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A stylized model of home buyers' and bankers' behaviors during the 2007-2009 US subprime mortgage crisis: A predatory perspective

CAHIER DE RECHERCHE

UNIVERSITÉ DE SHERBROOKE

Préambule

La gestion financière responsable vise la maximisation de la richesse relative au risque dans le respect du bien commun des diverses parties prenantes, actuelles et futures, tant de l'entreprise que de l'économie en général. Bien que ce concept ne soit pas en contradiction avec la définition de la théorie financière moderne, les applications qui en découlent exigent un comportement à la fois financièrement et socialement responsable. La gestion responsable des risques financiers, le cadre réglementaire et les mécanismes de saine gouvernance doivent pallier aux lacunes d'un système parfois trop permissif et naïf à l'égard des actions des intervenants de la libre entreprise.

Or, certaines pratiques de l'industrie de la finance et de dirigeants d'entreprises ont été sévèrement critiquées depuis le début des années 2000. De la bulle technologique (2000) jusqu'à la mise en lumière de crimes financiers [Enron (2001) et Worldcom (2002)], en passant par la mauvaise évaluation des titres toxiques lors de la crise des subprimes (2007), la fragilité du secteur financier américain (2008) et le lourd endettement de certains pays souverains, la dernière décennie a été marquée par plusieurs événements qui font ressortir plusieurs éléments inadéquats de la gestion financière. Une gestion de risque plus responsable, une meilleure compréhension des comportements des gestionnaires, des modèles d'évaluation plus performants et complets intégrant des critères extra-financiers, l'établissement d'un cadre réglementaire axé sur la pérennité du bien commun d'une société constituent autant de pistes de solution auxquels doivent s'intéresser tant les académiciens que les professionnels de l'industrie. C'est en mettant à contribution tant le savoir scientifique et pratique que nous pourrons faire passer la finance responsable d'un positionnement en périphérie de la finance fondamentale à une place plus centrale. Le développement des connaissances en finance responsable est au cœur de la mission et des intérêts de recherche des membres du Groupe de Recherche en Finance Appliquée (GReFA) de l'Université de Sherbrooke.

Cet article est théorique. Nous présentons l'idée que les investisseurs et financiers de ce monde adoptent une position soit de prédateur, soit de proie. La crise des *subprime* de 2007-2009 est particulièrement éloquente à ce sujet (Mesly and Bouchard, 2014; voir aussi Mesly, 2013, 2016). Ceci n'est pas sans rappeler la fameuse expérience de l'université Stanford durant laquelle des participants volontaires étaient appelés à jouer le rôle de gardiens ou de prisonniers; rapidement, les comportements de prédateurs et de proie se sont développés, et ce, tout naturellement.

Nous examinons le comportement des agents du marché durant les années menant à la crise hypothécaire de 2008 aux États-Unis en utilisant le modèle d'évaluation des actifs financiers (MEDAF; CAPM en anglais). Nous prenons pour acquis que l’investisseur moyen est anxieux de faire de l’argent en achetant et revendant des maisons en prenant avantages des taux privilégiés offerts par les banques. Nous examinons les mécanismes psychologiques et comportementaux de ces deux agents du marché. Notre analyse pointe vers une tendance historique vers la prédation financière, nous permettant ainsi de mettre l’emphase sur l’importance de réguler les marchés, car les biais de positivité, les peurs d’entrée ou de sortir du marché, les vulnérabilités de certains agents et les abus perpétrés par certains autres, sont autant de facteurs qui rendent le marché potentiellement irrationnel, le conduisant vers le chaos.

A stylized model of home buyers' and bankers' behaviors during the 2007-2009 US subprime mortgage crisis: A predatory perspective

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Abstract:

We examine the behavior of market agents during the years leading to the 2008 US subprime mortgage crisis using a stylized Capital Asset Pricing Model (CAPM) model. In our study, an average investor eager to make money by flipping houses meets a banker who offers him subprime mortgage deals. We refer to recent research that shows the mechanics of the psychological and behavioral components of these two market agents. In particular, much in line with the famous Stanford experiment, it is assumed that investors adopt a predator or a prey position. Our analysis shows that, given a historical tendency towards financial predatory acts on the part of market agents (including buyers), government regulations should be adapted and strengthened to face this dooming reality.

Keywords: behavioral finance; predatory mortgages; stylized CAPM; market bubbles; crashes

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1.Introduction

This article is mainly theoretical in nature[1]. We argue that investors and financiers adopt either a predator or a prey position when making financial decisions[2]. The context of the 2007-09 predatory-mortgage crisis is particularly suitable to illustrate such point of view (Mesly and Bouchard, 2016; see also Carney, Cuddy and Yap, 2010, and Mesly, 2013). This is much reminiscent of the famous Stanford experiment whereby would-be actors readily adopted predatory and prey behaviors in the most natural way.

To the best of our knowledge, we are the first to apply the concept of predator-prey positions in a formal manner, linking it to standard financial measures such as the Capital Asset Pricing Model (CAPM).

