 item j [price] of firms  - random-float(1) - 0.5
       if  p1 <= 0 [set p1 0.01]
       let d1 (count consumers in-radius consumer_radius with [item 0 price_list >= p1]) / count firms in-radius consumer_radius
       let profits1 (d1 * p1 - a * d1 ^ 2 - b * d1 - c)
       if profits1 > best_profits [
         set best_price p1
         set quantity d1
         set best_profits profits1]
       set j j + 1
     ]
   if quantity > capacity [set quantity capacity]
   set quantity_left quantity
   set quantity_sold 0
   set price precision (best_price)2
   ]
end
```

Figure 2: The code lines for correct_price procedure

This is one of the two possible procedures for adjusting price and quantity produced by competitive firms. The user decides which procedure to use through a switch in the interface. In this procedure each firm compares its own price with the price fixed by the other firms and decide if replicate the strategy of their competitors or not. In particular during each while cycle each firms takes the jth element of the vector of prices fixed and subtract a random float number (*"*$let p1 item j [price] of firms - random - float(1) - 0.5$*"*). In this way each firm tries to steal the demand of its competitor by pricing just below its price. Then the firm computes the demand that it would have if it prices just below the competitor price. The demand is given by the number of consumers within the "consumer_radius" with a reservation price above the price considered and it is

divided by the number of firms within the same radius (*"let d1 (count consumers in-radius consumer_radius with [item 0 price_list >= p1]) / count firms in-radius consumer_radius"*). Then it computes the profits (*"letprofits*$1(d1 * p1 - a * d1^2 - b * d1 - c)$*"*) and if the profits are best so far are saved in the variable "best_profits", while the theoretical demand is memorized as the quantity to be produced ("quantity") and the theoretical price is saved as "price". At the end of the while cycle it will result what is the best strategy for each firm, given the last period choices of the others. At the end of the cycle there is a just a control that the quantity produced is not exceeding the production capacity of the firm and the variables "quantity_left" and "quantity_sold" are set up.

2.3 The "ex_post_correct_price_procedure" procedure

```
to ex-post_correct_price
  ask firms with [cartel? = false] [
    set future_price_correction0 precision (future_price_correction)2

  if profits = profits0 [
    set future_price_correction random-float 1 - 0.5]

  if profits > profits0
   [
     if future_price_correction0 >= 0 [set future_price_correction precision (random-float 10)2]
     if future_price_correction0 <  0 [set future_price_correction precision ( -1 * random-float 10)2]
     ]
   if profits <  profits0
   [
     if future_price_correction0 >= 0 [set future_price_correction precision ( -1 * random-float 10)2]
     if future_price_correction0 <  0 [set future_price_correction precision (random-float 10)2]
     ]

   set price precision (price + future_price_correction) 2
   let p price
   set quantity count consumers in-radius consumer_radius with [item 0 price_list >= p] / count firms in-radius consumer_radius


   if quantity_sold = 0 [
     set price p - 10
     set future_price_correction -10]
   set quantity_left quantity
   set quantity_sold 0

   if quantity > capacity [
     set quantity capacity
     ]
  ]
end
```

Figure 3: The code lines for the ex_post_correct_price procedure

This alternative procedure for reviewing quantity and price is based upon the difference between profits in two consecutive periods. In each period the firms compare the profits of the current period with the one of the previous period. If the profits are the same (*"if profits = profits0 [")*, then a random correction, negative or positive, is made to the price fixed (*"set future_price_-correction random-float 1 - 0.5"*). If the profits are increased (*"if profits > profits0 ["*) then the correction will be of the same sign of the previous one: it will be positive if the previous correction was positive (*"if future_price_correction0 >= 0 [set future_price_correction precision (random-float 10)2]"*) and negative if it was negative (*"if future_price_correction0 < 0 [set future_price_correction precision (-1 * random-float 10)2]"*). In the opposite case in which profits are diminished the same line of reasoning as above, but with opposite signs, is

applied. Quantity, as in the "correct_price" procedure, is given by the number of consumers willing to buy at the fixed price in the radius, divided by number of firms present in that radius. An interesting thing of this procedure are the line which states that if the quantity sold is equal to zero then the firm will have to set a price which is equal to the price itself minus ten and then set minus ten as the future price correction. I needed to insert such lines to fix a bug in this procedure: during several experiments I have noticed that all firms converged from negative profits to profits equal to zero (i.e. production and quantity sold was equal to zero). Actually it is not totally clear to me why this happened, but anyway this was the only way to force firms to go away from that bad equilibrium and let them profitably produce goods. At the end of code there is the standard control that the quantity produced does not exceed the production capacity and, if this is the case, the production is constrained by the capacity.

