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Summary

We consider an industry in which mutual funds can form portfolios at lower cost than individual investors, because of scale economies. We assume that there is a distribution of investors with different risk aversion. These investors can gather their own portfolio from primary securities and/or buy shares of the mutual funds. In this context, we derive the demand for mutual funds as a function of their (risk-return) characteristics as well as their management fee. Competition between mutual funds is modelled as a non-cooperative game in which funds select their portfolios. We show that in equilibrium extreme portfolios, in terms of risks, will be provided. A small number of funds suffices to uniformly improve upon the market efficiency frontier.

1. Introduction

The importance of mutual funds in channeling savings is well documented. By specialising in fund management, these financial intermediaries benefit from economies of scale[1] and supply better investment opportunities than what could be achieved by direct purchase of the underlying securities. These economies of scale stem primarly from the fixed cost which is incurred in managing wealth. As a result, mutual funds can reduce the transaction cost supported by investors in the constitution of their portfolio. This fundamental role of intermediaries was recognised explicitely in the Wharton School study (1962) and by Friend-Blume-Crockett (1970) and Benston-Smith (1976). However, these authors stop short of developing a formal equilibrium model of the mutual funds industry. Apart from those contributions, mutual funds have been solely looked at from the perspective of the evaluation of their ex-post performance (see e.g. the pioneering work of Treynor (1965), Sharpe (1966) or Jensen (1968)).

Yet, the existence of economies of scale raises a number of issues. In particular, mutual funds derive market power ; the demand for their shares will depend on the own portfolio selection as well as the selection of their competitors. As a result, one cannot refer to some exogenous market equilibrium condition to describe the mutual funds' industry. We are in the realm of imperfect competition, firms select the characteristics of their products and mutual funds' behaviour

1 Recent evidence on economies of scale in the mutual fund industry is provided in Ferris-Chance (1987).

has to be modelled explicitely in terms of strategy. This is the object of the present paper.

The key, strategic, decision that mutual funds have to make is the risk-return combination that they want to offer. The strategy set of a mutual fund is the set of convex combinations of primary assets traded in the financial markets. Competition between mutual funds is then modelled as a non-cooperative Nash equilibrium in a simultaneous game. Notice that funds compete not only with each other, but also with the underlying securities market as investors can complete or undo the portfolio choice of mutual funds by buying directly the underlying securities. The source of the model proposed here is to be found in location theory [2]. However, a basic distinguishing feature of our model compared to standard location models is that here consumers (investors) can produce their ideal product (porfolio) in a number of alternative ways, which are dependent on firms' locations (the portfolios supplied). This changes drastically the structure of demand to the firms (the mutual funds) and calls for a new, specific analysis.

The two major results of our model are as follows. First, a non-cooperative equilibrium exists in which the industry is split in two groups, with on the one hand funds providing a low risk share and on the other hand, funds specializing in risky portfolios. This equilibrium is, no doubt, consistent with real world observations of money market funds competing with equity funds. Secondly, we show that the existence of four funds (at least) is **necessary and sufficient** to reach an

2 See Gabszewicz and Thisse (1987) for a recent survey.

equilibrium in which all investors are better off, such that the market efficiency frontier is uniformly improved upon.

The paper is structured as follows. Demand for shares of mutual funds is derived in the second section. The market equilibrium and its properties are analysed in the third section. We offer some conclusions in section four.

2. The mutual funds industry

The industry is described as follows :

. Two (underlying) securities are traded on a financial market, a risk free asset with return r_f and a risky asset with expected return μ and variance σ^2. Investors can purchase directly these securities but they incur an information or acquisition cost proportional to their holdings, α for the risk free asset and β for the risky one. Short selling is not allowed.

. There are n mutual funds operating in the market. They select portfolios made up of the two underlying securities. The income on each fund is returned to its shareholders less an administrative cost (γ) which represents the cost of promotion, auditors, legal and management fees. This administrative cost is exogenous and identical for each mutual fund. The model is concerned exclusively with the portfolio selection of each mutual fund.

. There is a continuum of investors who maximize a mean-variance utility function $U(\tilde{w})$, $\text{Max } U_b(\tilde{w}) = E(\tilde{w}) - \frac{1}{2b} \text{Var}(\tilde{w})$ where $\tilde{w}$ is the end-of-period wealth, E(.) and Var(.) are the expectation and variance operators and b is the degree of risk tolerance. Investors have identical wealth (normalized at unity) but they differ by their degree of risk tolerance. Risk tolerance is uniformly distributed over the interval $[\underline{b}, \bar{b}]$, $\underline{b}>0$ and $\bar{b}<\infty$. Investors can allocate their wealth among the mutual funds and the two underlying securities. The demand for the shares of mutual funds can be analysed as follows.