Recent literature has discussed the fact that people adopt a predator or a prey position (see Mesly and Racicot, 2012; Tokic, 2014). In a financial context, one of the market agents (the investor or the banker/financier) or both acts in a way to surprise the other, with the objective of maximizing his own profits, to the detriment of this other agent. Predatory behavior is based on asymmetry of information; hence, the ability to create a surprise effect that is detrimental to the market-agent-turned-prey (Mesly and Bouchard 2016).

Our stylized approach allows us to illustrate greed and panic behaviors, their interrelation, and the interaction between an investor (J) and his banker (J_2), acting as a provider of financial services. We show that the decision to invest (*DI*) might be related to two kinds of fear: the fear of missing out on the opportunity to *enter* the market (when the market is deemed a winner market), and the fear of missing out on the opportunity to *exit* the market (when the market is deemed a loser/chaotic market). We also show that predatory mortgages in the USA created an illusion trap

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[1] Our main objective is to revisit the last financial crisis using the financial predation hypothesis. Our approach is a heuristic one. We therefore rely on stylized or heuristic models and link them to existing classical financial models. We tried as best as we could to be consistent with the existing body of knowledge in economic and finance.

[2] See studies showing the neurobiological correlates of the predator-prey positions (Mesly, 2013a, Mesly, 2014; Mesly 2015).

in which naïve investors fell in, in part because their positivity bias was boosted by the likes of teaser rates (see Camerer, 1989; Brunnermeier and Julliard, 2008).

In order to illustrate this particular dynamic, we propose a stylized CAPM model by introducing a chaos factor (ε), and present a function for decision-to-invest (*DI*) that takes into account a positivity bias.

The remainder of the paper is organized as follows. We first focus on the ideas (1) that market and individual risks are correlated and evolve within a limited timeline, (2) that investors' behaviors are driven by the fear of missing out on an opportunity to enter or to exit the market, and 3) that investors' are constrained by a straight-line, negatively-sloped budget curve. We follow in the second section with an analysis of predatory mortgages during the 2007-09 crisis in the US, discussing the effects of a positivity bias (Ψ) and of a fear factor (φ) onto over-confident buyers[3] and markets, and show their intricate relationships. We conclude by outlying how our proposed stylized CAPM model can assist in governmental policy-making. Indeed, our paper provides background analysis that can be used to formulate regulations in the financial market and for preparing for future possible chaotic markets. The Appendix shows an application our theory to real world data.

2. The predator-prey positions

Some of the main tenets underlying the concept of predator-prey positions are as follows.

2.1 Market risk and individual risk are correlated and evolve within a limited timeline

Let σ_m express the market (external) risk and σ_J be the trader J's internal risk. J acts in the 2007-09 US market and is a homeowner who is interested in buying an additional home with the hope of selling it shortly thereafter by benefiting from the booming house market and from teaser rates associated with predatory mortgages. These predatory mortgages are, on a larger scale,

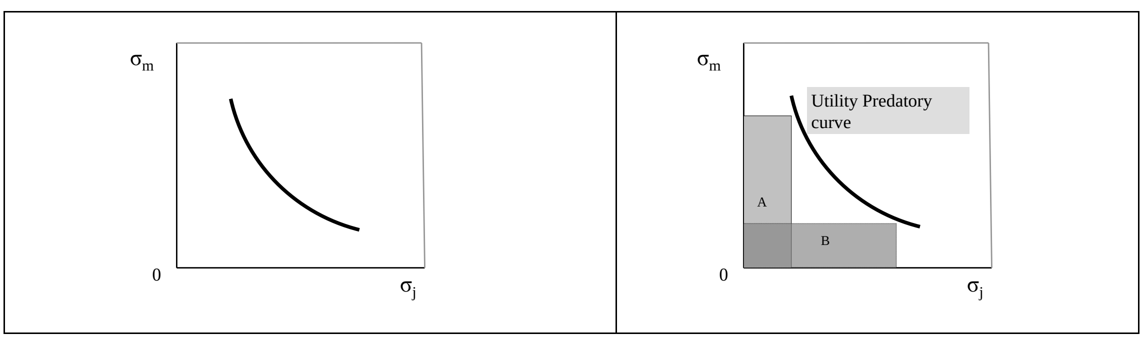
[3] Buyers can also at times act as financial predators by misleading the lenders (see Cowen, 2008).

securitized by way of pooling them and selling them to Special Purpose Entities (SPE) which will then sell them to investors (see Brunnermeir and Pedersen, 2005; Frame, Lehnert, and Prescott, 2008). J (the eager homeowner who wants to buy additional homes) has access to sufficient information *I*, and it is based on this information that he acts. He is bounded by a time constraint: if he doesn't buy the home now, someone else, J_2, will buy it and likely make a profit upon flipping it soon thereafter.

Hence, all such financial behaviors are bounded by time. Similarly, an arbitrageur is bounded by time as the speed of his reactions determines whether his trade-offs between, say, bonds and stock pay off in the end.

