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Abstract
Paolo Sylos Labini's *Oligopoly Theory and Technical Progress* (1957) is considered one of the major contributions to entry-prevention models, especially after Franco Modigliani's famous formalization. Nonetheless, Modigliani neglected Labini's major aim when reviewing his work (JPE, 1958), particularly his demonstration of the dynamic relation between industrial concentration and economic development. Modigliani addressed only Sylos' microeconomic analysis and the determination of the long-run equilibrium price and output, concentrating on the role played by firms' anticipations. By doing so he shifted attention from Sylos' objective analysis to a subjective approach to oligopoly problem. This paper discusses Sylos' and Modigliani's differing approaches, derives the origin of the Sylos postulate and sets Modigliani's interpretation of Sylos' oligopoly theory in the context of his 1950s research into firms' behaviour under uncertainty.

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1. *Introduction*

The two major contributions to oligopoly theory since the 1930s are the full-cost principle (which empirically undermined the validity of marginal analysis) and the limit pricing theory, which recognised that oligopoly must confront potential competition as distinct from actual competition among existing rivals. Introducing the threat of entry alongside the hypothesis that firms recognise their mutual interdependence set the foundation for theorising about firms' strategic behaviour (Bhagwati, 1970; Stigler 1983). This shift of attention occurred early due to P. W. S. Andrews (1949), R. Harrod (1952), H. R. Edwards (1955), J. Bain (1956) and P. Sylos Labini (1957), especially after Modigliani's formalization (1958).[1] Modigliani's review of Sylos's and Bain's books is considered the departure point for developments during the 1960s and 1970s of entry-preventing models (McGee, 1980, 308).[2]

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[1] Kaldor already recognized in his 1935 *Economica* paper "Market imperfection and excess capacity", the effect of potential competition in establishing that established producers will act as if their own demand curve were much more elastic than it is.

[2] McGee (1980, 308) characterized Modigliani's formalization as the 'purest and clearest' expression of the limit pricing theory, labelling it the 'classical' theory. For McGee's contribution to limit pricing theory, see Giocoli (2003).

However, Modigliani's interpretation diverged in many respects from Sylos' major aims, and his review should be considered an original development of Sylos' model, not simply as its translation into mathematical language. Sylos' analysis was devoted to the dynamic relations among market structures, income distribution, economic development and involuntary unemployment. In other words, he investigated the relation between technical progress and industrial concentration. In contrast and notwithstanding his interest in macroeconomic and Keynesian theory,[3] Modigliani's review examined only Sylos' microeconomic static analysis, notably the role of firms' expectations and the 'Sylos postulate' for determining long-run equilibrium price and output. In doing so, Modigliani departed from Sylos' objective approach to the oligopoly problem as an alternative to subjective analysis based on reaction functions.

There are two explanations for Modigliani's reading of Sylos' book. The first, evident in their correspondence, is that he rejected Sylos' macroeconomics for confusing real and monetary causes of involuntary unemployment. The second pertains to Modigliani's study during that period of firms' behaviour under uncertainty. Even if Modigliani was unfamiliar with then-current literature on oligopoly theory, the issues under discussion were similar, revolving around the role of expectations and the validity of the profit maximization assumption under uncertainty.[4]

This paper highlights Modigliani's and Sylos' differing approaches to the oligopoly problem as emerges from Sylos' *Oligopoly and Technical Progress*[5] from their long correspondence and Modigliani's famous review, 'New Developments on the Oligopoly Front' (1958). Modigliani's reading of Sylos' oligopoly model reflects the separate contexts in which they develop their research. It shows how Modigliani's business studies at Carnegie Tech influenced his reading of Sylos' theory.

The paper is organized as follows. Section 2 outlines early contributions to the limit pricing theory. Section 3 discusses Sylos' contribution to the oligopoly problem. Section 4 discusses Modigliani's interpretation of Sylos. Section 5 is devoted to final considerations.

According to Stigler (1983) the limit pricing theory «had a long prehistory under the name of potential competition, but it was given an explicit formulation by Sylos Labini (1962), Joe Bain (1949) and Franco Modigliani (1958)» (542).

[3] Modigliani was working on the relation between non-competitive markets, rigidity of real wages and involuntary unemployment in his monetary notes (1955) as the basis of his 1963 paper.

[4] The role of uncertainty can be read from different perspectives: uncertainty regarding the number of competitors, the price-output policy of existing and potential competitors (firms' reactions) and uncertainty regarding future production and sales.

[5] I refer to the 1956 provisional version that Modigliani referenced in his correspondence, the 1957 first Italian edition reviewed by Modigliani in the JPE and the 1962 first English edition.