For the sake of simplicity in exposition, we first consider the case of three mutual funds and subsequently generalize the analysis. Each mutual fund is fully characterized by its relative holding of the risky asset δ_i, with $\delta_i \in [0, 1]$. We index the funds by increasing order of risky asset share so that $\delta_1 \leq \delta_2 \leq \delta_3$. The efficiency frontier available to investors is depicted in Figure 1.

<Insert figure 1 here>

In the absence of mutual funds, the efficiency frontier available to investors is represented by the segment $[r_f-\alpha , \mu-\beta]$, where α and β represent acquisition costs. Because the fee paid to mutual funds is lower ($\gamma<\alpha,\beta$), the efficiency frontier available to investors shifts to the broken line $[r_f-\alpha , \delta_1] \cup [\delta_1 , \delta_2] \cup [\delta_2 , \delta_3] \cup [\delta_3 , \mu-\beta.]$. At one extreme, the investors with low risk tolerance will presumably find the first mutual fund too risky and they will invest part of their wealth in the underlying risk free security. At the other extreme, the investors with high risk tolerance will presumably find the third mutual fund too safe and they will invest partly in the risky security. Other investors will only combine mutual funds to reach their optimal portfolio.

The computation of the market demand for the shares of each mutual funds involves three steps. First, for each segment of the efficiency frontier associated with δ_1, δ_2 and δ_3, we derive the individual demand for each asset from the way in which investors constitute their optimal portfolio. Second, we determine the set of investors whose utility - maximizing portfolio belongs to the segment at hand. Finally, summing the demand of individual investors, we calculate the total demand for each fund. Detailed calculations are provided in Appendix.

i) Segment $[r_f-\alpha\ ,\ \delta_1]$

Standard utility maximization by an investor b whose optimal portfolio is in the segment $[r_f-\alpha\ ,\ \delta_1]$ yields the demand for mutual fund 1, i.e. λ_1^* (b) :

$$\lambda_1^*(b) = \frac{\delta_1(\mu-r_f) + (\alpha-\gamma)}{\delta_1^2\ \sigma^2}\ b \tag{1}$$

To determine the set of such investors we compute the degree of risk tolerance of the investor willing to invest his entire wealth in 1, i.e. b_1^1

$$b_1^1 = \frac{\delta_1^2\ \sigma^2}{\delta_1(\mu-r_f) + \alpha - \gamma} \tag{2}$$

So, all investors with risk tolerance in the interval $[\underline{b}, b_1^1]$ will mix the risk free asset and the fund 1 according to (1). The next segment to analyse is $[\delta_1, \delta_2]$.

ii) Segment $[\delta_1, \delta_2]$

In general, investors have two different investment strategies to reach segment $[\delta_1, \delta_2]$. They can mix the funds 1 and 2 or they can mix the funds 1 and 3[3]. This question is addressed below. We first consider the mix δ_1 — δ_2. Utility maximisation yields the demand for the second fund for an investor b, i.e. $\theta_1^*(b)$:

$$\theta_1^*(b) = \frac{\mu - r_f}{\sigma^2(\delta_2 - \delta_1)} b - \frac{\delta_1}{\delta_2 - \delta_1} \tag{3}$$

The set of investors who choose to mix 1 and 2 is bounded downwards by those investing 0% in 2 (b_1^R such that $\theta_1^*(b_1^R) = 0$) and those putting 100% in 2 (b_2 such that $\theta_1^*(b_2)=1$), i.e.

$$b_1^R = \frac{\delta_1 \sigma^2}{\mu - r_f} \tag{4}$$

and

$$b_2 = \frac{\delta_2 \sigma^2}{\mu - r_f} \tag{4'}$$

Investors in the interval $[b_1^R, b_2]$ can obtain the desired portfolio according to (3). A comparison of (2) and (4) shows that we have a set (positive measure) of investors $[b_1^1, b_1^R]$ who invest 100% in fund 1. The kink in the efficiency frontier leads to the existence of this set of investors. Intuitively, there will be a group of investors

3 For both realism and simplicity, we consider only the combination of two funds.

for which the indifference curve is tangent to the efficiency frontier at δ_1.