We postulate that σ_m and σ_J are correlated, given a finite time line. J can choose to act very swiftly in a risky market because he feels he knows his "stuff" well enough (he has sufficient information *I*, or put differently, he does not suffer from an asymmetry of information); or else he can choose to wait longer, hoping the market will become less risky, but realizing that his own vulnerability (his risk σ_J) increases because the line-up of home buyers (or line-up of traders) in front of him with access to information *I* keeps increasing (Mesly, 2014a). This dynamic is represented in Figure 1[4]:

Figure 1 – The Utility Predatory curve C_{PJ} for home buyer J given information *I*



[4] Note: For all intents and purposes, the graph is bounded by an upper time limit of 2.3. The mathematical reasoning for this assumption can be provided upon request.

Past research has shown that the Utility Predatory curve[5,6] is expressed as follows[7] (Mesly, 2010)[8]:

$$\sigma_m = \frac{k}{\sigma_j}$$

(Eq.1)

In short, under certain circumstances, J's positioning in the market can lead to financial predatory acts. At every point along this curve, the surface underneath is the same: this means J is consistent with himself at all times[9]. Because time is considered, the derivative of this function corresponds to the velocity of the trade between the risk the market incurs and the risk associated with J, the homebuyer (or trader) since he suffers to some degree from an asymmetry of information *I*. The first derivative is as follows[10]:

$$\frac{\partial\sigma_m}{\partial\sigma_j} = \frac{-k}{\sigma_j^2}$$

(Eq. 2)

[5] The Utility Predatory curve expresses the fact that investor J finds a certain utility by developing predatory behaviors given market risks and his own risk. A Utility Predatory Curve meets the five characteristics of utility curves: 1) no quantities of risk – market or individual – are negative; 2) more is always preferred to less; 3) they use an ordinal measure; 4) they can be associated with a budget constraint; 5) They cannot cross each other.

[6] Note: J is only active on a small portion of the Utility Predatory curve. The mathematical reasoning can be provided upon request.

[7]Where k = 1.3. This number has been consistently obtained in more than 45 groups we studied, including the Mount Real Fraud case in Quebec, and results from a predator-prey ratio as measured by an established questionnaire. As such, we consider it to be a constant that keeps reappearing in all of our researches with groups presenting various financial stakes. While there has been mild variations around this constant depending on the group, overall, the average sets in at k = 1.3.

[8] Note that, for example, the pair σ_{m1} and σ_{j1} represents a point lying on our stylized indifference curve (Figure 1) for a certain level of utility and can be interpreted similarly to a standard utiliy function. In this context, more is preferred to less. More precisely, we could have written equation (1) as $x_2=c/x_1$, where x_2 is a function of a quantity x_1 (and c is a constant) and represents a portion the rectangular hyperbola commonly used in managerial economics.

[9] If this did not hold true, we couldn't infer on the rest of the behaviors that we shall examine.

[10] The derivative will be used further along in this paper.

The covariance (*Cov*) can be calculated as[11]:

$$cov(\sigma_m, \sigma_j) = Corr(\sigma_m, \sigma_j)\sigma'_m(\sigma_m)\sigma'_j(\sigma_j)$$

(Eq. 3)

In equation 3, σ' refers to the standard deviation of its associated risk σ (which is itself a standard deviation) and where the correlation value (*Corr*) is equal to *k'*. At the point along the Utility Predatory curve where the function $\sigma_m = k/\sigma_J$ equals the function $\sigma_m = k{\cdot}\sigma_J$; the value of $\sigma_J = 1$ and that of $\sigma_m = 1.3$; this point is called the Point of equilibrium[12].

This gives a beta β for asset a (e.g., a house) in the standard CAPM formula of (Sharpe, 1970):

$$\beta_0 = \frac{k' \ \sigma'_m \ (\sigma_m) \ \sigma'_j \ (\sigma_j)}{\sigma_m^2}$$

(Eq. 4)

With the standard CAPM formula being:

$$E(r_a) = r_f + \beta_0 \ [E(r_m) - r_f]$$

(Eq. 5)

Where $E(r_a)$ is the expected return on asset a (the extra house that buyer J wants to buy), r_m is the current market rate of return and r_f is the risk-free rate of return with $r_m > r_f$ at all times (otherwise, J will not be interested in buying an extra house; he would rather, for example, put his money in US T-Bills).

[11] Note that in the present case, we assume that σ_m and σ_j are stochastic variables, while we previously assumed in equation (1), that they were realized values sitting on our stylized indifference curve.

[12] For all intents and purposes, this is the only point of interest as, at that point, as we will proceed to show, J maximizes his position in all respects.