2. *From actual to potential competition*

Following Chamberlin's and Joan Robinson's contributions to imperfect competition, the study of non-competitive markets increased rapidly but fragmentally in constructing a general theory of price.[6] This literature developed around several issues. They included (1) the rationale underlying the full-cost principle, introduced by Hall and Hitch (1939) in England[7] and, independently, by Sweezy in the US (1939); (2) its consistency with marginal analysis; (3) the validity of the profit maximization assumption (especially the relation between short and long-run profit maximization); (4) the role of psychological variables (such as Cournot's reaction functions) in determining equilibrium price and output (Giocoli, 2003).

According to Hall and Hitch, firms' awareness of their interdependence leads to an indeterminate individual demand curve and corresponding marginal revenue (1939, 15). Their empirical investigations showed that firms generally make no effort to estimate the demand curve, its elasticity and their marginal costs; they price by applying the simple "full-cost formula." Among their significant conclusions was that any maximum profit resulting from applying this rule of thumb emerges accidentally or as an evolutionary by-product. This outcome partly is the consequence of the threat of entry: «If prices are in the neighbourhood of full cost, they are not raised by actual or tacit agreement because it is thought that, while this would pay in the short run, it would lead to an undermining of the firms by new entrants in the long run» (1939, 22). They also showed the impossibility of a uniquely determined equilibrium price.[8]

The introduction of firms' reactions to potential competitors underpinned the interpretation of non-maximizing behaviour as intentionally intended to forestall entry, giving a rational foundation for using a simple rule of thumb.[9] It also represented the departure point for constructing a new analytical framework based on strategic considerations (Rothschild, 1947).

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[6] Still in 1953, Joan Robinson explained that 'the reason oligopoly is neglected in the *Economics of Imperfect Competition* is not that I thought it unimportant, but that I could not solve it. I tried to fence it off by means of what unfortunately was fudge in the definition of the individual demand curve' (1953, 584). As reminded by Stigler, 'Not one of the earlier analysis (…) has been absorbed into the mainstream of price theory as a regular and significant part of the analysis of the working of markets and industries' (Stigler, 1983, 537). According to Shubik (1959): «the theory of games of strategy … opens the possibility … of unifying the numerous casuistic treatments of oligopolistic market forms. The theory of games provide a model for economic behavior no matter what the market structure is» (viii).

[7] Hall and Hitch's full cost theory emerged from empirical research of firms' behaviour in England. Some results had been presented by Harrod and Hall in papers before the British Association in 1937 and 1938.

[8] According to them, the price can be set by the strong firm at its own full cost level and accepted by other firms in the 'group'; it can emerge as the result of an agreement among firms, or by trial and error with all firms making adjustments.

[9] See also Andrew (1949): 'In such a world, the firm must keep in step both with its existing competitors' prices and with that which would render its product attractive to new entrants. This meant frequently revised calculations, both for the many products it produced and for those it might produce. Recalculating the exact optimal price each time would be prohibitively costly even if possible. In contrast, the normal cost rule provided an almost costless method of

Recognition of a crucial role for conditions of entry in determining equilibrium price was due to Bain (1949, 1956), Andrews (1949), Harrod (1952), Edwards (1955), Lydall (1955), Sylos Labini (1957) and Modigliani (1958). Even if their models addressed different hypotheses—such as collusive or non-collusive oligopoly and homogeneous or differentiated products—all investigate the relation between conditions of entry and deterrent pricing by established firms; they abandon the profit maximization assumption and accept a cost-based rule (rather than marginal analysis) for determination of equilibrium price, establishing the basis for subsequent developments and refinements of the limit pricing theory.[10] Disagreements among economists who followed their respective approaches mainly concerned the level of the entry-prevention price as the result of different hypotheses about existing firms' reactions to threats of entry.

3. *Sylos' Oligopoly Theory and Technical Progress*

Sylos and Modigliani first met in 1948 in Chicago. Sylos was in the US on a Fulbright research scholarship to study with Schumpeter; Modigliani was teaching at the University of Illinois (Sylos, 2005).[11] They began a lengthy relationship and correspondence, sharing many intellectual interests. Sylos persuaded Modigliani to return to Italy in 1954, thereafter visiting throughout the 1960s to collaborate with the Bank of Italy Research Center to develop the first macroeconometric model of the Italian economy.

In 1956, Sylos Labini published for private circulation a provisional version of *Oligopoly and Technical Progress*, sending it to his 'economist friends' in the US for comments, particularly Alfred Kahn and Modigliani.[12] Sylos' book was divided into three parts: The first was devoted to determination of the long-run equilibrium price and output under oligopoly. The others discussed the relation between market structure and economic development. Following Schumpeter's study of big corporations and Galbraith's analysis of market power in US, Sylos devoted his attention to a new oligopolistic form: the 'concentrated oligopoly' characterized by few giant firms who control

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recalculating, at changed prices, the profitability of a product produced with a given technique and fixed coefficients…' (see Andrew, 1949). See also Dewey (1959), among others.

