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Comment on Nomidis "Revisiting Cournot and Neoclassical Economics"[1]

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February 2023 Revised March 2023

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Journal of Economic Literature classification: B0, C0, D0.

Keywords: Cournot oligopoly; price-taking behavior.

[1]I thank Giacomo Rubbini for superb research assistance.

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1 Introduction

In an interesting paper that displays impressive erudition, Nomidis (2023) revisits the Cournot (1838 [1897]) oligopoly model and its connection with the market of perfect competition. The author claims that the Neoclassical economics tradition misinterprets the Cournot model, but this assertion should be called into question. The current paper begins by focusing on the main point made by Nomidis (2023), i.e., that the individual demand for each oligopolist is downward-sloping in the Cournot model, different from the assumption of infinite elasticity needed for the perfectly competitive firm. Examples are provided to clarify when Cournot's competitive limit result is obtained. But the paper goes on to document how different Neoclassical economists, while admiring Cournot's work, understood very well that the perfectly competitive assumption of price-taking behavior is a different model altogether, whose implications they went on to analyze. This is not to say that the Neoclassical economists did not have any criticism of Cournot's work, including his assumption that each firm believes its competitor's output to be constant, or the lack of a proper dynamics, as some of the quotes below will illustrate.

2 The Conditions for Cournot's Competitive Limit Result

Cournot (1838 [1897], p.90) studies in Chapter VIII what he calls *unlimited competition*, by allowing an arbitrarily large number of firms in the market:

"The effects of competition have reached their limit, when each of the partial production D_k is inappreciable, not only with reference to the total production $D = F(p)$, but also with reference to the derivative $F'(p)$, so that the partial production D_k could be subtracted from D without any appreciable variation resulting in the price of the commodity. This hypothesis is the one which is realized, in social economy, for a multitude of products, and, among them, for the most important products. It introduces a great simplification into the calculations, and this chapter is meant to develop the consequences of it."

In the remainder of this section, we make a succinct presentation of Cournot's findings, using modern conventional notation.

Let $p(y)$ be the inverse market demand for a homogeneous good. Assume it is downward-sloping, i.e.,

$p'(y) < 0$. Let y denote the total output taken to the market, sold at a price p. There are n identical firms producing the good, and hence, $y = y_1 + \ldots + y_n$, where y_i represents the output produced by firm $i = 1, \ldots, n$. Let $C(y_i)$ be firm i's cost function, for each $i = 1, \ldots, n$.

In an equilibrium with positive output, the first-order condition of profit maximization for firm i in the Cournot oligopoly model is:

$$p(y) + \frac{\partial p(y)}{\partial y_i} y_i = \frac{dC(y_i)}{dy_i}. \tag{1}$$

The discrepancy between this first-order condition and the one derived by a price-taking firm in a perfectly competitive market is that the second term of the left-hand side is zero, leading to the equality of price and marginal cost.

Cournot's remarkable competitive limit result is that, as $n \to \infty$, the sequence of equilibria in the oligopolistic market converges to the equilibrium in the perfectly competitive market. This happens because, as $n \to \infty$, the second term of the left-hand side of equation (1) becomes negligible. And there are two reasons for this:

a Either because $y_i \to 0$, which is not convincing, as it describes a model in which each firm is negligible not only in relative terms, but also in absolute terms;

b Or $\partial p(y)/\partial y_i \to 0$. That is, in this case, each firm becomes almost a price-taker, facing individual demand curves that become infinitely elastic. This is the sense in which oligopolistic behavior, as the number of oligopolists grows unbounded, becomes perfectly competitive. This is a much more convincing reason, especially if one can substantiate it in a model in which firms become only negligible in relative terms, not in absolute terms.

To illustrate, consider the following examples. In all of them, let the cost function $C(y_i) = cy_i$ for a constant $c \geq 0$:

Example 1. Let $p(y) = a - y$, with $a > c$. Then, firm i's individual output in the Cournot equilibrium is $y_i^* = \frac{a-c}{n+1}$. The market price in the Cournot equilibrium is $p^* = a - \frac{n(a-c)}{n+1}$. As $n \to \infty$, the Cournot equilibrium price converges to c, the perfectly competitive price. But the reason is unconvincing: it does so because the sequence of y_i^* converges to zero.