2.2 Fear of missing out on an opportunity to enter or exit the market

We posit that fear is at the heart of an investor J's (such as homebuyer) decision (Mesly, 2015a). There are two scenarios for fear to take place: the fear of missing out on an opportunity to *enter* the market (fear of not entering or F_{ne}) and the fear of missing out on an opportunity not to *exit* the market (fear of not exiting or F_{nx}) (see Lux, 1995). F_{ne} takes place when the J's in the US market rush to buy an asset (an extra house) in search for quick and high rewards, such as Return on Investments (ROI's), as happened during the booming US housing market in 2006-07. F_{nx} occurs when the J's in the US market believe the value of their assets is threatened due to a negative change in the market (i.e., by chaos – see Mandelbrot and Hudson, 2004), such as was the case in the crash of 2008. It could certainly be the case that J sells a profitable asset too quickly for fear of missing out on the opportunity to exit, or *a contrario*, that he holds on to a poor asset in the vain hope that he will need to enter an activated market. This is in line with Shefrin and Statman (1985)'s disposition effect. In both cases, fear-of-not-entering and fear-of-not-exiting the market positions are at the heart of J's behavior[13].

These two fears, when put together, create three possible profiles for J: risk-averse, risk-taker or risk-neutral[14]. The CMFP considers that the decision to invest (*DI*) is what needs to be measured rather than the $E(r_a)$ per say. Hence:

$$DI = E(r_a)\psi = f(fear\ of\ not\ entering\ or\ not\ exiting\ on\ time)$$

(Eq. 6)

In equation 6, Psi (Ψ) refers to a positivity bias. It encompasses all biases regularly cited in behavioral finance (e.g., overconfidence bias – see Scheinkman, and Xiong, 2003; Shiller, 2005; Campello and Graham, 2013; see also Kahneman and Tversky, 1979; Lam, Liu and Wong, 2010)

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13 In either case, there is potential predator/prey interplay: taking advantage of a position (out of fear) to gain an advantage (predator) or withdrawing from a position (out of fear) (prey).

14 J can adopt any of these profiles over time; the market at large is considered to consist of an aggregate of these three investors' profiles.

because in the end it is a sense of optimism (or its opposite) that is at the core of perceived predation (or threat from the market): a high positivity bias leads to little perceived predation while a low positivity bias generates a higher sense of perceived predation. Equation 6 states that the decision to invest is based on two forces: the expected return the asset *a* (the extra house) is likely to generate in the mind of J (the investor) and J's belief that the odds are playing in his favor, that is, his positive outlook on market and personal risks (σ_m and σ_J).

Given this, we re-arrange by introducing a stylized CAPM model, as follows[15]:

$$E(r_a) = r_f + \beta_0 \; [E(r_m) - r_f] - \varepsilon$$

(Eq. 7)

We use $E(r_a)$ in $DI = E(r_a)\ \Psi$ (Eq. 6). The decision to invest (*DI*) is equal to the expected return on asset *a* as amplified by a positivity bias (Ψ[16,17]). "$E(r_a)$" is equal to an initial level of trust endowment in the market[18] (or risk-free rate r_f) plus a risk premium (i.e., $\beta_a\ [E(r_m)- r_f]$) that includes a systematic risk measured by (β_a) influencing the anticipated extra gain (gain over the risk free rate, hence "$E(r_m)$ - r_f)" or market risk premium, as jeopardized by the tendency of the market to reach chaos (ε)[19]. In a situation of panic, regardless of the level of optimism (of Ψ, set between 0 and 1) in the market, J's expected return "$E(r_a)$"equals zero (0) so that:

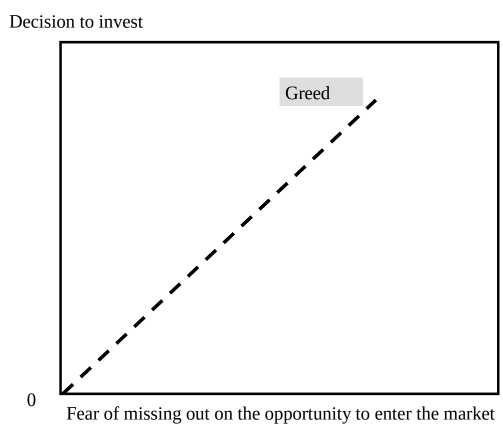
$$DI = E(r_a)\, \psi^{\varphi} \; where \;\; E(r_a) = r_f + \beta_{a}^{\varphi} \, [E(r_m) - r_f] - \varepsilon$$

[15] Note that the addition or subtraction of a factor such as ε is in line with the well-known build-up method used to estimate the required return of an asset (Pinto *et al.*, 2015).
[16] At $\Psi = 1$, J suffers from total blind trustfulness.
[17] Recall that Sharpe (1991) had a similar provision in his version of the CAPM model, variable τ_m standing for "societal risk tolerance". See also Dawson (2015).
[18] The formula is similar to the one found in past research (Mesly, 2013, 2014): Cooperation (or decision to invest) = 0.3 (initial trust endowment or, put differently, r_f, within the upper limit of the model set at 2.3) + 0.9 Trust + ε, where 0.9 = 3 * (*k*-1). Trust = self-confidence in ability to make money. The mathematical reasoning can be provided upon request.
[19] The chaos function follows a logistic map function in the form of $Panic_{t+1} = k\ Panic_t\ (1-Panic_t)$ where t is time. Within the boundaries set by our model, ε = the Feigenbaum value, or twice the upper limit of 2.3 (2.3 for σ_m and 2.3 for σ_J). The mathematical reasoning can be provided upon request.