2.4 The "create_cartel" procedure

```
;creation of the cartel
to create_cartel
  ask firms[
    let % capacity * 100 / (sum [capacity] of firms)
    if  % >= minimum_% [set cartel? true]]
  ask firms with [cartel? = false] [
      set color red
      ]

  let p []
  ask firms with [cartel? = true] [
    set color green
    set p lput price p
    set p sort-by [?1 > ?2] p
    ]
  let reservation []
  ask consumers [
    set reservation lput item 0 price_list reservation
    set reservation sort-by [?1 > ?2] reservation
  ]

  ask firms with [cartel? = true] [
    set price item 0 p * (1 + cartel_%_surcharge / 100)
    if price > item 0 reservation [
      set price item 0 reservation
      ]
    ]
end
```

Figure 4: The code lines for the create_cartel procedure

This procedure creates the cartel of firms. The cartel is composed only by firms which have percentage of the total production equal or higher than a certain threshold (*"let % capacity * 100 / (sum [capacity] of firms) if % >= minimum_% [set cartel? true]]"*). Then the procedure makes the firms inside and outside the cartel recognizable by coloring the first in green and the latter in red. The next code lines are about the cartel price. In order to take the maximum price among those fixed by the firms which are going to create the cartel a vector "p" is made. The vector, initially empty, is filled by all the firms

prices and ordered descending (*"ask firms with [cartel? = true] [set color green set p lput price p set p sort-by [?1 > ?2] p"*). In order not to fix a price too high, the firms should know what is the higher reservation price among consumers. Therefore a similar vector as the previous one is created filled by the descending reservation prices of consumers. Finally the cartel price is fixed as the maximum price plus the surcharge, decided by the users through a slider, and the control that it is not above the the maximum reservation price is made (*"ask firms with [cartel? = true] [set price item 0 p * (1 + cartel_%_surcharge / 100) if price > item 0 reservation [set price item 0 reservation]"*).

2.5 The "create_demand" procedure

With this procedure the demand can be controlled by the user through the slider "demand_growth". This allows the user to experiment the behavior of firms under different assumption about the economy of the industry. There can be no growth, stable growth, stable recession and the dynamics of the demand can be changed during the simulation in order to allow the maximum flexibility. About the code there is little to say about it. It creates for each consumer

```
to create_demand   ; This procedure creates a decreasing reservation price vector which evolves over time
  ask consumers[
  let random_list n-values purchases [precision (random-float demand_growth ) 2]
  set price_list (map + price_list random_list)
  set price_list sort-by [?1 > ?2] price_list
  ]
end
```

Figure 5: The code lines for the create_demand procedure

a list of random numbers generated according to the slider "demand_growth", then with the "map function" it sums up the number of the random list with the element of the list of reservation consumers each of them has. Finally it re-orders the list "price_list" in a decreasing order.

3 The experiments

Since there are so many parameters to be changed in my model it is possible to experiment a lot of different settings. I decided to focus on the impact of the four following variables on my model:

- The "consumers_radius";
- The "firms_number" in the market;
- The "minimum_%" in order to be part of the cartel;
- The "cartel_%_surcharge"(i.e. the mark-up of the cartel).

In each experiment I have let the model run without a cartel for 100 ticks, in order to make the firm adjust the price, on the 100th tick the cartel was created. All the following graphs start recording from the 40th tick in order not to register the negative profits of the first phase. In every test I have used only the "ex_post_correct_price_prodcedure"

3.1 The "consumers_radius" experiments

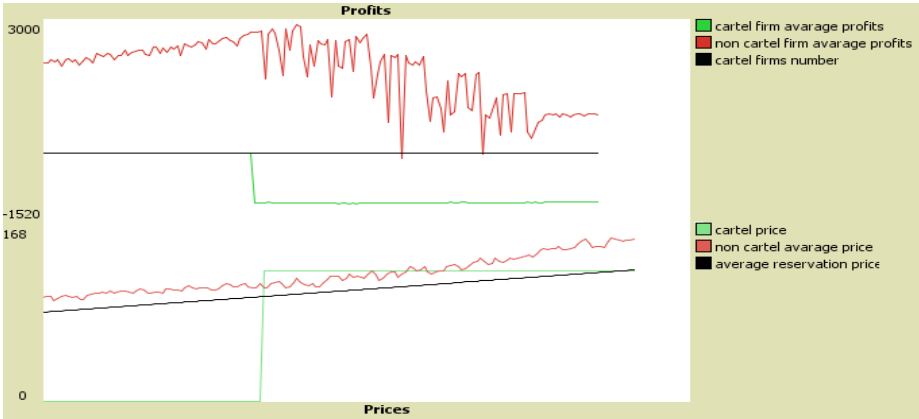
The aim of this experiment is to verify if a greater radius can affect negatively the cartel profits since it exposes them to the competition of the non-cartel firms. In order to do so, I have made different tests with different settings. More specifically I have chosen three different ranges: very low, medium and very high. Since the NetLogo world is a square of 32X32 patches the maximum distance between two objects can be:

$$\sqrt{16^2 + 16^2} = \sqrt{512} \cong 22.6 \tag{2}$$

which I have approximated to 23 (in order to be sure that consumers encompass every part of the world in their radii). Hence the very low consumer radius was equal to 5, the medium one was equal to 10 and the high one was 23. For each of these radii I have investigated the effect of an increasing, decreasing and stable demand, which is controlled through the slider "demand_growth".