Example 2. Let $p(y) = a - \frac{y}{n}$. Now, in the Cournot equilibrium, $y_i^* = \frac{n(a-c)}{n+1}$, and the Cournot price is $p^* = a - \frac{n(a-c)}{n+1}$. As $n \to \infty$, the sequence of Cournot prices also converges to c, the perfectly competitive price. But now the reason is the convergence of individual firms' behavior to price-taking behavior, in the sense that they face individual demand curves –and a market demand curve as well– that become infinitely elastic in the limit. Moreover, each firm is only negligible in relative terms, not in absolute terms, as y^* stays away from zero, even in the limit. Each firm ends up producing a finite level of output, while the total output taken to the market goes to infinity, because so does the number of firms.

Example 3. And, of course, it is not true that any sequence of Cournot models where one increases the number of firms in an unbounded way achieves the competitive limit result. If neither component in the second term of the left-hand side of equation (1) vanishes, then the market does not become perfectly competitive. For instance, let $p = na - y$. Then, the Cournot equilibrium output for each firm is $y_i^* = \frac{na-c}{n+1}$, leading to a Cournot price $p^* = na - \frac{n}{n+1}(na - c)$. As $n \to \infty$, each firm's output stays finite and positive, producing approximately a. Total output grows unbounded, because of the infinite number of firms. As for the sequence of Cournot prices, now the limit as $n \to \infty$ is $a + c$, different from the marginal cost c, which is the perfectly competitive prediction.

These results are all well-known in the literature (see, e.g., Novshek and Sonnenschein (1978), Novshek (1980), Mas-Colell (1980)), and Nomidis (2023) is correct in pointing out that Cournot's original assumption was that each firm's individual demand is downward-sloping. It only becomes infinitely elastic in the limit, under some conditions. The above analysis puts this fact in simple math.

3 Neoclassical Views of Cournot and Perfect Competition

Nomidis (2023) makes a number of claims about Neoclassical economics that do not follow logically from his coverage of the Cournot connection. Citing from Nomidis' (2023, p.1) abstract:

"Cournot's idea for price stability and perfect competition through an infinite number of firms, each of inappreciable production that cannot affect the price, has been fully adopted by subsequent neoclassical theorists and embodied in today's mainstream economics. But, in the passage of this idea from Cournot to neoclassical economics, there was a misinterpretation of this price stability condition that led neoclassical economics to the notion of price taking and horizontal demand curve for the individual firm, while Cournot himself considered this individual demand curve to be sloping. This misconception led neoclassical and mainstream economics to erroneous models and outcomes. The most serious implication is that the equilibrium price in perfect competition is not at the minimum average cost, as neoclassical economics argues, but at a higher cost, which, in turn, has further implications for social welfare."

This section argues that there is no misinterpretation or misconception in which the Neoclassical economists fell, and certainly, one should be careful of asserting that they were making such egregious errors. Indeed, with respect to Cournot oligopolies, the model of perfect competition is a different model altogether, based on the ideal assumption of price-taking behavior for buyers and sellers, and the Neoclassical economists were fully aware of that difference. They were careful to describe circumstances under which the price-taking assumption is pertinent and when it is not.

For instance, Walras (1874 [1896]) describes in Lesson 5 how a model of competition works, allowing for departures of price-taking behavior (p.42):

[...] "Value in exchange left to itself occurs naturally in the market under the regime of competition. As buyers, the traders make offers to buy at higher prices; as sellers, they make offers to sell at lower prices, and their competition thus leads to a certain value in exchange that is sometimes rising, sometimes falling, sometimes stationary. Depending upon whether the competition functions more or less well, the value in exchange is determined in a more or less precise manner."