(Eq. 8)

In short, the equation says that the decision to invest is influenced by the expectations of rewards as expressed by "$r_f + \beta_a [E(r_m)-r_f]$" but that this expectation must be higher than the limit of market chaos set at ε. In a panic market (such as was the case during the market crash of 2008), the decision to invest turns to zero (0) and the expectations of rewards "$r_f + \beta_a [E(r_m)-r_f]$" grows smaller compared to the state of chaos ε. We conjecture that in upward market, the decision to invest grows as the fear of not entering the market on time grows, because investors turn greedy. This creates a positive slope (Figure 2). We also posit that in a downward market, people become anxious to quickly leave the market for fear of losing everything, and thus disinvest. This creates a negative slope (Figure 3).

Figure 2 – The fear of missing out on the opportunity to *enter* the market



As can be seen, the ascending slope reflects the decision to invest as per equation 8, with no chaos effect in sight. J is eager to buy extra houses because he does not want to miss out on the opportunity to flip them and make a quick and substantial profit, given the heated market trends and the time pressure, as other J's line up that long for the same extra houses.

The fear of missing out on the opportunity to exit the market (F_{nx}) as panic starts looming is shown in Figure 3, as follows:

Figure 3 – The fear of missing out on the opportunity to *exit* the market

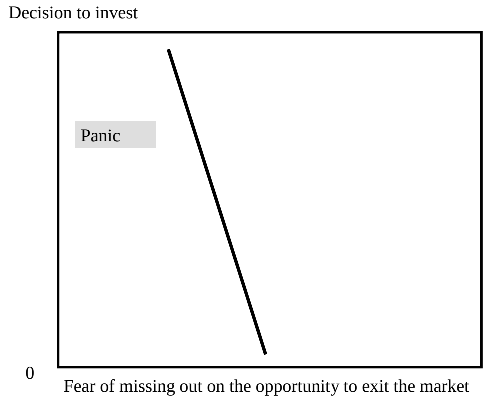


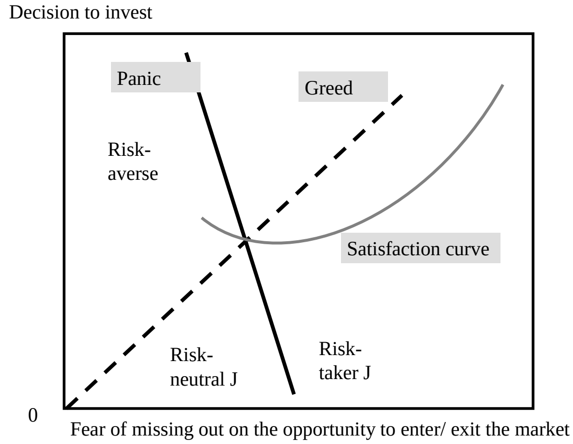
Figure 3 is not truly representative of the market as it actually takes place, for two reasons. First, Ψ for the J's that fear of missing out on the opportunity to enter the market (Ψ_{ne}) is necessarily higher than Ψ for the J's that fear of missing out on the opportunity to exit the market (Ψ_{nx}), so that, during a market bubble:

$$\psi_{ne} > \psi_{nx} \quad \text{(Eq. 9)}$$

Historically, crises have shown that the slope of the downfall is much steeper than the slope of the upward trend during a bubble period. This asymmetry is in line with Black (1976)'s leverage effect. Second, a crisis (a wind of decreasing optimism, or, put differently, pessimism) follows the uptrend, so that there is a delay between the moment Ψ_{ne} starts and the moment Ψ_{nx} starts. Hence, we can summarize the observations (Figure 2 and 3 are combined) as per Figure 4[20]:

Figure 4 – The fear of missing out on the opportunity to enter and to exit the market

[20] Note: we can calculate the exact slope of both F_{ne} and F_{nx} curves because we know the shape of the Utility Predatory curve (see further in the paper) and we know that its lowest point corresponds to $y = 0$ for the Panic curve. The mathematical reasoning can be provided upon request.