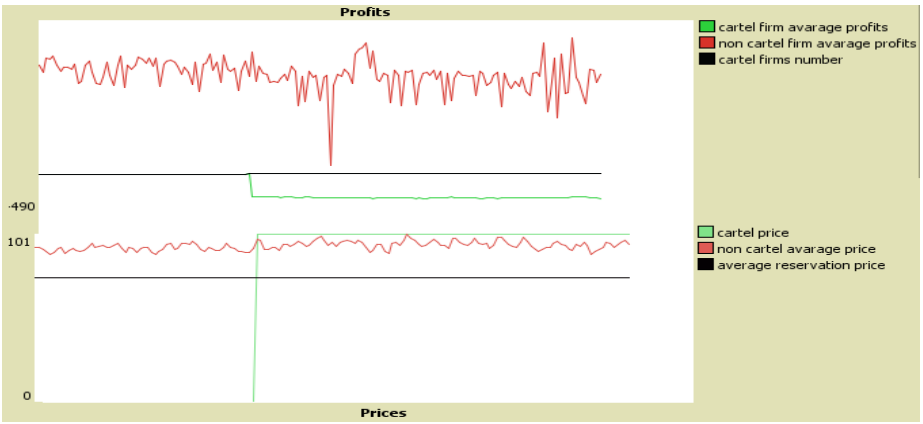
3.1.1 maximum "consumers_radius"

The following NetLogo graphs are put together into a single graph in order to better understand the price and profits dynamics for cartel and non-cartel firms in a context of rising demand. As we can easily see from profits, when the cartel



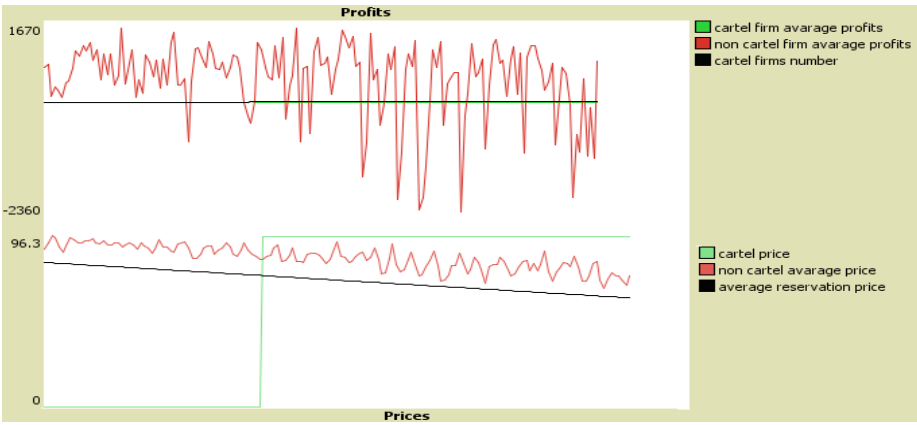
is created it suffers a lot from the competition of the non-cartel firms. The cartel firms do have a potential demand of consumers and they produce in order to meet this demand which is stolen by the lower prices non-cartel firms. Since cartel fixes a price which is forever it does not react to the competitors strategies and it continues with its own price. In particular is interesting to notice that, during the first part of the simulation, the price of the non-cartel firms is under the cartel price. In this period it is more favorable for non-cartel firms to price under the cartel price since the demand, and therefore the reservation prices, is not so high to price above the cartel price. This can be also seen from the two downward spikes of non-cartel profits, which becomes even negative. This means that in the interval between the two spikes is not so clear if it is better to try to price above the cartel price or use it as a ceiling not to get over in order not to have to compete with the cartel firms. Hence in during this interval the price fluctuates around the cartel price. From the perspective of the non-cartel firms the introduction of a cartel as sharply increased the volatility of profits in the period following the birth of the cartel and then lowered them. The explanation lays again in the prices dynamic. When the two prices were closed just a little shift in fixing the price could make the difference among cartel and non-cartel firms. Whereas when the demand becomes sufficiently high the volatility of non-cartel firms profits disappears, but their level decreases. The latter effect is due to the competition of the cartel firms whose price is now the best one in the market, stealing demand from the non-cartel firms. The first effect is linked to the second, since the volatility disappeared because of cartel and non-cartel firms were not directly competing each other: the cartel firms will take all the demand it can take and what left is taken by the non-cartel firms. I have to make two clarifications: first, the profits of the non-cartel firms, if the upward demand trend continues, will continue to rise, even above the previous top. Second, the cartel firm average profits in this graph are divided by 1000. This explains why we cannot observe an appreciable rising of the cartel profits in the long run.

The following graph represents the result of the same test with a constant demand. With a constant demand the introduction of the cartel does not affect



particularly the profits and the price of the non-cartel firms. The only thing that can be noticed is that now the cartel price is an upper bound for the non-cartel firms. When the non-cartel average price touches the green line of the cartel price, on the profits graph we can see a sharply decrease in non-cartel firms average profits. Therefore firms outside the cartel prefer to price just below the cartel price in order to have as much as demand as possible, leaving nothing to the cartel firms.