But then, he goes on to describe effective supply and demand functions, i.e., supplied and demanded amounts as a function of the price, which is a clear use of price-taking behavior. He also connects in this passage with market clearing (supply=demand), a condition of his equilibrium (p.43, pp.47-48):

[...] "Let us take, for example, the trading activities in 3% French government bonds on the Paris Bourse, separating them from all other operations. The three per cent is, as is said in market terminology, quoted at 60 francs. Agents who have received some orders to sell at 60 francs or less offer a certain quantity of 3 per cent government bonds, that is, a certain number of bonds each yielding 3 francs annually payable by the French State, at a price of 60 francs. We will call an offer made in that way of a definite amount of a commodity at a definite price an effective supply. On the other hand, the agents who have received orders to buy at 60 francs or more will demand a certain quantity of 3% government bonds at a price of 60 francs. We will call that demand for a certain amount of a commodity at a certain price an effective demand.

[...] Let D_a, O_a, D_b, and O_b be the effective demand for and supply of commodities (A) and (B) at their respective prices $p_a = 1/\mu$ and $p_b = \mu$. There is an essential relationship between the quantities demanded and supplied and prices that must be indicated first of all. Effective demand and effective supply are, as we have seen, the demand and the supply of a given quantity of a commodity at a given price. Consequently, to say that a quantity D_a of (A) is demanded at the price p_a is, ipso facto, to say that a quantity O_b of (B) equal to $D_a p_a$, is being offered. Thus, to say, for example, that there is a demand for 200 hectoliters of oats at the price 1/2 in terms of wheat is to say that there is a supply of 100 hectoliters of wheat. In general, therefore, there is, between D_a, p_a, and O_b, the equation $O_b = D_a p_a$."

Thus, while competition is sometimes imperfect –as the first passage cited demonstrates–, Walras was fully conscious of the price-taking assumption as a way to model competition between buyers and sellers in large markets, such as the stock exchange. For another comparison, here is a quote of how he viewed price being determined by a monopolist, with a very explicit description of its price-making. The monopolist understands it is serving a downward-sloping demand (Walras (1874 [1896], Lesson 37, p.443)):

[...]"Let us assume there is an entrepreneur who, for one reason or another, has a monopoly of some product in the sense that we have agreed to understand that word. That entrepreneur has the power to set the price of his product as he wishes. But what does not depend on him, for example, is the quantity of the product that is demanded, sold, consumed at whatever price is charged. In this respect, only one thing is certain: the dearer the product is, the less will be demanded, and the cheaper it is, the more will be demanded. It is absolutely certain for any given product that the demand for any product decreases as its price rises and increases as its price falls. The only thing that varies from one product to another is the law of the increase or decrease in demand as the price rises or falls; that is what Cournot and Dupuit call the law of demand, of sales, or of the consumption of each product."

In *The Theory of Political Economy*, Jevons (1871 [1888]) expresses admiration towards Cournot's work, yet note the last sentence cited, where Jevons makes it clear that Cournot's model and his own are very different. We cite from the Preface to the 2nd edition (pp.xxix-xxx):

[...] "Cournot starts from the assumption that the débit or demand for a commodity is a function of the price, or D = F (p); and then, after laying down empirically a few conditions of this function, he proceeds to work out with surprising power the consequences which follow from those conditions. Even apart from its economic importance, this investigation, so far as I can venture to judge it, presents a beautiful example of mathematical reasoning, in which knowledge is apparently evolved out of ignorance. In reality the method consists in assuming certain simple conditions of the functions as conformable to experience, and then disclosing by symbolic inference the implicit results of these conditions. But I am quite convinced that the investigation is of high economic importance, and that, when the parts of political economy to which the theory relates come to be adequately treated, as they never have yet been, the treatment must be based upon the analysis of Cournot, or at least must follow his general method. It should be added that his investigation has little relation to the contents of this work, because Cournot does not recede to any theory of utility, but commences with the phenomenal laws of supply and demand."

The following passages describe Jevons' view of competition, leading to price-taking behavior. He starts with the assumption of a homogeneous good leading to a single price, arguing also how trade of large quantities of the good may be able to affect the price; but note the price-taking assumption in the last sentence of the paragraph (p.91, pp.92-93):

"The Law of Indifference:

[...] If, in selling a quantity of perfectly equal and uniform barrels of flour, a merchant arbitrarily fixed different prices on them, a purchaser would of course select the cheaper ones; and where there was absolutely no difference in the thing purchased, even an excess of a penny in the price of a thing worth a thousand pounds would be a valid ground of choice. Hence follows what is undoubtedly true, with proper explanations, that in the same open market, at any one moment, there cannot be two prices for the same kind of article. [...]