[10] In particular, Bain (1949) explained the contradiction between marginal analysis and empirical evidence on the basis of entry threats. He introduced a definition of 'limit price' as the (current) price low enough to avoid potential entry. Bain's analysis differed from the kinked demand curve, which referred to non-collusive oligopoly. Bain's limit pricing theory required that collusive oligopolists are aware of it. Finally, according to Bain, potential competitors decide to enter the market on the basis of present price policy because it signals both the character of the industry demand curve and of rivals' policy after entry. He concluded that abandoning the assumption of profit maximization as a goal leads to rejection of conventional price theory and 'the emphasis often placed on non-profit motives, uncertainty, irrationality, and oligopolistic rivalry as explanations of low price policy in concentrated industries may be unduly heavy, and the effect to threatened entry seem certainly to deserve consideration' (1949, 464).

[11] On Sylos' and Modigliani's biographical notes see Roncaglia 2006 and Modigliani 2001.

[12] In Italy he sent the draft to Becattini, Breglia and Lombardini, among others, and to Pasinetti in the UK.

the market and a number of small satellite producers. His study of the dynamic effects of industrial concentration on economic development and employment was influenced by his 'rediscovery' of classical economists (especially Smith, Ricardo and Marx) and by his Cambridge background. He especially referred to Kaldor, Joan Robinson and Sraffa.[13]

Sylos' microeconomic analysis sought to show that industry equilibrium price and output depend on conditions of entry. He attempted to fill the lacuna of the kinked demand curve, which, Sylos believed, assumed without explaining the amount of mark-up, and to demonstrate the rational foundation of the full cost principle and its inconsistency with marginal analysis. The singularity of his oligopolistic model originated in its assumption of technological discontinuity as a barrier to entry and the coexistence of large, medium and small firms within an industry. Sylos numerically demonstrated that the equilibrium price (defined as the price that does not attract new firms) depends on the initial industrial structure (*criève par hazard)* and conditions of entry. His examples were based on both the full cost formula and the distinction between a price that guarantees minimum profit (P_m) and the 'exclusion price' that discourages potential competitors (P_c, with $P_c<P_m$):

> If the price leaders intend to prevent the entry of new firms of a given type, they must keep the price below the level which would give the new firms their minimum profit rate: the "entry preventing" price, P_c, is lower than P_m (1956, 1957, 1962, 40 see also 1957, 50 and 1956, 48).

He also introduced the definition of «elimination price» as a price beneath the variable cost of firms that price leaders want to eliminate (ibid.). Nonetheless, Sylos argued that most efficient firms are uninterested in starting price wars to eliminate established rivals because their costs may exceed possible gains. Sylos concluded that even if several equilibrium prices exist, each corresponding to the initial industrial structure, the price generally settles at a level slightly above the entry-preventing price of the least efficient firms (i.e., smaller firms). Consequently, larger firms maintain

[13] After studying with Schumpeter, Sylos continued research with Dennis Robertson at Cambridge, where he met Sraffa and Robinson, among others. For biographical notes, see especially Roncaglia (2006).

[15] Lydall (1955) recognized the possibility that most efficient firms could realize extra-profit even in the presence of limit-price policies: 'The relevant question for a new entrant is *not* whether existing firms are making above-normal profits, but whether they are charging prices at which the *new entrant* can make above-normal profits … Mr. Harrod's model leads to the paradoxical result that no firm can afford to make more than normal profit if it wishes to stave off new entrants. In our model, however, the limit is in the *price*, not the *profit*. The distinction is important because at the same price-level one firm can make much larger profits than other: and this is the essence of the struggle …. If we look at the pricing problem in this terms we shall see that there is nothing surprising in the tendency of monopolistic firms to limit their prices to what they regard as a 'normal' level. This level is somewhere in the region below the no-entry ceiling .... It fluctuates with the conditions of new entry, which themselves depend on the policy of the existing firms. But, given all the conditions, there will be a 'normal' price to which serious firms, which have their long-term interests in mind, will limit themselves …. [The full-cost pricing method] can be understood as an unconscious application of the no-entry ceiling price' (1962, 304, 308).

extra-profits in the long run thanks to their higher efficiency (resulting from employing different technologies, not from entrepreneurial abilities).[15]

Following Sraffa's approach to value theory[16], Sylos' model was conceived to set an objective foundation under the analysis of oligopolistic markets, rejecting Cournot-type and Edgeworth-type solutions based on «abstract hypothesis of an essentially psychological nature» (1962, 19):

One method often used to put some sort of order into the galaxy of hypotheses and solutions is to start with the simplest case of oligopoly, duopoly, and to distinguish between Cournot-type and Edgeworth-type solutions. The former end up with the conclusion that price is determinate and equilibrium stable, the latter with the conclusion that price is not necessarily determinate nor equilibrium necessarily stable. Both types of solutions rest on abstract hypothesis of an essentially psychological nature. More and more complicated assumptions have been made about "reaction curves" and "conjectural variations". The production of such hypotheses and solutions has assumed alarming proportions … *In contrast with this school of economists there is another that propounds a single, very simple and perfectly determinate, solution, based on the assumption of a kinked demand curve* (1962, 19-20; see also 1957 and 1956, 25-26).[17]