The fact that those firms do not price just below the cartel price is due to the absence of coordination among firms: the firms outside the cartel react to their own profits variations, so they could benefit from a price even lower than the optimal one because this allows them to steal demand from the competitors. Anyway it is pretty amazing to observe that with no coordination among firms they price so near to the optimal price.
This could imply that even quite stupid firms (i.e. firms without a strategic thinking) can be optimal in their decisions.

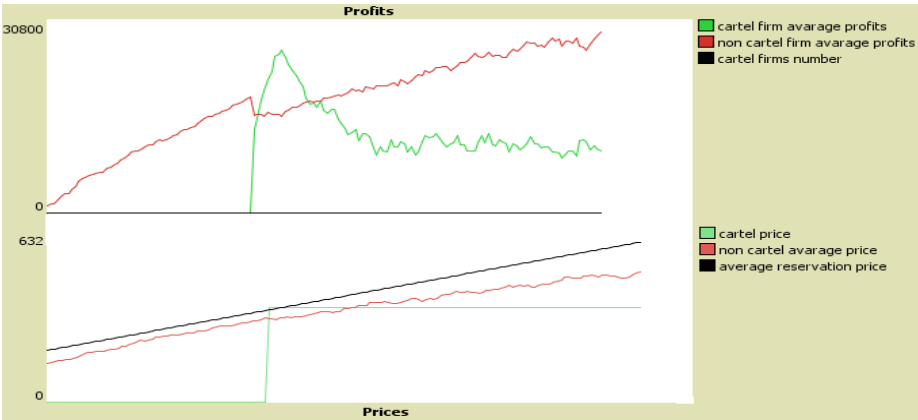
This last experiment with the maximum radius has a downward demand dynamics. Of course a decreasing demand implies troubles for firms with or without the presence of a cartel, what is interesting to notice is if the presence of the cartel diminished the inevitable price war among firms or if it contributes to it.



From the graphs we can notice that, as said above, even without a cartel, firms can have troubles: we can notice to downward spikes with negative profits before the cartel is created and a high volatility among profits. This is easy to explain: the cake is getting smaller and smaller so if you want a piece of it you have to fight with your competitors and , since price is the only gun everybody has, a price war starts immediately.
When the cartel is created the volatility of non-cartel firms average profits becomes higher. One could think that this is the effect of the creation of the cartel: this is partly true because it is just an algebraic effect of the creation of the cartel. When the cartel is created some firms become cartel firms, leaving the non-cartel firms group, this makes the average profits based on less firms and therefore more variable. Another thing to add is that the more it decreases the demand the more the profits becomes thinner and thinner, so there is also this effect to bear in mind which negatively affects non-cartel firms profits.
The cartel has negative profits and finally equal to zero. This is due to the fact that its prices are too high and consumers cannot afford them. The cartel firms are aware of the fact that there is no demand for their high-price goods and therefore the stop to produce (i.e. they leave the market).

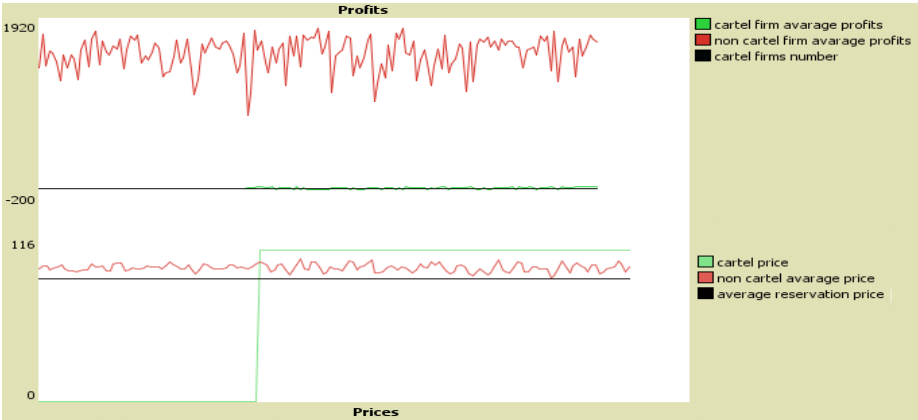
3.1.2 medium "consumers_radius"

In the following graphs there is a medium radius setting, again under different demand dynamics.