[...] Though the price of the same commodity must be uniform at any one moment, it may vary from moment to moment, and must be conceived as in a state of continual change. Theoretically speaking, it would not usually be possible to buy two portions of the same commodity successively at the same ratio of exchange, because, no sooner would the first portion have been bought than the conditions of utility would be altered. When exchanges are made on a large scale, this result will be verified in practice. If a wealthy person invested £100,000 in the funds in the morning, it is hardly likely that the operation could be repeated in the afternoon at the same price. In any market, if a person goes on buying largely, he will ultimately raise the price against himself. Thus it is apparent that extensive purchases would best be made gradually, so as to secure the advantage of a lower price upon the earlier portions. In theory this effect of exchange upon the ratio of exchange must be conceived to exist in some degree, however small may be the purchases made. [...] The quantity of any article purchased is a function of the price at which it is purchased, and the ratio of exchange expresses the rate at which the quantity of the article increases compared with what is given for it."

Indeed, in the next passage (note especially the first two sentences), Jevons assumes the quantities traded are so small that their effect on prices is negligible, another key assumption of perfect competition:

"Problems in the Theory of Exchange (p.112):

[...] We may, firstly, express the conditions of a great market where vast quantities of some stock are available, so that any one small trader will not appreciably affect the ratio of exchange. This ratio is, then, approximately a fixed number, and each trader exchanges at that ratio just so much as suits him. These circumstances may be represented by supposing A to be a trading body possessing two very large stocks of commodities, a and b. Let C be a person who possesses a comparatively small quantity c of the second commodity, and gives a portion of it, y, which is very small compared with b, in exchange for a portion x of a, which is very small compared with a. Then, after exchange, we shall find A in possession of the quantities a - x and b + y, and C in possession of x and c - y."

In his *Mathematical Psychics*, Edgeworth (1881, p.47) references Cournot and his limit competition result, again distinguishing between Cournot's assumption and perfect competition. Edgeworth frames it in the context of his final settlements, which we today call the core. Under suitable conditions – replicating the economy–, Edgeworth's final settlements converge to perfect competition (what we call today the core convergence theorem):

[...] "The third imperfection may have any degree of importance up to the point where a whole interest (labourers or entrepreneurs) is solidified into a single competitive unit. This varying result may be tolerably well illustrated by the case of a market in which an indefinite number of consumers are supplied by varying numbers of monopolists (a case properly belonging to our first imperfection : namely, limited number of dealers). Starting with complete monopoly, we shall find the price continually diminish as the number of monopolists increases, until the point of complete fluidity is reached. This gradual ' extinction ' of the influence of monopoly is well traced by Cournot in a discussion masterly, but limited by a particular condition, which may be called uniformity of price, not (it is submitted) abstractedly necessary in cases of imperfect competition. Going beyond Cournot, not without trembling, the present inquiry finds that, where the field of competition is sensibly imperfect, an indefinite number of final settlements are possible; that in such a case diferent final settlements would be reached if the system should run down from different initial positions or contracts."

In his review of Cournot in connection with mathematical economics, Fisher (1898, p. 127), referring to Cournot (1838 [1897], Chapter VIII), makes it clear that the result in that chapter is an anticipation of marginal cost pricing, i.e., of the different price-taking model of Walras, Jevons, and other Neoclassical economists. Fisher writes:

[...] "Passing on to the case of "unlimited competition (Chapter VIII.)", Cournot shows that the price is, in this case, equal to the "marginal cost of production." Cournot himself does not use this term nor any other verbal description of the magnitude involved. He confines himself to mathematical symbolism. $\phi(x)$ being the total cost, to a particular producer, of producing x units, $\phi'(x)$ will be equal to the price. Since $\phi'(x)$ is the rate of increase of cost per unit of increased product,- i.e., "marginal cost," - Cournot must be counted among the anticipators of Jevons, Menger, and Walras. These anticipators now appear to be Bernoulli, Anderson, Ricardo, Von Thunen, Rae, Cournot, Dupuit, and Gossen."