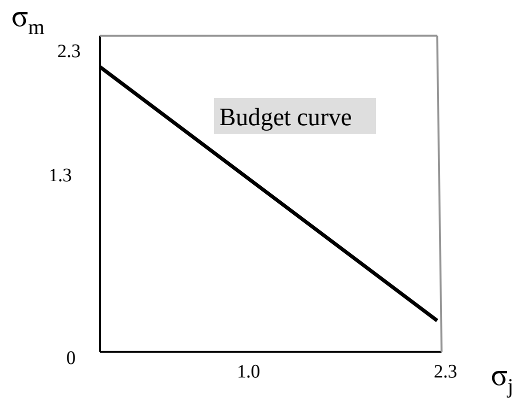


Looking at Figure 4, there are a few observations that need to be made. First, the area to the left of the meeting point between the two curves is a reflection of a risk-averse J (quadrants II and III). In this position, he experiences more fear-of-not-exiting (F_{nx}) the market than fear-of-not-entering the market (F_{ne}), so that he will reluctantly invest in the market. With time, J moves towards the meeting point between the two curves; he then gains in confidence up to the point where he is neutral, that is, where he is indifferent between the options of not exiting and not entering the market. This is the Point of Equilibrium. To the right of the meeting point between the two curves, J becomes an active investor, he becomes a risk taker (quadrants I and IV). His fear-not-to-enter the market becomes increasing larger compared to his fear-not-to-exit the market. Hence, Figure 4 portrays the three core profiles of investors or, put differently, the three core profiles J (the home buyer) can adopt depending on the market circumstances: risk-averse, risk-neutral (meeting point), or risk-taker.

2.3 The Budget curve

J does not buy new homes without access to cash; even if he contracts predatory mortgages by overlooking his financial data and their teaser rates, he must still have some cash reserves. J operates on a budget constraint, as minimal as it is. This is represented in Figure 5:

Figure 5 – J's budget curve[21]



This curve is the inverse of the function Decision-to-invest. Knowing the upper limit of the closed system[22] in which J behaves (2.3), we have:

$$B(x_j) = 2.2 - 0.9\, x_j$$

(Eq. 10)

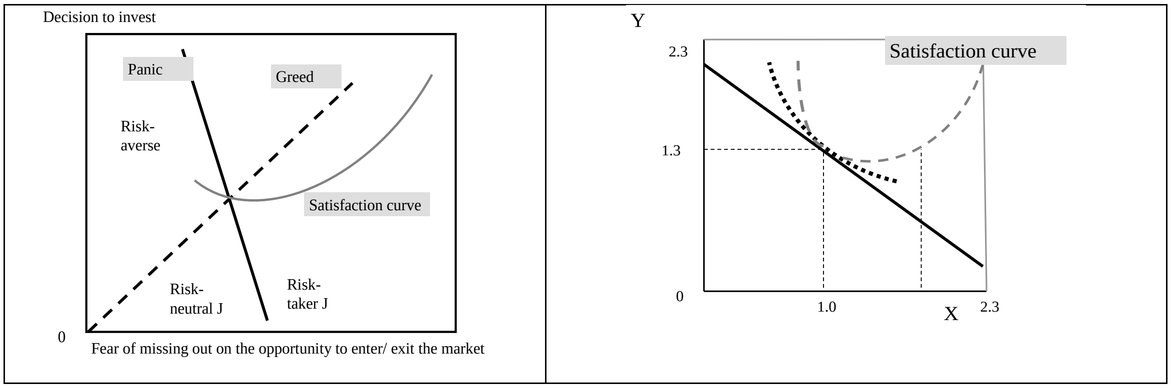
J's budget curve touches the Utility Predatory curve at the Point of Equilibrium. This signifies that J will, overall, try to balance his risks (σ_m and σ_J), as they translate in the Utility Predatory curve, with his budget and his desire to benefit from the market (his Satisfaction Curve – Mesly 2013a).

When we calculate the geometric distance between the two curves (the Utility Predatory curve and the Budget curve) and plot it in absolute values to represent the willingness to take risks, we obtain Figure 6:

Figure 6 – Curve expressing the trade-off between F_{nx} and F_{ne}

[21] We are using a linear Budget curve. We set the boundaries of the system at 2.3, which amount to [1 + *k*]. The rationale for this can be provided upon request.

[22] The system is closed (in the sense used in dynamic systems theory) because J operates on a finite time horizon. The mathematical reasoning can be provided upon request.



This curve has somewhat of a U-shape, with a tendency to grow rapidly past its near lowest point. It reflects how investors generally behave: J first examines a prospect house (in the US, in 2005); he has doubts; he questions. Then, as he gains in confidence, he becomes excited, buys the house and the increasing value the house gains in the speculative market that is building up (still in the US, in 2006) motivates him further. This curve has been named the Satisfaction curve[23] (Mesly, 2013) The Satisfaction curve $S(x_J)$ touches the Utility Predatory curve at the above-mentioned Point of equilibrium. It is linked to the positivity bias Ψ as it develops over time because as satisfaction increases, the positivity bias will naturally tend to increase as well.

2.4 Summary of tenets

Investor J's behaviors can be represented through a series of functions that interact together around a constant $k = 1.3$, and whereby J tends to seek an equilibrium between the various forces and constraints that guide his actions. The CAPM expected return formula is slightly transformed to take into account a positivity bias that influences the judgment of J (Ψ), and the potential influence of chaos (ε). The various interpretations given to the curves that have emerged have allowed us to identify three types of investors: the risk-averse, the risk-neutral and the risk-taking individual. In all cases, the basic assumption is that J is driven by fear: the fear of missing out on an opportunity to either enter or exit the market.