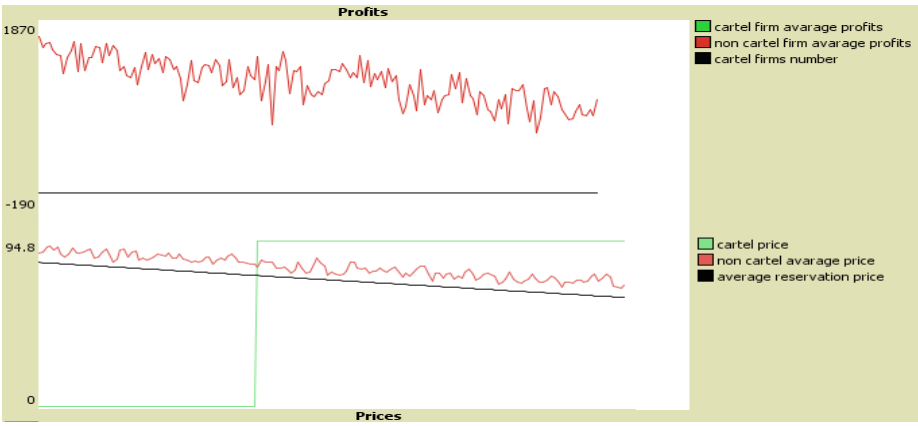


With an increasing demand we observe that, differently from the previous case, the cartel profits are positive. It is interesting also to notice that in the periods following the creation of the cartel the average cartel profits are higher than the non-cartel one. This is the first time we can see that the cartel, at least in the short run, has better performances than the non-cartel firms. However in the long run the non flexible cartel strategy does not provide better results and the non-cartel firms get over it. Even if the cartel price in the long run is the cheapest one, they do not optimize their profits, leaving the most rich consumers to the non-cartel firms.
It is also interesting to ask ourselves why the cartel profits drop so much before they stabilize to their long run level. I think that the drop in the average cartel profit is due to the competition of non-cartel firms within the range of some cartel firms. When a cartel firm is near to a non cartel firm the latter do consider the cartel price as a ceiling because otherwise most of its demand will be stolen by the cartel firm. Therefore it cut prices in order to have positive profits and real competition do happen between those two firms; whereas it do not happen if two firms are not in their respective ranges. Therefore the drop in the cartel firms average profits is due to the competition between some competitive firms and some cartel firms.
As in the maximum radius case the cartel price is not a ceiling for the non-cartel firms: the non-cartel firms average price goes beyond it quite fast, as the non-cartel firm average profits with respect to the cartel one.

The following graph shows the same simulation as above with constant demand.



With a constant demand we observe that the cartel firm average profits are always almost equal to zero. This could be due to the fact that some cartel firms have positive and some other negative profits or, more likely, that the cartel price was too high in order to have a good number of consumers willing to buy from the cartel. This hypothesis is also validated by the behavior of prices. The cartel price is never reached by the non-cartel firms average price which stops before it. This means that the ceiling for non-cartel prices is far lower than the cartel price.
The cartel profits are now equal to zero instead of being negative. The lower radius means lower competition among firms, so the few consumers willing to buy from a cartel firm and within its range are more likely not contended by other firms.
The following graph shows the same simulation as above with decreasing demand.

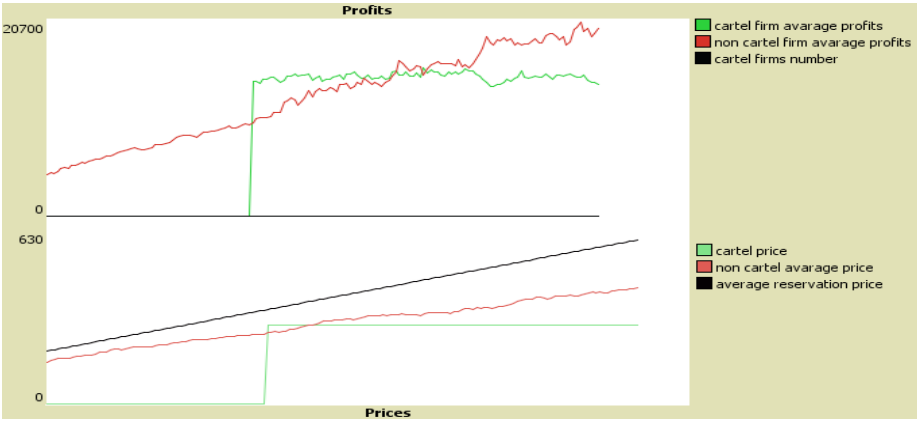


The same reasoning previously mentioned about the cartel average profits equal to zero can be applied also to this experiment: the profits are equal to zero since there is no consumer willing to buy because the cartel price is too high. The thing to be noticed are the positive non-cartel firms. In the maximum radius

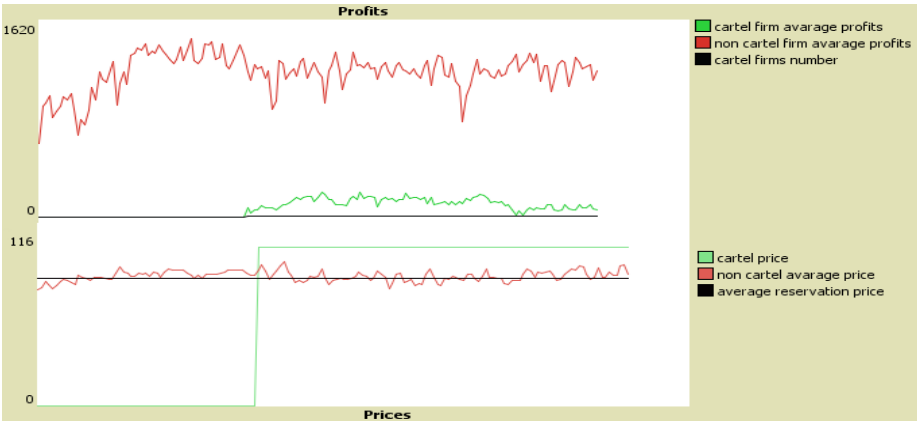
simulation with decreasing demand they were pretty inconstant with upward and downward spikes. The variation among profits now disappears because the radius is lower: lower radius means, again, less competition among firms.