The analysis of the third segment $[\delta_2 , \delta_3]$ proceeds along similar lines.

iii) Segment $[\delta_2 , \delta_3]$

The fraction of wealth invested in fund 3 is given by:

$$\theta_2^*(b) = \frac{(\mu - r_f)b}{\sigma^2(\delta_3 - \delta_2)} - \frac{\delta_2}{\delta_3 - \delta_2} \tag{5}$$

The set of relevant investors is given by the interval $[b_2, b_3^1]$ where b_2 represents the investor putting all its wealth in 2 (see (4')) and b_3^1 the one putting 100% in 3, i.e.,

$$b_3^1 = \frac{\delta_3 \ \sigma^2}{(\mu - r_f)} \tag{6}$$

As there is no kink on the segment $[\delta_1 , \delta_3]$, there will be only one investor b_2 who invests 100% in 2.

As already observed, any portfolio in $[\delta_1 , \delta_2]$ or $[\delta_2 , \delta_3]$ can also be obtained by an appropriate combination of funds 1 and 3. Hence this segment must be considered :

iv) Segment $[\delta_1 , \delta_3]$

The demand for fund 3 by investors who combine 1 and 3 is given by:

$$\theta_3^*(b) = \frac{\mu - r_f}{\sigma^2(\delta_3 - \delta_1)}b - \frac{\delta_1}{\delta_3 - \delta_1} \tag{7}$$

The set of relevant investors is the segment (b_1^R, b_3^1) as $\theta_3^*(b)=0$ yields (4) and $\theta_3^*(b)=1$ yields (6). The set of investors who could combine 1 and 3 is the union of $[b_1^R , b_2]$ and $[b_2, b_3^1]$. Finally, we consider the last segment $[\delta_3 , \mu - \beta]$.

v) Segment $[\delta_3 , \mu - \beta]$

Denoting by $\lambda_2^*(b)$ the fraction of wealth invested in the underlying risky security, we have:

$$\lambda_2^*(b) = \frac{(\mu - r_f) + \dfrac{\gamma - \beta}{1 - \delta_3}}{\sigma^2(1 - \delta_3)} b - \frac{\delta_3}{1 - \delta_3} \tag{8}$$

The set of relevant investors is the interval $[b_3^R, \bar{b}]$ where b_3^R invests 100% in fund 3 ($\lambda_2^*(b_3^R) = 0$), i.e.

$$b_3^R = \frac{\sigma^2 \delta_3}{(\mu - r_f) + \dfrac{\gamma - \beta}{1 - \delta_3}} \tag{9}$$

As there is a second kink on the efficiency frontier at δ_3, there will be a mass of investors (b_3^1, b_3^R) who invest their entire wealth in fund 3.

Expressions (8) and (9) are well defined only if $\mu - r_f + \dfrac{\gamma - \beta}{1 - \delta_3} \geq 0$, that is when δ_3 is not too large. Intuitively and with reference to Figure 1, this condition requires that the slope of the efficiency frontier does not become negative. As δ_3 becomes large, the slope of the last segment can be negative, implying that the risk tolerant investors $(b_3^R - \bar{b})$ would invest 100% in 3.

The analysis of each segment of the efficiency frontier associated with δ_1, δ_2 and δ_3 allows us to write the total market demand for each fund , say D_1 , D_2 and D_3 respectively. For instance, D_1, is given by:

$$D_1(\delta_1, \delta_2, \delta_3) = \int_{\underline{b}}^{b_1^1} \lambda_1^*(b)db + (b_1^R - b_1^1) + 1/2 \int_{b_1^R}^{b^2} [1-\theta_1^*(b)]db$$

$$+ 1/2 \int_{b_1^R}^{b_3^1} [1-\theta_3^*(b)]db \tag{10}$$

The first term in (10) describes the demand for investors who mix the risk free asset with 1. The second term represents the mass of investors located at the kink who put their entire wealth in 1. With respect to the last two terms, we observe that investors who want a portfolio in between 1 and 2 can mix 1 and 2 or 1 and 3. We assume that either combination occurs with equal probability. Consequently, the demand generated by these investors is given by:

$$1/2 \int_{b_1^1}^{b_2} [1-\theta_1^*(b)]db + 1/2 \int_{b_1^1}^{b_2} [1-\theta_3^*(b)]db \tag{11}$$

Similarly, investors who locate their portfolio between 2 and 3 can mix 2 and 3 or 1 and 3. Assuming again equal probability of choice, we find that the demand for 1 originating from this set of investors is equal to :

$$1/2 \int_{b_2}^{b_3^1} (1-\theta_3^*(b))db$$

Summing these three integrals yields the last two terms in (10).