From the macroeconomic viewpoint, his study of the dynamic implications of the oligopolistic market aimed to supplant Keynes' psychological explanation of unemployment with an objective explanation based on market structures. Thus, his microeconomic theory related closely to his dynamic analysis in the second and third parts of the book. In the 1962 English edition, Sylos emphasized that his work represented an attempt to find common ground where micro and macro methods of analysis can meet and combine (1962, viii-ix):

The problem of effective demand, which concerns the economy as a whole, have always been discussed separately. The two questions have been treated by two different methods of analysis: microeconomic analysis in the neoclassical theory and macroeconomic analysis in Keynesian theory. The neoclassical theory of market forms has found severe critics on Sraffa and his successors … Yet integration of the two types of analysis seems feasible and desirable. In particular, it seems that the psychological assumptions, which are a

[16] Sylos derives from Sraffa (1926) the hypothesis of constant marginal cost up to the limit of plant capacity while firms generally produce in regime of decreasing average cost, as well as the conclusion that in modern industrial situations competition is a limiting case. In his letter Modigliani criticized Sylos' identification of direct costs with short and long run marginal costs and consequently his conclusion on the inconsistency with perfect competition.

[17] Sylos is quoting Dante (Inferno, Canto XIII): «I believe that he believed that I believed». The objective basis of his analysis is often re-affirmed, see for example: «*We shall try to identify such objective elements as may, in real situations, serve as a basis for price determination.* Otherwise, we would run the danger of remaining in the fantastic world of reaction curves and conjectural variations … And we would risk propounding explanations which may be formally correct but of little or no help in a concrete analysis of any particular industry» (1962, 34, also in 1957 and 1956, 42 emphasis added).

weak point in Keynesians theory, may conveniently be replaced by objective assumptions. Such integration would surely be highly fruitful for the further progress of economic theory (1962, 186–187).

4. *The origin of Sylos postulate*

In a 14-page letter of comments to Sylos' 1956 provisional version, Modigliani discussed Sylos' oligopolistic model and his macroeconomic analysis. As further emerges from their correspondence, they had discussed several of Sylos' issues before the draft circulated. Modigliani's letter is his departure point for his 1958 review of the article.

Modigliani defined Sylos' theoretical model, developed in Chapters II and III, as the most convincing contribution to oligopoly theory because its definition of barriers to entry combined economies of scales and established firms' price-output policy. However, he rejected Sylos' macroeconomic analysis and his dynamic implications, commenting extensively on his confusion between real and monetary causes of unemployment and his definition of the investment function (Modigliani to Sylos, September 14, 1956).

Modigliani's comments on the microeconomic analysis focused on Sylos' numerical examples and the hypothesis of constant output on which they are constructed. Modigliani considered this hypothesis as Sylos' most original assumption since it implies that potential rivals, in evaluating the possibility to enter the market, look at the price after entry introducing anticipations in his analytical framework. He read Sylos' numerical examples concerning effects of entry on equilibrium price and output as alternative strategies adopted by established firms and anticipated by potential competitors to forestall entry. In doing so, however, Modigliani shifts attention from Sylos' objective descriptions of the entry effect to a subjective approach based on behavioural assumptions. In fact, Sylos differed from Modigliani in considering the hypothesis of constant output simply as the result of empirical evidence (Roncaglia, 2006).

Why did Modigliani propose this interpretation? His letter suggests he was seeking rational explanations for firms' non-maximization behaviour that was implicit in the hypothesis of constant output after entry. Modigliani declared that hypothesis unrealistic, along with the hypothesis that potential entrants expect established firms to let the equilibrium price fall. Instead, new firms should expect to share the market at the pre-entry price because larger firms reduce production.

Using Sylos' examples, Modigliani shows that constant prices, not constant output, would appear more profitable to larger firms after entry. However, under his hypothesis the peculiarity of Sylos' model, based on coexistence of different-sized firms, disappears. New large firms could find it profitable to share the market with established firms, excluding small and medium-sized plants. It also followed that Sylos' price was not an equilibrium price: «Once the possibility of entry is taken

into account, potential competitors will be induce to enter, unless a policy of price reduction, and the equilibrium solution will be a Chamberlin-Robinson tangency solution with extra-profits eliminated trough excess capacity» (Modigliani to Sylos, my translation).
According to Modigliani, the conclusions above could be avoided and Sylos' constant output hypothesis could be set on a rational foundation by interpreting it as evidence of established firms' strategic behaviour to deter entry:

We can suppose that larger firms can forestall entry showing that they intend to cut temporary the price … Since they have lower costs they can reduce the price to a level still profitable for them but not for firms of inferior sizes (Modigliani to Sylos, September 14, 1956).