3.1.3 low "consumers_radius"

In the following graphs there is a low radius setting, under different demand dynamics.



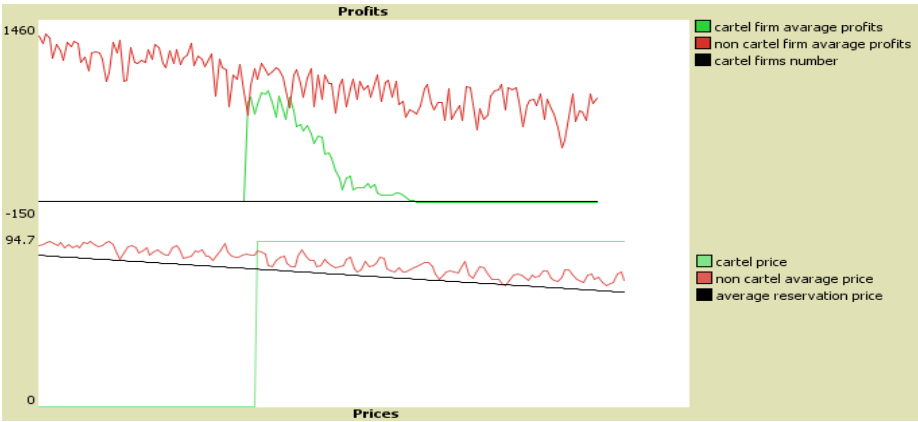
With a low radius and increasing demand the cartel profits seems not to be touched by the non-cartel firms competition, whereas the non-cartel firm average profits goes up following the reservation price.
The intuition behind this is always the same: the less the radius the less the competition. With a so little radius firms act as monopolist within their range.



With a low radius and a constant demand the cartel profits are positive even if very low, whereas in the medium range test they were zero. The profits are low since the price is high and only few consumers are willing to buy from a cartel firm, even if it is very likely to be the only firm in the range of many consumers. Since the demand does not grow over time also the cartel profits do not and they can show sharply variations, even if they are never less than zero (strict control of the consumers within their low radius). Those variations,

which occur also to the non-cartel firms, are due to the fact that with a smaller radius the firms profits depend on a smaller and much more volatile bunch of consumers (it is more volatile since consumers move and with a lower range is more probable that they could exit from the firm range).

With a decreasing demand there are no particular differences between this experiment and the same experiment with a medium radius.



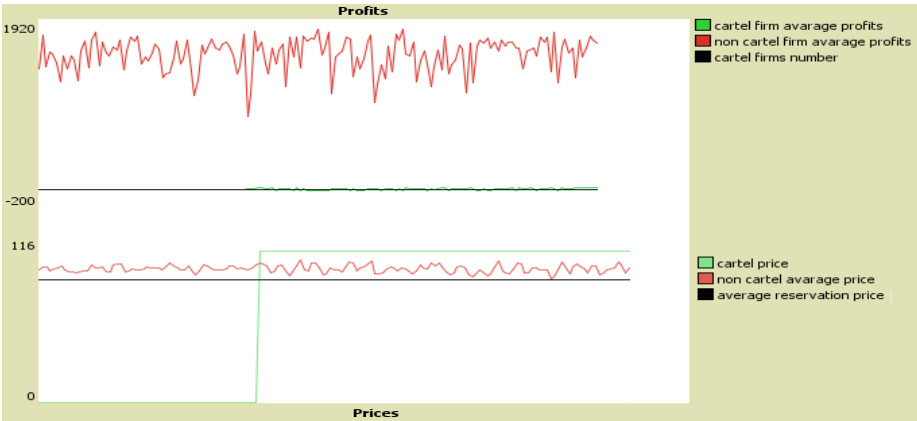
Differently from the medium radius experiment, the cartel shows positive profits in the short run which rapidly vanishes. That different is not significant and it is due to the different setup of the experiment.

3.2 The "firms_number" in the market experiments

In order to observe if the number of firms in the market has some impact I decided to make three experiments: one with the maximum number of firms, ten, one with five firms and one with three firms. I set a medium consumer radius, constant demand and the minimum percentage threshold of capacity in order to join the cartel was set differently from test to test in order not to have all/nothing firms become cartel ones.