The market demand for fund 2 is given by:

$$D_2(\delta_1, \delta_2, \delta_3) = 1/2 \int_{b_1^R}^{b_2} \theta_1^*(b)db + 1/2 \int_{b_2}^{b_3} \theta_2^*(b)db \tag{12}$$

Investors buying 2 are of two types: First, the investors who mix 1 and 2. These are represented by the first integral. The second integral represents the investors who mix 2 and 3. Given our rule of equal probability, both terms are weighted by one half.

Finally, the demand for fund 3 can be obtained, mutatis mutandis, as the demand for 1 and can be written as follows:

$$D_3(\delta_1, \delta_2, \delta_3) = 1/2 \int_{b_2}^{b_3^1} \theta_2^*(b)db + 1/2 \int_{b_1^R}^{b_3^1} \theta_3^*(b)db$$

$$+ (b_3^R - b_3^1) + \int_{b_3^R}^{\bar{b}} [1 - \lambda_2^* (b)]db \qquad (13)$$

The last integral has to be replaced by $(\bar{b}-b_3^R)$ when $\mu-r_f + \frac{\gamma-\beta}{1- \delta_3} < 0$. In this case, the slope of the last segment of the efficiency frontier is negative and investors invest their entire wealth in 3.

The pattern of demand for more than three funds (say n) will have the same nature as the one described above. More specifically, the demand for the two peripheral funds, 1 and n, exhibit the same structure as in (10) and (13). The first two terms in (10) (and the last two in (13)) remain the same. With respect to the demand originating from investors forming portfolios in between 1 and n, we have to consider the demand generated by all possible combinations involving 1 (or n). For the interior funds, we have to consider all possible combinations involving these assets. As before, when any given portfolio between 1 and n can be formed by different combinations, each of which being supposed to occur with the same probability. Portfolio selection by mutual funds and the market equilibrium are discussed in the next section.

3. Portfolio Selection by Mutual Funds and Market Equilibrium

We assume that each fund, denoted by i ($i = 1 \ldots n$) offers a single portfolio δ_i. Competition is modelled as a non-cooperative game in which all firms choose simultaneously their portfolios, each of them maximising its own profit. Since fees are equal across funds and given, this amounts to maximising the volume of demand [4]. Formally, an equilibrium outcome is described as a n-tuple, $(\delta_1^* \ldots \delta_n^*)$ such that :

$$D_i\ (\delta_1^* \ldots \delta_n^*) \geq D_i\ (\delta_1^*, \ldots \delta_{i-1}^*, \delta_i, \delta_{i+1} \ldots \delta_n^*)$$
$$\forall\ \delta_i \in [0,\ 1] \qquad \forall i = 1 \ldots n$$

In game-theoretic terms, this outcome is a non-cooperative Nash equilibrium in a game where players are mutual funds and strategies are the proportion (δ_i) of the risky security in the funds' portfolio.

Before stating the main results, we need to introduce the following definitions. Let δ_{MIN} represents the optimal fund portfolio from the point of view of the investor with the least risk tolerance. Therefore, δ_{MIN} is the solution of $\theta_1^*(\underline{b}) = 0$ with θ_1^* given by (3). That is :

$$\delta_{MIN} = P\underline{b} \tag{14}$$

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4 It is implicitly assumed that operating expenses are either fixed or strictly proportional to assets.

where $P = \frac{\mu - r_f}{\sigma^2}$ is the market premium per unit of risk.

Similarly, let us define δ_{MAX} as the fund preferred by the investor with the highest risk tolerance $\bar{b}$. This is the solution of $\theta_3^*(\bar{b})=1$, where θ_3^* is given by (7)[5]:

$$\delta_{MAX} = P\bar{b} \tag{15}$$

Our main results can be stated as follows:

Proposition 1 : Assume $n \geq 4$. (i) If $n=2m$, where m is an integer, then there exists an equilibrium given by $\delta_1^* = \dots \delta_m^* = \delta_{MIN}$, and $\delta_{m+1}^* = \dots = \delta_N^* = \delta_{MAX}$. (i) If $n=2m+1$, then $\delta_1^* = \dots \delta_{m+1}^* = \delta_{MIN}$ and $\delta_{m+2}^* = \dots \delta_N^* = \delta_{MAX}$ (or $\delta_1^* = \dots \delta_m^* = \delta_{MIN}$ and $\delta_{m+1} = \dots \delta_n^* = \delta_{MAX}$ is an equilibrium).