In the formation of potential competitors' anticipations, Modigliani highlighted the importance of larger firms' reputations in effecting price reductions: «a policy of threat towards outsiders combined with a policy of "live and let live" towards established firms is much easier when there exist only one or few very large firms that are able to exercise an effective leadership and to create a record about their attitude towards potential competitors» (ibid., my translation).

Nonetheless, Modigliani understood that by introducing strategic behaviours into Sylos' model he was suggesting a reading based on game theory, with solutions that become different, indeterminate and unstable:

For example could always exist the possibility of one large firm able to set a monopoly price low enough to forestall entry of firms of inferior size…however this solution can be unstable because it can induce a new plant of maximum size to enter and share the market… (Modigliani to Sylos, September, 14, 1956).

From game theory Modigliani also borrowed the criterion for distinguishing stable from unstable equilibrium positions. He defined equilibrium position A as more stable than B if, as the result of random disturbances or intentional price wars, it is profitable to move from B to A but not vice versa. In other words, A is more stable than B if and only if its profits exceed B.
The hypotheses of constant output and strategic behaviour also led Modigliani to restrict the validity of Sylos' model to small markets. By formalizing the conditions of entry, Modigliani showed the inconsistency between Sylos' hypothesis of a large market size and coexistence of plants adopting different technologies:

$$p[x(p_1^m) + x_j] < p_j^m \quad \textit{condition of entry}$$

where p_1^m is the equilibrium price (technology 1 is the less efficient), and p_j^m is the minimum price allowed by method of production j.

When the above condition is not satisfied, a firm adopting technology j will find it convenient to enter the market. Thus, following Sylos' hypothesis of constant output, the equilibrium price will fall below p_1^m, eliminating firms of size 1 and 2. This mainly happens under the hypothesis of large market size (with respect to j) where a production increases equal to x_j is negligible as well as the corresponding price reduction. Thus, according to Modigliani, there will be only firms adopting the maximum scale of technology (that is, the number of coexisting techniques of production will tend towards one) and extra-profit will tend towards zero.

Modigliani also pointed out that his definition of the entry condition is consistent with Sylos' conclusion that «large markets … increase the likelihood of an aggressive price policy on the part of large firms, designed to eliminate small and medium firms. Therefore, the larger the market, the larger tends to be the average size of firms and the lower the equilibrium price» (1956, 1957, 1962, 50). However the two economists derived opposite implications. To Modigliani this situation does not contradict the case of perfect competition and zero concentration, since there will be only firms of equal efficiency and size. For Sylos, it represented the case for higher concentration.[18]

Finally, according to Modigliani, limiting the validity of the model to small markets was consistent with Sylos' assumption of one or few established firms able to exercise an effective leadership combining a limit-price policy towards potential entrants with a live-and-let-live attitude towards smaller firms. Furthermore, when the auto-discipline of the group is easy, extra-economic factors will induce lager firms to accept and support coexistence alongside small firms. Those factors may include antitrust laws and the argument that the highly efficient firms cannot cut prices because doing so leads smaller firms to bankruptcy. To Modigliani, his interpretation also suggests that large plants have excess capacity only for strategic reasons.

Despite Modigliani's detailed comments and suggestions, Sylos introduced only minor changes to his microeconomic analysis in his 1957 definitive edition. In fact, many of Modigliani's comments are followed by Sylos' notes of disagreement. In particular, with reference to Modigliani's discussion of entry conditions and the hypothesis of constant output, Sylos wrote: «This is not my hypothesis, the interpretation of this point is not correct» (ibid., my translation).

[18] 'I want to point out to you that your last conclusion in section 6 is extremely incorrect: if there exist many plants of maximum size the concentration will be not high … there will be zero' (ibid.).
An example of Modigliani's differing interpretation of the concentration process is his decision in the 1958 review to present Sylos' term 'concentrated oligopoly' as 'homogeneous oligopoly'. Modigliani's translation emblemizes his different focus: the determination of equilibrium price rather than the dynamic implications of industrial concentration.

5. Modigliani's 1958 article review

Although Sylos' disputed Modigliani's interpretation of his oligopolistic model, in July 1957 he asked him to review the book.[19] Modigliani initially appeared sceptical, claiming to be unacquainted with recent English literature on the subject:

Last year I spent a considerable time and effort in going over the first version of Sylos' book … At that time I was very favourably impressed … notably by part I and the oligopoly model developed there. On the other hand I had serious reservations about other parts and stated my criticisms to Paolo. *I have not had the opportunity to look over the revised edition so I do not know to what extent he may have taken care of my observations*.… In recent years I have not been too closely interested in oligopoly theory and market structures and therefore my knowledge of the literature is at least spotty… It is quite possible that what really impressed me in Paolo's book is really not so original … I have for instance the feeling that Paolo focus on entry as the essential element in price behaviour has been exploited by others in recent years but don't know precisely when and where… Perhaps you could relieve my worries on this point by letting me know if you too regard the analysis of part I (especially chapter II) as very significant and perhaps by suggesting me some major pieces of literature (Modigliani to Alfred Kahn, July 29, 1957).