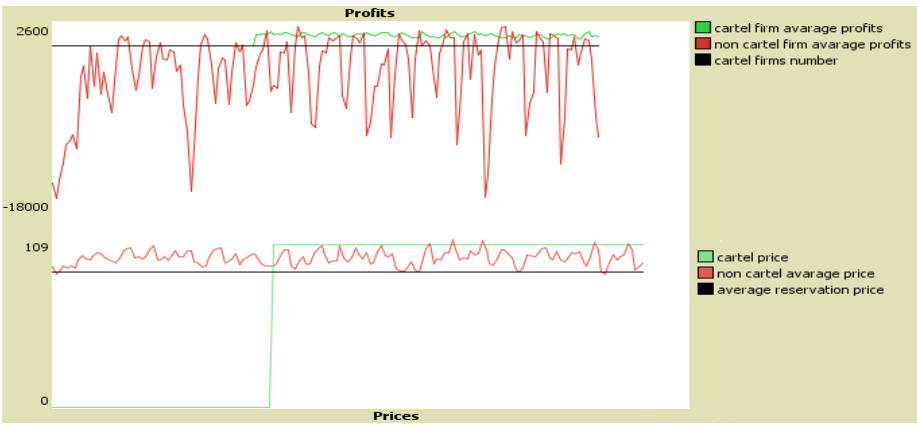
3.2.1 Ten firms

This experiment is the same done for the consumer radius equal to ten with constant demand, so we will make reference to the same graphs and I will not make further considerations about it. I will use it for making comparisons with respect to the next graphs.



3.2.2 Five firms

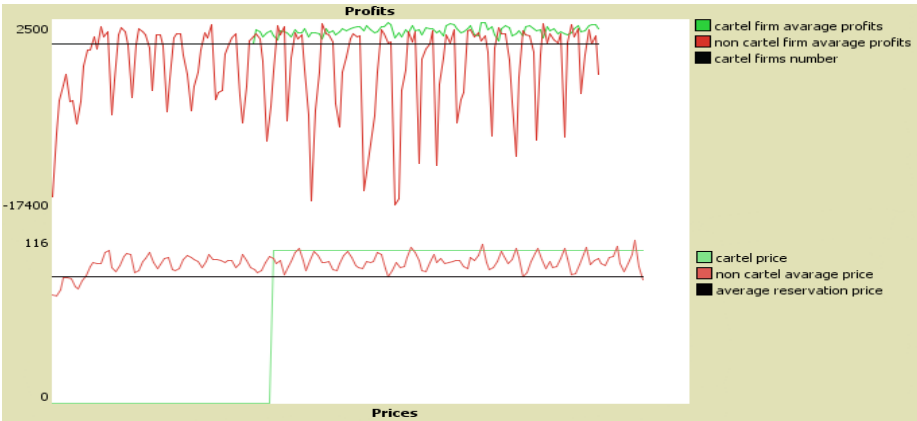
With five firms we have a really interesting situation. We observe that the the cartel firms average profits are positive, whereas the non-cartel firms average profits are mainly negative.



About prices we notice that the cartel price is a de facto upper bound for the non cartel firms and we also notice a big variation among profits. First of all we have also to observe that the even before the cartel creation the variability of profits among non-cartel firms is very big. This is simply because the firms are less than in our previous experiments. The creation of the cartel simply modify this variation in the short run (in this case it diminishes, in the next one instead it amplifies it), whereas in the long run it returns to its previous levels.

3.2.3 Three firms

As in the previous case we observe positive cartel profits, a great variation among non-cartel profits and a cartel price which is a ceiling for the non-cartel firms.



3.3 The "minimum_%" experiments

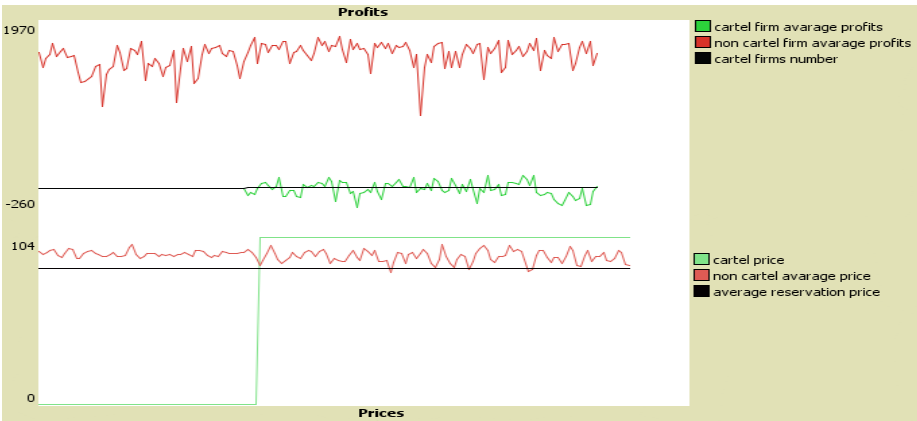
Those experiments did not provide useful outcomes to be interpreted. The main result from those experiments is that cartel and non-cartel profits seem to be independent from the "minimum_%" threshold (i.e. from the cartel's members).

3.4 The "cartel_%_surcharge" experiments

With this series of experiments we want to understand how the cartel greediness can affects the market. In the following tests I have used the maximum number of firms and a medium consumer radius, while I have changed the parameter "cartel_%_surcharge" setting it equal to 0%, 5% and 10%.