Proof : (i) Let $N=2m$. Assume that $\delta_1^* = \dots \delta_{m-1}^* = \delta_{MIN}$, $\delta_{m+1}^* = \dots \delta_N^* = \delta_{MAX}$ and $\delta_m \in \,]\, \delta_{MIN}, \delta_{MAX} \,[$. Then demand for fund δ_m is, by analogy with (12), equal to :

$$D_m = \frac{m-1}{(m-1)m+(m-1)} \int_{\underline{b}}^{b_m} \theta_{MIN}^* (b)db + \frac{m}{(m-1)m + m} \int_{b_m}^{\bar{b}} (1-\theta_{MAX}^* (b))db \tag{16}$$

where θ_{MIN}^*(resp. θ_{MAX}^*) is the demand for δ_m(resp. δ_{MAX}) by investors who mix it with δ_{MIN}(resp. δ_{MAX}) in order to form portfolios in between δ_{MIN} and δ_m(resp. δ_m and δ_{MAX}). Both integrals are therefore to be interpreted as those in (12).

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5 We have defined $\delta_{MIN}(\delta_{MAX})$ from $\theta_1^*(\underline{b})=0$ ($\theta_3^*(b)=1$). Given the kinks in the efficiency frontier, there exists an alternative approach with $\delta_{MIN}(\delta_{MAX})$ such that $\lambda_1(\underline{b})=1$ ($\lambda_2(\underline{b})=0$). This later approach would lead to a smaller interior (in between peripheral firms) region which would yield another equilibrium outcome. It exhibits the same properties as the equilibrium describes in proposition 1.

The probability weights are however different. Given the rule of equal probability when different combinations are available, any portfolio in between δ_{MIN} and δ_m can be obtained by combining $\delta_{MIN} = \delta_1 = \ldots \delta_{m-1}$ with either δ_m or any of the funds $\delta_{m+1} = \ldots \delta_n = \delta_{MAX}$ ($(m-1)m + (m-1)$ possibilities), hence the weight given to the first integral. In the same way, any asset in between δ_m and δ_{MAX} can be found by a combination of δ_{MAX} and either δ_m (m possibilities) or any of the asset $\delta_1 = \ldots \delta_{m-1} = \delta_{MIN}$ ($m(m-1)$ possibilities), and hence the weight given to the second integral in (16). By analogy with (4′), we have:

$$b_m = \frac{\delta_m}{P} \tag{17}$$

Using (3) and (5) in which δ_1 is replaced by δ_{MIN}, δ_2 by δ_m and δ_3 by δ_{MAX}, we obtain the analytical expression for θ^*_{MIN} and θ^*_{MAX}. Inserting these expressions in (16) and using the definition of b_m, δ_{MIN} and δ_{MAX} as given in (17), (14) and (15) yields after integration:

$$D_m = \frac{1}{m+1}\left[\frac{1}{2P}\,(\delta_m + P\underline{b}) - \underline{b}\right] + \frac{1}{m}\left[\bar{b} - \frac{1}{2P}\,(P\bar{b} + \delta_m)\right] \tag{18}$$

The demand for the shares of mutual fund δ_m is linear in δ_m with a slope given by $\frac{1}{2P}\,(\frac{1}{m+1} - \frac{1}{m})$, which is negative. Since D_m is continuous over the interval $[\delta_{MIN}, \delta_{MAX}]$, fund m maximizes demand at $\delta_m = \delta_{MIN}$[6]. Consequently, given $\delta^*_1 = \ldots \delta^*_{m-1} = \delta_{MIN}$ and $\delta^*_{m+1} = \ldots \delta^*_n =$

6 Given that $\delta_{MIN}>0$ and $\delta_{MAX}<1$, the strategy subsets $]0, \delta_{MIN}[$ and $]\delta_{MAX}, 1[$ have to be considered. First, as there is no investor who prefers a portfolio less risky than δ_{MIN}, the demand for $\delta_m \in\,]0, \delta_{MIN}[$ would be lower than the demand at δ_{MIN}. In the same way, no investor wants a portfolio more risky than δ_{MAX}, so that the demand for any $\delta_m \in\,]\delta_{MAX}, 1[$ will be lower than the demand accruing at δ_{MAX}.