He then accepted on the basis of detailed comments of the 1956 draft he wrote the year earlier and asked to Sylos to return them. Modigliani's review parallels them closely. The main difference is that in his review he does not discuss Sylos' macroeconomic analysis, giving the impression that the second and third parts of the book were separate from the oligopoly model whereas the connection between the micro and macroeconomic analysis represented one of Sylos' major aims.
Furthermore, in «New Developments on the Oligopoly Front», Modigliani discusses Sylos' (1957) and Bain's (1956) books jointly (Sylos suggested the reading of Bain). As in the letter, Modigliani emphasizes the definition of oligopoly as strictly connected with behavioural assumptions that emerge from Sylos's and Bain's contributions. He calls their theory «a welcome major breakthrough on the oligopoly front» (1958, 215) because they describe barriers to entry as the combined result of economies of scale and established firms' price-output policies. He also notes that their analysis of «the behaviour of potential competitors» is neglected by previous literature.

[19] Alfred Kahn also asked Modigliani to review Sylos' book: «I have already offered my good offices in getting the book reviewed by the AER and the JPE … in one case taking the liberty of suggesting you as possible reviewer …. I have now a rather urgent letter from Paolo dated July 18th asking whether there is any possibility of getting a review published … before the Commission meet in October …. The only possible remaining question that may occur to you is why I have not volunteered to write the review myself. My honest reply would be that I am still too uncertain about my own ideas and qualifications in the area, as you very well known, the relation between the micro and the macro involves very ticklish problems, and numerous pitfalls that I feel I may not succeed in avoiding …» (July 25, 1957).

Then Modigliani concentrates on Sylos' static analysis, suggesting possible extensions in the so-called Sylos-Bain-Modigliani (S-B-M)'s model. As before, Modigliani diverges from Sylos' objective approach, ascribing a crucial role to psychological variables such as potential entrants' anticipations.[20] To Modigliani, in fact, the central problem of oligopolistic markets is the ability of potential entrants to anticipate effect of entry on equilibrium price as the result of anticipating existing firms' reactions. The solution appeared in Sylos' hypothesis of constant output. The hypothesis had been introduced as new entrants' expectations being consistent with a minimax approach to uncertainty: «potential entrants behave as though they expected existing firms to adopt the policy most unfavourable to them, namely, the policy of maintaining output while reducing the price (or accepting reductions) to the extent require to enforce such an output policy» (1958, 217). Modigliani labelled this hypothesis 'Sylos postulate'. It was introduced as a necessary condition to solve the impasse of the indeterminacy of firm's reactions and «to find a definite solution to the problem of long-run equilibrium price and output under homogeneous oligopoly, or at least a definite upper limit to the price, to be denoted by P_0 and a corresponding lower limit to aggregate output, say X_0» (1958, 217).[21] As before, Modigliani also borrows from game theory the criterion of dominance to distinguish between stable ('rational') and unstable ('less rational' and 'irrational') structures, repeating the reasoning developed in the letter.[22]

In October 1957, Modigliani sent a copy of his review to Sylos, hoping he would be satisfied with the possible extensions he suggested. Sylos replied that Modigliani's review represented an original work with original developments of his model. He especially complains about Modigliani's

[20] He also neglected the relation between the full cost principle and marginal analysis, to which Sylos devoted the final chapter of part one (Sylos reinforced this argument in the English edition).

[21] Introducing 'Sylos postulate' enables Modigliani to use the notion of the 'marginal demand curve' that potential entrants confront. Following Sylos' conclusions, he shows that the entry-preventing price tends to rise with economies of scale and fall as market size increases (it approaches the competitive price as the market approaches infinity). Modigliani does not address Sylos' demonstration of inconsistency in the relation between the full cost principle and marginal analysis. He indicates only that his framework was consistent with both methods of analysis, even if the use of marginal analysis 'would be merely an exercise in semantic and formal logic and would in no way increase our understanding of what is involved' (1958, 226).