3.4.1 "cartel_%_surcharge"=0%

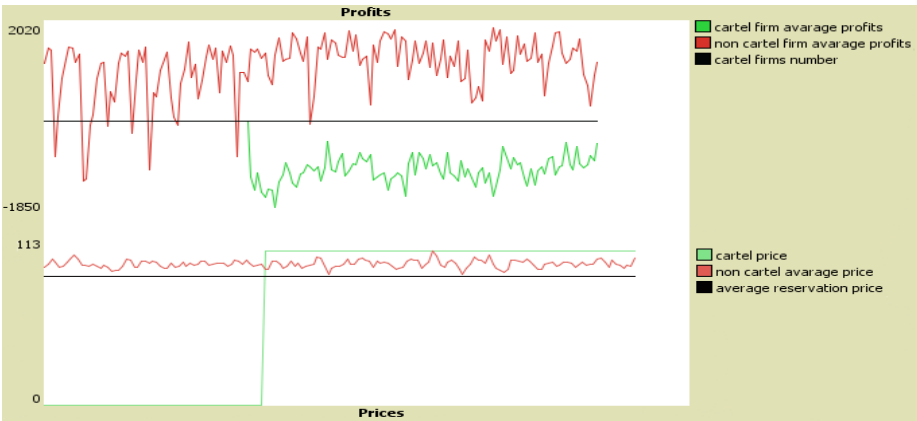
With zero surcharge the cartel profits oscillate between positive and negative profits.



The cartel price is taken as the upper bound for the non-cartel firms, so the cartel firms take only the residual demand and this explains why the profits are between negative and positive profits.

3.4.2 "cartel_%_surcharge"=5%

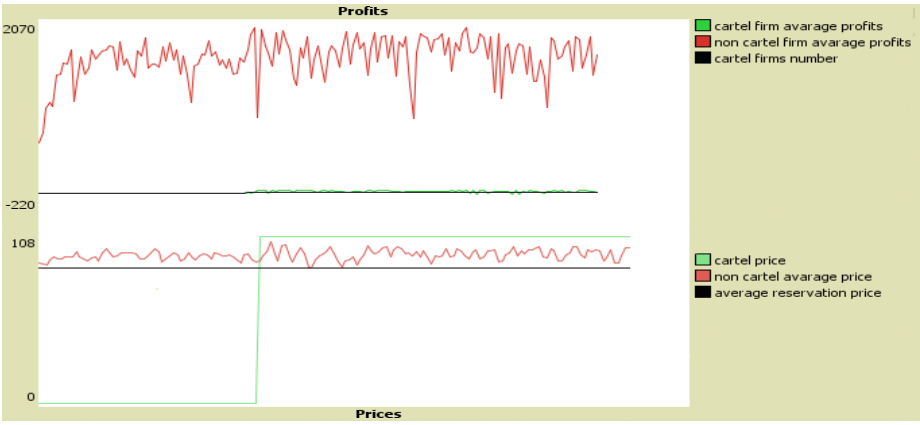
In this test the cartel profit are strictly negative. This means that even with a modest surcharge the cartel can be easily beaten by the non-cartel firms which will price under the cartel price.



Since profits are negative this means that the cartel firms produce goods which are not sold. This means that the cartel firms recognize that there are consumers that would buy from them, but this potential demand is stolen by the other firms which fix a lower price.

3.4.3 "cartel_%_surcharge"=10%

With a more substantial surcharge the cartel profits are not negative, as in the previous case, but equal to zero.



This means that if the cartel is too greedy there is no potential demand for it and the firms in the cartel do not produce goods (i.e. they exit the market). Also looking at the prices the same thing can be noticed: the cartel price is no more an upper bound for the non-cartel one which stops at a lower level.

4 Final considerations

Making reference to the experiments described above we can draw the followings conclusions.
The radius plays a vital role in determining the success or the failure of a cartel. In particular a large radius implies negative profits for cartel firms, no matter how is the demand trend. With a medium radius we can have a profitable cartel only if we have a growth trend, with cartel firms becoming low cost goods producers. Finally a low radius implies a profitable cartel in almost all the possible demand dynamics. More specifically, with an increasing demand the cartel outperform the non-cartel firms in the short run, whereas in the long run the latter overtakes the first (even if the cartel profits remain constant over time). With a constant demand we have positive small cartel profits, whereas with a decreasing demand we have positive cartel profits in the short run and zero cartel profits in the long run since the price fixed by the cartel becomes too high.
The number of firms operating in the market is significant in determining the cartel profits only with respect to the number of non-cartel firms left after the creation of the cartel. Generally speaking the less firms are in the market the higher are the cartel profits. The same reasoning is applied also to the capacity threshold to be part of the cartel, since it indirectly determines the number of cartel/non-cartel firms.
The surcharge applied by the cartel confirms that the greediness of the cartel can be source of negative or zero profits. It is anyway interesting to notice that the a greater degree of greediness can be better than an average one. In the latter case there is some potential demand for the cartel firms which is captured by the non-cartel firms, whereas in the first case, since there is no potential demand, the cartel firms exit the market.

References

[1] Bos, I., Harrington, J.E., "Endogenous cartel formation with heterogeneous firms", RAND Journal of Economics, RAND Corporation, vol. 41(1), pages 92-117, 2010.