δ_{MAX}, the best strategy for funds δ_m is to choose $\delta_m^* = \delta_{MIN}$. This will also hold for firm i=1 ... m-1. A similar argument applies, mutatis mutandis, for funds i=m+1 ... N which will choose $\delta_i^* = \delta_{MAX}$. It follows that $\delta_1^* = \dots \delta_m^* = \delta_{MIN}$ and $\delta_{m+1}^* = \dots \delta_n^* = \delta_{MAX}$ is an equilibrium.

ii) Let N=2m + 1 and suppose that $\delta_1^* = \dots \delta_m^* = \delta_{MIN}$, $\delta_{m+2}^* = \dots \delta_n^* = \delta_{MAX}$ and $\delta_{m+1} \in]\delta_{MIN}, \delta_{MAX}[$. By analogy with (18), the demand for δ_{m+1} is written :

$$D_{m+1} = \frac{1}{m+1}\left[\frac{1}{2P}(\delta_m + P\underline{b}) - \underline{b}\right] + \frac{1}{m+1}\left[\bar{b} - \frac{1}{2P}(P\bar{b} + \delta_m)\right] \qquad (19)$$

Clearly, the demand for fund δ_{m+1} is independent of the portfolio choice. Any δ_{m+1} in the interval $[\delta_{MIN}, \delta_{MAX}]$ and, in particular, δ_{MIN} or δ_{MAX} is a best strategy for fund m+1. If fund m+1 chooses $\delta_{m+1}^* = \delta_{MAX}$, then any fund i=m+2 ... n cannot increase demand by choosing another strategy. Indeed, any such fund would find itself in the situation of fund m+1 just described. Next any fund i=1 ... m would get a lower demand by choosing a strategy in $]\delta_{MIN}, \delta_{MAX}[$. Indeed, any such firm would find itself in a situation similar to fund m described in case (i). The same argument applies, mutatis mutandis, if $\delta_{m+1}^* = \delta_{MIN}$. Q.E.D.

The equilibrium, just described, is Pareto superior in the sense that <u>the portfolio characteristics of mutual funds meet perfectly the demand by investors</u>. Furthermore, <u>the acquisition costs α and β are totally eradicated by the mutual fund industry</u>.

As we show in proposition 2, four funds at least are necessary to obtain this equilibrium.

Proposition 2 : Assume n=2,3. Then, there exists no equilibrium in which in which both δ_{MIN}, and δ_{MAX} are chosen[7].

Proof : (i) Let n=2. By analogy with (10), the aggregate demand for 1 is given by :

$$D_1 = \int_{\underline{b}}^{b_1^1} \lambda_1^*(b)db + (b_1^R - b_1^1) + \int_{b_1^R}^{b_2^1} [1-\theta_1^*(b)]db \tag{20}$$

Integrating (20) and using relations (1) to (4) yields :

$$D_1 = -\frac{1}{2} \frac{\delta_1^2}{P\delta_1+B} - \frac{1}{2} \underline{b}^2 \left(\frac{P\delta_1+B}{\delta_1^2}\right) + \frac{\delta_2+\delta_1}{2P} \tag{21}$$

where $B = \dfrac{\alpha - \beta}{\sigma^2}$.

Differentiating (21) w.r.t. δ_1 leads after some manipulations to:

$$\frac{\partial D_1}{\partial \delta_1} = \frac{1}{2} \frac{B^2}{P(P\delta_1+B)^2} + \frac{1}{2} \underline{b}^2 \frac{(P\delta_1+2B)}{\delta_1^3}$$

which is strictly positive. Hence, whatever δ_2, fund 1 wants to choose δ_1 as close as possible to δ_2. Hence, if there is an equilibrium, it must be such as $\delta_1 = \delta_2$.

(ii) Let n=3. The argument developed in (i) applies, mutatis mutandis, thus showing that δ_1 wants to be as close as possible to δ_2. Therefore, if an equilibrium exists, it must be that $\delta_1=\delta_2$. Next, assume $\delta_1=\delta_2=\delta_{MIN}$. Then, the demand for δ_3 is given by (13), in which $\delta_1=\delta_2=\delta_{MIN}$ and $b_3^1=\bar{b}$. It is never profitable for fund 3 to choose $\delta_3=\delta_{MAX}$, for by taking slightly less risky assets, it can gain a

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7 We have not been able to prove or disprove the existence of an equilibrium in the cases of two or three funds. We offer the conjecture that in general (i.e. without additional restriction), no equilibrium exists in such cases.

positive mass of investors who invest their entire wealth in δ_3. Similarly, when $\delta_2=\delta_3=\delta_{MAX}$, it is clear by the argument above that $\delta_1=\delta_{MIN}$ is not the best strategy for fund 1. Q.E.D.