[22] In a letter to Modigliani, Nordhaus raises the problem of equilibrium stability: 'what is the force that prevents internal expansion from lowering price? Consider a firm that already has a chunk of the market. By expanding output he can realize lower average cost than an entrant can. Put differently, since his marginal demand already includes his own output, the limit price for discouraging internal expansion must be lower than that for external expansion. As long as the "Sylos postulate" is appropriate for internal as well as external entry, one can work out the equilibrium for this case in the same way as the one you present in your article. The equilibrium is clearly the Chamberlin, with zero long run profits … Is this obvious?' (January, 29, 1974). Modigliani replied that he thought, implicitly in his article to this interesting question, however: [Remark 14] 'because in the standard case, a reduction in price below the entry preventing price is disadvantageous to the entire group of firms in the industry, and a higher one cannot be maintained, I would expect them to keep the price at that level. …the task may be made easier by the fact that the smaller firms that would be more inclined to break the explicit or implicit agreements, already have fairly high costs. So their gain from expansion is limited. Needless to say, equilibrium under the circumstances would likely be somewhat unstable, tending on the average, to keep the price below its optimum, which is indeed what I would expect to find…' (1974).

neglecting of the last parts of the book, in particular the relation between effective demand and involuntary unemployment (Sylos to Modigliani, October 18, 1957).
Modigliani's review was followed by the English translation of Sylos' *Oligopoly and Technical Progress* in 1962. There Sylos indicates the main differences between his model, his major aims and Modigliani's interpretation:

Considering the scientific value of Modigliani's analysis and the original approach to certain specific problems and their solution, his paper is to be regarded as more than a critical review of the two books; *it is a new and significant contribution to the theoretical problem of oligopoly* …. Nor have I attempted to work out the whole analysis in the light of Bain's and Modigliani's contributions [with regards to the first part] … It seemed to me that if I were to recast my whole analysis, this would not only involve a *radical revision of the logic structure of my book,* but, just because of the kinship between my analysis and the two others mentioned, might also impair the homogeneous texture of my argument (1962, vii-ix, emphasis added).[23]

In particular, Sylos does not emphasize, as Modigliani did, the role of Sylos postulate. In subsequent editions he still read the hypothesis of constant output as the result of empirical evidences rather than in terms of established firms' strategic price-output policy. He did not discuss the postulate in the 1957 edition, even if Modigliani had already suggested his behavioural interpretation in his letter. He introduced Sylos postulate in the English edition without, however, ascribing to it a significant role in determining the equilibrium solution:

if new firms enter the market, the existing ones continue to produce as much as before. *They do so not only to discourage the entry of new firms … but also because by lowering their output the existing firms would raise their total average cost (since on our assumptions total average cost is decreasing up to the limit of plant capacity) … if existing firms decide to produce less than maximum output, they do so not under pressure of new entry, but on the basis of independent economic calculations* (1962, 43, emphasis added).

Publication of Modigliani's paper was followed by a debate in the JPE (1959). Donald E. Farrar and Charles F. Phillips Jr. from Harvard University criticised the S-B-M model. They defined it as reminiscent of Cournot's duopoly theory and criticized the 'bad psychology' expressed by the Sylos postulate. They claimed the postulate assumed away the «very essence of oligopoly theory» (1959,

[23] As reminded by Sylos (2005) «[Modigliani] overall judgment of my analysis was decidedly positive, and the article prompted the then director of the prestigious series published by the Harvard University Press, John Kenneth Galbraith, to have the book translated and bring it out in the series, which in turn led to invitations and translations of that and other books in various countries. All this I owe to Franco» (42).

416), that is the recognition of mutual interdependence, which represented the oligopoly's major problem. Nonetheless, they admit that the «Recognition of entry provides oligopoly theory with a *new* point of joint profit maximization for existing firms – the entry precluding price-output combination …» (1959, 417).
Modigliani's reply referred to the differing hypothesis and conclusions of Cournot's and the B-S-M' models[24] and defended the plausibility of the Sylos postulate:

> It requires a good deal of obtuseness for the members of the closed Cournot group not to see that they can all improve their lot by cooperating …. But it would seem to be the best part of prudence for a potential entrant to give serious consideration to the possibility that the existing firms will make him as unwelcome as they possibly can (1959, 418).

Despite differences between Modigliani's and Sylos' approaches to the oligopoly problem, the subsequent literature quoted the two works jointly, often referring to Modigliani's review as the «brilliant formalization of Sylos' model» (see, for example, Bahawti, 1970). Contrary to Sylos' intentions, the S-B-M model comes «to be accepted as part of the mainstream theory of non-competitive markets» (Roncaglia, 2006) and a 'classical' contribution to the limit pricing theory. It represented a first step towards application of game theory and strategic behaviour to the oligopoly problem. The Sylos postulate was in fact regarded during the 1970s as Nash-Cournot behaviour by entrants with the incumbent acting as a Stackelberg leader (see Obsborne, 1971, Gilbert 1989, among others). According to R. J. Gilbert (1989,107):

> Potential competition has been recognized as a mechanism to control the exploitation of market power at least since the work of J.B. Clark (1902), but it was not until 50 years later that economists, most notably Joe Bain and Paolo Sylos-Labini, refocused attention on the idea. With inputs from the theories of imperfect competition, optimal control, and dynamic games, their work evolved into ever more sophisticated models of the reactions of existing competitors to the threat of new competition.