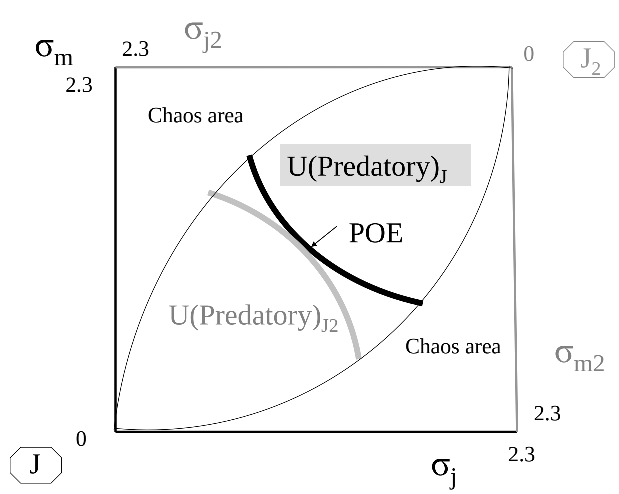
[23] In our model, this curve has the function: $S(x_J) = -2k^{1/2} + 2k/x + x = -2.28 + 2.6/x + x$, within the boundaries set at 2.3 with k =1.3. The $S(x_J)$ is related to the Utility Predatory curve, which is the geometric resulting curve between the Budget curve and this Satisfaction curve. The mathematical reasoning can be provided upon request.

3. Predatory mortgages

So far, we have looked at J assuming the market is not predatory in nature. Normally, J achieves a balancing act between his eagerness to earn money and his vigilance towards the market; he operates within his budget and time constraints, decides on investing with the information *I* he holds, and he displays some degree of positivity bias.

Let's assume that J is an older, poorly-educated (or illiterate) individual pertaining to a US ethnic community. J_2 is a banker approaches him, knowing he is vulnerable[24], and offers him an outstanding opportunity to enter the booming housing market: a 1% interest rate on a mortgage with virtually no questions asked, for an initial period of two years. In short, J is granted a predatory mortgage by J_2. J_2 operates exactly like J, so that his motivations are identical. He too is constrained by a budget and a finite time line; he too wants to make money. All in all, J and J_2 would have a mutual advantage to find a common equilibrium point and to aim for a win-win situation. This is represented in Figure 7, using a stylized Edgeworth box[25]:

Figure 7 – Stylized Edgeworth box representing J and J_2



[24] Research has shown that the positivity bias increases with age (Mesly, 2015). Furthermore, J is likely financially illiterate (Gorton, 2008; Tremoulinas, 2009; Wang, 2009; Gayraud, 2011).

[25] The predator-prey model can be used in other types of interactions: equal-to-equal, buyer-seller, supervisor-supervisee, etc. Here, we show the interaction between the naïve investor J and a sneaky banker J_2.

There is a point where J and J_2 meet[26]; at this point, each market agent displays some of his strengths and hopefully manages to hide his weaknesses. For example, J could actually be engaged in predatory borrowing, a phenomenon that occurred during the 2007-2009 crisis; yet, J_2 could be engaged in predatory lending, using predatory mortgages, for example. The point where the two Utility Predatory curves of J and J_2 meet is called the dynamic Point of Equilibrium[27] (POE) (Mesly, 2014). At this point, J and J_2 are both in equilibrium. Neither J nor J_2 can improve their respective position without damaging the other's position, which could lead to retaliation. Yet, each agent has achieved the maximum benefit he could achieve given the existence of the other market agent. This is a fair assumption if there are no hidden agendas, that is, if there are no predatory intentions on the part of J, J_2, or both of them.

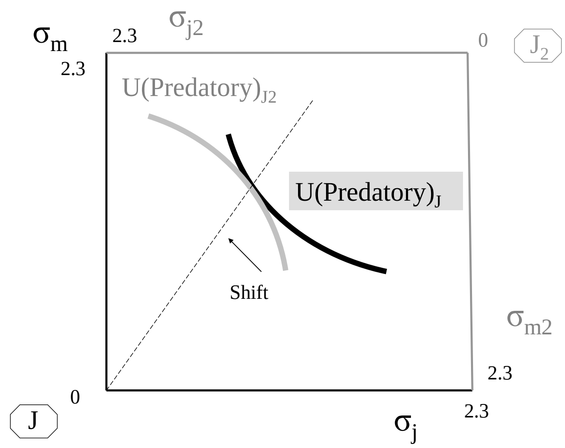
All seems normal to J except that J_2 is actually a financial predator – he has a dark side. He has identified his prey – a vulnerable individual, J – and will try to maximize his own profits to the detriment of this prey J, using predatory mortgages as a tool to achieve his selfish goal, with no sentiment whatsoever for the prey J and the financial harm he will cause. J_2 boosts to J the opportunity to earn money by depicting a rosy scenario whereby J will buy houses, flip them, make money, buy more houses and keep on making more money with no end in sight. J_2 gives a shot of financial steroid to J's Ψ. J_2 can take the risk of luring J who otherwise would not qualify for a loan, because the subprime mortgages that J will take will be blended (hidden) with other mortgages to create Collaterized Debt Obligations (CDO's) that a separate legal entity (SPE) will sell to investors – a process called securitization. Everybody is happy while J displays increasing disregard for his own vulnerability σ_J. Graphically, this means that J_2's Utility Predatory curve exercises a force onto J's Utility Predatory curve that pushes its Point of equilibrium off track, to the left, along J's Utility Predatory curve, where J has less time to think and work out his investment