In the following passage, Fisher discusses the contributions of Cournot to the theory of duopoly. He criticizes Cournot for his assumption that each duopolist conjectures that the quantity of the competitor is given, and seems to favor Bertrand's (1883) assumption of each duopolist believing that the competitor's price is fixed (note how the Bertrand assumption of infinitely-elastic individual demand is taken to counter Cournot's). The criticism Fisher raises, actually, is about both models –Cournot and Bertrand– in that they ignore dynamics. Nowadays, of course, with the development of the theory of repeated games, we understand a great deal more about the dynamic problem, while the standard current presentations of the Cournot and Bertrand model concern simultaneous choice of output and price, respectively. Here is Fisher's account (pp. 125-127):

"In passing from the study of perfect monopoly to that of perfect competition, Cournot considers also the intermediate case of a few, say two, competitors. The operation of self-interest in this case will, Cournot contends, cause an equilibrium price to emerge, which will be lower than if the two rivals had combined, but higher than if a third competitor should enter the field. Cournot's treatment of this difficult problem is brilliant and suggestive, but not free from serious objections. The fault to be found with the reasoning is in his premise that each individual will act on the assumption that his rival's output is constant, and will strive only to so regulate his own output as to secure the largest profits. He is regarded as oblivious of the consequences of his action on the tactics of his rival, and as assuming that the price which will be charged by that rival will be neither more nor less than that necessary to take off the fixed output imputed to him plus the output decided upon by himself. Under these conditions, Cournot's conclusions will hold true. But the conditions are not those which actually apply to competition between two producers. A more natural hypothesis, and one often tacitly adopted, is that each assumes his rival's price will remain fixed, while his own price is adjusted. Under this hypothesis each would undersell the other as long as any profit remained, so that the final result would be identical with the result of unlimited competition. But, as a matter of fact, no business man assumes either that his rival's output or price will remain constant any more than a chess player assumes that his opponent will not interfere with his effort to capture a knight. On the contrary, his whole thought is to forecast what move the rival will make in response to one of his own. He may lower his price to steal his rival's business temporarily or with the hope of driving him out of business entirely. He may take great care to preserve the modus vivendi, so as not to break the market and provoke a rate war. He may raise his price, if ruinously low, in hopes that his rival, who is in the same difficulty, may welcome the change, and follow suit. The whole study is a "dynamic" one, and far more complex than Cournot makes it out to be. The completest treatment of this intricate and neglected problem is contained in Professor Edgeworth's brilliant articles in the *Giornale degli Economisti*."

To be fair to Cournot, Cournot (1838 [1897], Chapter VII, p.81) includes a dynamic justification of his equilibrium, what we call today Cournot or best-response dynamics:

"The state of equilibrium [...] is therefore stable; i.e. if either of the producers, misled as to his true interest, leaves it temporarily, he will be brought back to it back by a series of reactions, constantly declining in amplitude," [...]

Contrasting it to the instability of the collusion outcome, where both producers cooperate to form a monopoly (p.83):

"The reason is that, producer (1) having fixed his production at what it should be according to equation (4) and the condition $D_1 = D_2$, the other will be able to fix his own production at a higher or lower rate with a temporary benefit. To be sure, he will soon be punished for his mistake, because he will force the first producer to adopt a new scale of production which will react unfavourably on producer (2) himself. But these successive reactions, far from bringing both producers nearer to the original condition [of monopoly], will separate them further and further from it. In other words, this condition is not one of stable equilibrium; and, although the most favourable for both producers, it can only be maintained by the means of a formal engagement." [...]

Edgeworth (1891) talks about perfect competition as an "ideal market," a limit of Cournot oligopolies. He discusses Cournot's model and Bertrand's critique as follows (pp.16-18):