6. Final Considerations

Modigliani's different reading of Sylos' book appears clearly influenced by his different background and economic interests. After studying with Schumpeter, Sylos carried on his research at Cambridge, working with Dennis Robertson. His major references were Sraffa's, Joan

[24] In the same number of the *Journal*, Franklin Fisher extended Cournot to the case of free entry and applied Sylos postulate to entrants. He showed that aggregate output and prices generally will not coincide with those implied by the S-B-M model.

Robinson's and Kaldor's contributions to study of non-competitive markets, rejecting the validity of marginal analysis. His microeconomic aims were to develop the theory of the kinked demand curve as an alternative to the prevailing behaviourist approach based on firms' reaction functions.

On the other hand, Modigliani earned his PhD from the New School for Social Research under Marshack's supervision. He was a mathematical economist who collaborated during the 1950s with the Cowles Commission, then considered the avant-garde of new mainstream economics. From 1949 through the 1950s, Modigliani worked on two projects (at the University of Illinois, then at Carnegie Tech) researching firms' behaviour under uncertainty. These investigations likely influenced why he related the threat of entry strictly to the uncertainty problem, ascribing to new entrant's anticipations a crucial role in determining the limit price. Even if he did not know the recent literature on oligopoly theory, the main issues under discussion, such as the validity of the maximization assumption and the role of expectations in decisions, were similar.[25]

Discussing Marshack's and Savage's minimax regret rule of choice (the basis of Sylos postulate) at the 1949 AEA Conference, Modigliani defined it as reasonable and promising for introducing in the «process of choice under ignorance the fundamental economic principle of opportunity cost, of balancing what is lost under the most favourable event against what is gained in the least favourable event» (1949, 207). Thus, according to him, the minimax regret principle «might be of considerable help in explaining and forecasting economic decisions … There is a tendency, in decision making, to follow more or less consciously a procedure similar to this» (ibid.).[26]

Furthermore, the Illinois research originated from the dissatisfaction for the traditional postulate of rationality considered of little or no use under uncertain conditions. Its aim was to investigate the formation of anticipations and plans in economic activity through compilation of a systematic body of data to provide direct evidence of the course of expectations in the US economy (in Modigliani, Cohen, 1961, 3).

The second research, on firms' production planning, took place at Carnegie Tech with Charles Holt, John Muth and Simon in collaboration with the Cowles Commission and financed by the Office for Naval Research.[27] Their departure point was a definition of uncertainty in terms of scarce and costly information and a definition of rationality as strictly connected to entrepreneurs' abilities to obtain

[25] 'Even in those cases where the theory of rational behaviour exists, or can be elaborated, we frequently suspect that actual behaviour follows a different pattern, and that this pattern is not an erratic one. This pattern may be simply irrational … or it may be rational, or close to it, though in a sense not fitting our postulate of rationality. *For instance, the cost of making the best decision, both psychological and material, is hardly taken into account in our theorizing, thought it may in fact be a very important factor in explaining rule of thumb and non-optimal decisions*' (Modigliani 1949, 203; emphasis added).

[26] Modigliani was familiar with game theory. In 1954, he and Herbert Simon published posthumously a paper of Henderson's (their colleague at Carnegie) who used a matrix game to describe duopoly behaviour. In a paper with Grünberg (1954), Modigliani used the Brower fixed theorem to reject the recursive argument and to demonstrate that expectations can be self-validating. In his letter Modigliani suggested to Sylos the reading of Henderson' paper.

[27] See Rancan A., *Modigliani's and Simon's Early Contributions to Uncertainty (1952–1960)*, forthcoming.

and use scarce information. In other words, they departed from the idea that the best decision should be defined in relation to the cost of determining it. The research's signature result was the implementation of the quadratic cost function, which generated linear decision rules and limited the amount of information required to solve decision-making problems, at the basis of both, Muth's rational expectations theory and Simon' s satisfacing behaviour. Even if Modigliani did not abandon the optimization assumption under 'normal' conditions, since it presents «the great advantage of a unique answer» (1983, 119) he accepted Simon's hypothesis of satisfacing behaviour as useful to analysing how firms behave under oligopoly: «Simons' distinction between the two criteria [maximizing and satisficing behaviour] is, indeed, useful to analyze the importance of the outside world for a firm's activity. Given the cost of a decision, if you find yourself in an environment in which a satisficing solution is sufficient to produce profits, you don't go beyond it, for it would be more expensive» (2001, 87).[28]

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[28] Sylos as well, in the 1962 English edition, adds a section on 'profit maximization'. He argues that, in the case of relatively small changes in direct cost or other equilibrium conditions, application of routine principles may be sufficient to achieve the desired aim—i.e., 'what Cyert and March [1956] call a "satisfactory level of profit"' (1962, 82–84).

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