One observes that the equilibrium pattern depends very much on whether there are at least four firms in the industry. Indeed, with less than four firms, it is not clear that an equilibrium even exists and if it does, the "extreme" portfolios will not be selected. Hence, with less than four firms, the market efficiency frontier cannot be uniformly improved upon (in equilibrium).

The question then arises of why four seems to be a "magic" number in this model. The reason is as follows : when there are less than four funds, whatever the position of these funds, there will be some "captive" consumer. In other words, there will always be one (or two) fund(s), which are absolutely necessary to form some portfolio. These funds thus have some market power, which stems from the fact that for some consumers they cannot possibly be dispensed with[8]. By contrast, with four funds, there is an (equilibrium) configuration where funds can always be dispensed with : for all consumers, there is always an alternative investment opportunity which is equivalent from their point of view. As a result, funds loose their market power and nobody has an incentive to move from the pattern in which market power is diluted.

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8 This will be true for both portfolios when there are only two. It will be true with at least one portfolio in the case of three funds.

4. Conclusions

The mutual fund industry enables investors to reduce the costs incurred in managing wealth. In selecting portfolios, funds compete not only with each other but also with the underlying securities that can be bought directly by investors. We have shown that a non-cooperative equilibrium exists where the industry is split in two groups: the funds specialized in safe assets and those investing in risky ones. Pareto superior improvement is achieved once and only when the number of funds in not smaller than four, investors relying exclusively on mutual funds. Interestingly, 4 firms are thus sufficient to generate an oligopolistic equilibrium which bears resemblance with a perfectly competitive outcome. Indeed, increasing the number of funds above four would not affect the equilibrium portfolio configuration. It only takes four funds to dilute market power. This result, quite surprising in the context of oligoplistic competition, suggest that the mutual funds' industry is naturally more competitive than differentiated product ones which require a large number of firms to lessen market power. This is in accord with intuition. In the present context, investors have access to multiple combinations to form their desired portfolio. This puts strong contraints on strategies that funds can implement as a response to their competitors. In a way, because of multiple combinations, investors can induce direct competition among all funds[9]. If there are less than four funds, this will not however be possible : the number

9 This is in sharp contrast with what we observe in differentiated product markets where competition is "localized".

of combinations is too small, some funds cannot be dispensed with and as a result, these funds keep a significant market power.

Simplifying assumptions of the model include the uniform distribution of risk tolerance, the restricted number of securities, and exogenous management fees. Although, we can only offer conjectures, it seems that the uniform distribution is not essential. The breakdown of the industry in groups of equal size would not hold with an asymmetric distribution but Pareto improvement would likely remains. The restricted number of securities forces to center on the risk free - risky assets choice, although the risky security can be interpreted as the tangent portfolio on a more complex efficiency frontier. Finally, free entry and explicit cost structures would be necessary to endogenize the number of firms and the equilibrium zero profit management fees. Clearly, relaxing this last assumption should provide further useful insights on the nature of equilibrium in the mutual funds industry.

Appendix: The Demand for Shares of Mutual Funds

The demand for the shares of three mutual funds is derived from expected utility maximisation applied to each segment of the efficiency frontier (see Figure 1).

i) Segment $[r_f-\alpha \ , \ \delta_1]$

Investors who want to mix the risk free asset and the first mutual fund δ_1 will maximize the following utility function, λ_1 denoting the fraction of wealth invested in δ_1 :

$$\underset{\lambda_1}{\text{Max}}\ U_b = E\ (\tilde{w}) - \frac{1}{2b}\ \sigma_w^2$$

where $E(\tilde{w}) = (1-\lambda_1)(1+r_f-\alpha) + \lambda_1(1+(1-\delta_1)r_f + \delta_1\mu-\gamma)$

and $\sigma_w^2 = \lambda_1^2\ \delta_1^2\ \sigma^2$.