[...] "One can find another way to determine the genealogy of prices in the famous theory of Cournot. Cournot assumes an ideal market considered as the limit point where the last degree is approached when starting from the monopoly regime by successively introducing a first, second..., fifth competing seller. It will suffice for us to consider his method applied to the first case or the first degree, in which there are two competing sellers (with an indefinite number of buyers present). In this case, according to Cournot, each seller (or each competitor) varies its offer (without considering the price) in order to maintain constant the quantity offered by its competitors. After thus determining the movements that must be executed in this game of competition, if I may say so, Cournot, by a very beautiful analysis, determines the point beyond which all movement becomes impossible - at which the game leads to a stalemate. The only objection to this conclusion is that it is possible that the parties do not play the game well. It may be that one of the parties plays badly, like Napoleon who - according to the judgment of the Austrian general he had defeated - had violated all the rules of war with his tactics. I would have hesitated to say that Cournot made some serious errors in his applications of mathematics to political economy, if I could not cite the authority of the eminent mathematician Bertrand in support of my assertion. Mr. Bertrand expresses himself thus in a remarkable article inserted in the *Journal des Savants* of 1883: 'A peremptory objection arises: in this hypothesis no solution is possible, the decrease would have no limit; whatever the common price adopted, if one of the competitors alone lowers his, he will attract to himself, neglecting unimportant exceptions, the totality of the sale, and he will double his revenue if his competitor lets him do so. If Cournot's formulas mask this obvious result, it is because, by a singular inadvertence, he introduces, under the name of D and D', the quantities sold by the two competitors, and treating them as independent variables, he supposes that, if one changes by the will of one of the owners, the other can remain constant. The opposite is obviously true'."

And we close this section by confirming Fisher's assertion in the afore cited passage. Edgeworth

(1888 [1925], pp.116-118) also went ahead to criticize Cournot's dynamic adjustment process leading to his equilibrium:

"Section II. — Proof of the proposition that when two or more monopolists are dealing with competitive groups, economic equilibrium is indeterminate.

To establish this proposition it will suffice to consider the typical cases formed by two monopolists, each of whom, acting independently, offers to a competitive group one of two articles that are either (A) rival or (B) complementary as objects of demand.

A. The simplest case under this head is that in which the rival articles are not merely substitutes for each other, but actually identical. 'This case is treated by Cournot as the first step in the transition from monopoly to perfect competition. He concludes that a determinate proposition of equilibrium defined by certain quantities of the articles will be reached. Cournot's conclusion has been shown to be erroneous by Bertrand for the case in which there is no cost of production; by Professor Marshall for the case in which the cost follows the law of increasing returns; and by the present writer for the case in which the cost follows the law of diminishing returns. In the last case there will be an indeterminate tract through which the index of value will oscillate, or rather will vibrate irregularly for an indefinite length of time. There will never be reached that determinate position of equilibrium which is characteristic of perfect competition defined by the condition that no individual in any group, whether of buyers or sellers, can make a new contract with individuals in other groups, such that all the recontracting parties should be better off than they were under the preceding system of contracts."

4 Conclusion

The infinite elasticity of individual demand or price-taking behavior is one of the workhorses of economic theory. While it is an ideal assumption, it is useful in the study a class of important economic interactions. The Neoclassical economists understood this, and in particular, how circumstances best modeled by perfect competition differ from those in the Cournot oligopoly model, yet they admired Cournot for his insightful result of connecting both paradigms. Indeed, while under some assumptions, the perfectly competitive conclusions can be obtained by limits of other models, one can study a perfectly competitive market in its own right and obtain results for it; for treatments of the topic in modern textbooks, see Serrano and Feldman (2018, Chapters 11, 15, and 16) at the undergraduate level, and Mas-Colell, Whinston, and Green (1995, Chapters 10 and 17) at the graduate level.

Despite Nomidis' repeated uses of terms like "fallacy," "misconception," "flawed," "error" attributed to Cournot and the Neoclassical economist, based on the above quotes, it seems more appropriate to assert that they understood the differences in the sort of competition that each model depicts. On the other hand, there are some unfortunate misunderstandings in Nomidis (2023). For example, the fundamental theorems of welfare economics, associated with the model of perfectly competitive markets, do not require the assumption of zero profit for firms, as Nomidis (2023) claims. Defining an allocation as a collection of production plans and consumption bundles, a competitive equilibrium is a price-allocation pair satisfying:

- (i) that firms maximize profit at the equilibrium production plan, given the equilibrium prices (at the equilibrium prices, the equilibrium production plan is what they would like to supply);
- (ii) that consumers maximize utility at the equilibrium bundle given the budget set determined by the equilibrium prices (at the equilibrium prices, the equilibrium bundle is what they would like to demand); and
- (iii) that aggregate supply equals aggregate demand in every market.