The utility function is concave in λ_1 and the first order condition $\frac{\partial U}{\partial \lambda_1} = 0$ yields

$$\lambda_1^*\ (b) = \frac{\lambda_1(\mu-r_f) + (\alpha-\gamma)}{\delta_1^2\ \sigma^2}\ b \tag{1}$$

ii) Segment $[\delta_1 \ , \ \delta_2]$

Investors who mix δ_1 and δ_2 will maximize the following utility function, θ_1 denoting the fraction of wealth invested in δ_2 :

$$\underset{\theta_1}{\text{Max}}\ U_b = E(\tilde{w}) - \frac{1}{2b}\ \sigma_w^2 \quad \text{where}$$

$E(\tilde{w}) = (1-\theta_1)(1+(1-\delta_1)r_f + \delta_1\ \mu-\gamma) + \theta_1(1+(1-\delta_2)r_f + \delta_2\ \mu-\gamma)$

and $\sigma_w^2 = ((1-\theta_1)\delta_1 + \theta_1\ \delta_2)^2\ \sigma^2$.

The first order condition implies :

$$\theta_1^*\ (b) = \frac{\mu - r_f}{\sigma^2(\delta_2-\delta_1)}\ b - \frac{\delta_1}{\delta_2-\delta_1} \tag{2}$$

iii) Segment $[\delta_1 , \delta_3]$ and $[\delta_2 , \delta_3]$

The demand for these segments is derived as in (2) , mutatis mutandis.

iv) Segment $[\delta_3 , \mu-\beta]$

Finally,, the last segment involves the mix of δ_3 and the risky security. λ_2 denoting the fraction of wealth invested in the risky asset, we have :

$E(\tilde{w}) = (1-\lambda_2)(1+r_f(1-\delta_3) + \mu\delta_3 - \gamma) + \lambda_2 (1+\mu-\beta)$

and $\sigma^2 w = [(1-\lambda_2)\delta_3 + \lambda_2]^2 \sigma^2$.

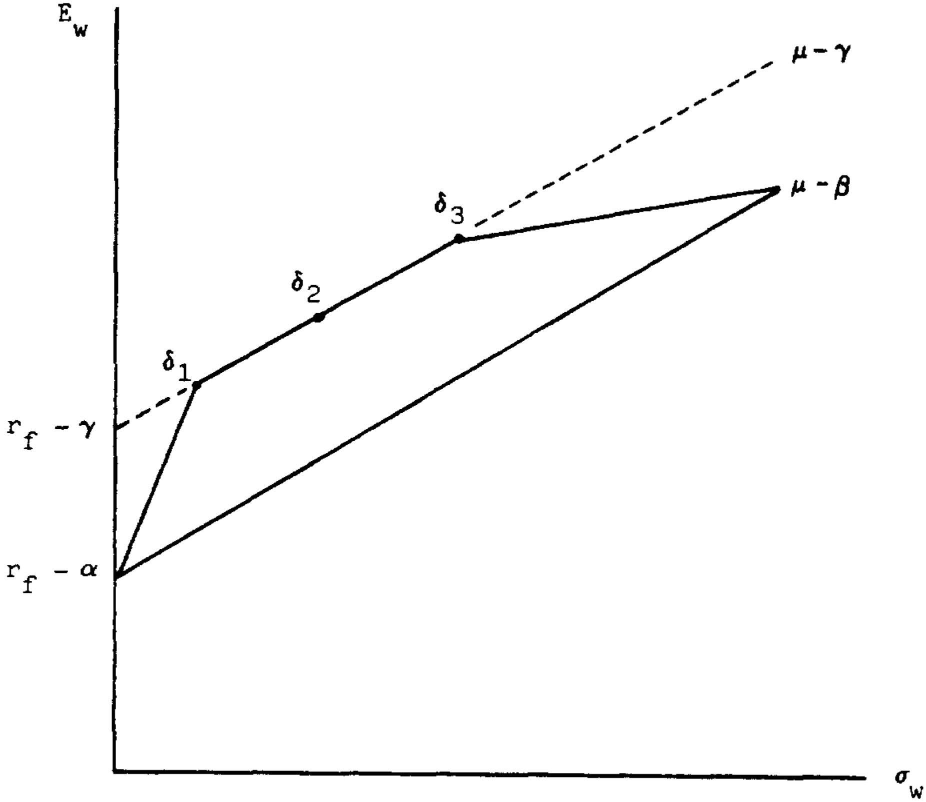

Figure One: The Efficiency Frontier

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