While one could assume free entry of firms in the market, which would lead to zero profit, conditions (i)-(iii) still allow for nonzero profit –e.g., a short run situation– under which all the results of perfect competition can still be obtained, such as the welfare theorems.

In particular, the model proposed by Nomidis (2023) in Section 4, by imposing the zero profit condition while still allowing downward-sloping individual demand curves in profit maximization, is what we call the model of monopolistic competition (Chamberlin (1933)). For this model, it is indeed known that a deadweight loss is created and the conclusions of the welfare theorems fail. That is, because some monopoly power is retained by firms (brands of a differentiated good), the free entry process does not eliminate all monopoly power –price exceeds marginal cost, and each firm is imposing a mark-up. Free entry, though, eliminates all positive profits, and both facts ensure that each firm is not producing at minimum average cost, but at a point in which average cost is decreasing.

Finally, the standard notion of a competitive or Walrasian equilibrium is not mathematically flawed (a price-allocation pair satisfying (i)-(iii) above), as claimed by Nomidis (2023). A different matter is that the Walrasian equilibrium relies on the notion of an equilibrium price vector, and that no agent in the model –consumer or firm– is directly responsible for it. Indeed, the competitive price seems to "fall from heaven" as the one that equates total demand and supply. But this is why approaches like the one in Cournot's competitive limit result or 'Edgeworth's core convergence conjecture are very useful, i.e., to suggest competition environments in which prices are obtained from the market interaction, and study under what circumstances such prices converge to the perfectly competitive ones. Being aware of this shortcoming, Walras (1874 [1896]) himself suggested a 'tatonnement' process used by a fictitious auctioneer. This dynamic adjustment of prices has been questioned for being somewhat *ad hoc*. For example, we will close with a passage in Edgeworth (1891, pp.18-20), in which he criticizes (somewhat harshly) Walras for that process, while praising him for his equilibrium notion; the passage also refers to Edgeworth's own finding that the Cournot best-response dynamics has problems:

"I do not attribute to Professor Walras such a considerable oversight. It is only his method and not his conclusion that seems open to criticism. If we compare the play of supply and demand on the market to the descent of a liquid mass on the slopes of a valley with successive basins, we can say that Cournot's way of reasoning distorts the fact itself, in that, in the case considered by him, there is no point towards which the system gravitates. There are indeed many basins in which the descending liquid can stop. On the contrary, in the case considered by Walras, there is a well-defined equilibrium position and it is very well indicated by the author. But sometimes he arbitrarily represents the liquid as flowing into a particular channel, whereas the only thing we can say is that the fluid mass will arrive at the equilibrium position in one way or another. Let's consider, for example, the case of a composite market on which the prices of two goods are determined in terms of a third one (cf. *Elements of Pure Economics*). The particular method of trial and error described by Mr. Walras corresponds to a path traced along our metaphorical valley, consisting of a series of broken lines that can lead in two different directions at right angles to each other — let's say, for example, east or west and north or south. We begin by moving along a latitude parallel until we reach the lowest point where this line can lead us into the valley. At this point, we turn sharply at a right angle and descend, following the degree of longitude, to the lowest point of this meridian. But this will not yet be the bottom of the valley, except in the particular case where the shape of the basin is perfectly spherical. Therefore, once again, we follow the parallel of latitude and descend with it as far as we can. And so on until we reach the true bottom. This conception seems to me useful "to fix ideas," as mathematicians say, and to serve as an illustration of this question of equilibrium. But I have expressed some regrets that the author had diluted an idea that he could have expressed very well in a few paragraphs in some twenty-five pages. Because after all, this is not a very good idea. It does not have the advantage that any conception appropriate to its object must present of being able to serve as a type for reality, which is the case with the idea of a state of equilibrium. The laborious studies of Professor Walras do indicate a path, but not the path by which the system tends towards equilibrium. The effort of such an investigation is out of proportion to the importance of its results. The prolonged and repeated analysis of this dynamic problem runs the risk of appearing purely speculative to the economist and insignificant to the mathematician."

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