[26] In fact, there are a number of possibilities where J and J_2 can meet, depending on the capacities of each. In Figure 7, it is assumed that J and J_2 have equal capabilities and weaknesses. This point is called a dynamic POE. At all points where J and J_2 meet along the contract curve (see Varian, 2006), there is Pareto efficiency: there is no reallocation between DI and Trust that could make J better off without making J_2 worse off, and vice-versa.

[27] A political example of such equilibrium is the episode of the Bay of Pigs opposing two super-powers: both the US and the Soviet Union had the capacity to destroy the archrival enemy, however destroying oneself by the same token.

decision, and where J has come to believe he is less vulnerable[28]. This dynamic is displayed in Figure 8 (note how J_2's curve partially invades J's predatory territory, underneath J's Utility Predatory curve, a situation that would not exist in a dynamic POE):

Figure 8 – Predatory mortgages in action



As greed emerges, every aspect of J is affected: his budget line assumes a sharper negative slope, his Utility Predatory curve is moved to the left.

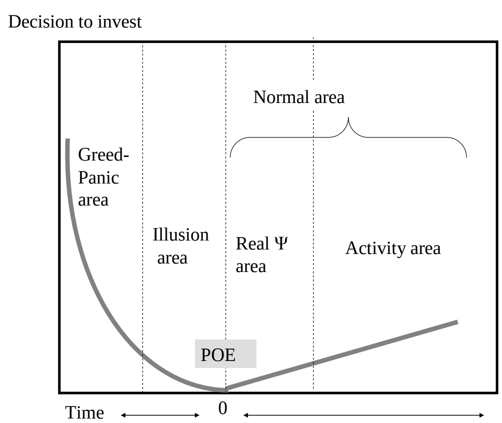
What actually happened is that J_2 has pressured J into investing, by allowing less and less time to decide. He enticed him to accumulate assets (extra houses) to the detriment of actively and rigorously investigating the market. J has moved into an area of higher velocity, as indicated by the derivative of the Utility Predatory curve (Eq. 2). As J buys houses in multiple numbers and at an increasing rate, that is, as he succumbs to greed, the market that is formed of all the J's in the US market becomes more volatile, with σ_m increasing to alarming degrees.

To represent this predatory dynamic mathematically, we first transform the derivative of the Utility Predatory curve (which is an expression of the velocity involved). But before, we replace $k = 1.3$ by $k = 1$ because we want to create a point with a value of 0 which will be our reference

[28] Recall that once J faces J_2, the timeline goes both ways: left to right (initially from J's perspective) and right to left (initially from J_2's perspective). Hence, the Edgeworth box displays the fact that J can have an effect on J_2's agenda, and J_2 could possibly have an effect on J's agenda. In a predatory situation, J_2 imposes his agenda upon J.

point[29]. We then turn the values emerging from the derivative into absolute values. This exercise leads to a curve that needs to be brought as closely as possible into a linear curve, which we do by computing its natural log ("ln"). The "ln" also allows us to put the Point of equilibrium (Figure 9) at the minimum value of zero (0) which is why we had set up *k* as 1, so that it constitutes the reference point of the behavior we are trying to assess. Because we want to show that there is an opportunity to invest while on the left side of the equilibrium along the Utility Predatory curve and on the right side of it, we turn all values into absolute values once more (thus making all values positive). This result is displayed in Figure 9. It provides a fair representation of the behaviors that J is adopting at some point in time.

Figure 9 – Greed and panic in action



A number of observations can be made regarding Figure 9. First, we have set a point 0, which corresponds to the equilibrium where J's normal Utility Predatory curve sits. Second, we note that there is a potential for growth on both sides of this POE. To the left of it, we identify two areas. The first area is called the Illusion area: it somehow mimics a normal growth curve as the one found on the right of the equilibrium (which is where J should normally stand). It has a slope of 6%, whereas there is a slope of 5%[30] on the right side of the equilibrium point. J is pressured by J_2

[29] This is equivalent to taking the r_f rate, established at 0.3 in the original model by Mesly (2013), out of *k*, the reasoning being that this value corresponds to the initial trust endowment a person has towards another. This is like saying that the first person considers the second as being at a minimal risk, expressed by the level of 0. The mathematical reasoning can be provided upon request.

[30] Interestingly, the ln of 5% is ln 0.05 = -3, which is -10 * *k*.

to make rapid decisions so as not to miss out on the opportunity to enter the market. Teaser rates provide the illusion that this will give the investor a chance to earn money. The positivity bias is thus artificially inflated. J is quite happy – he who has been ignored or even has been the subject of disdain in the past by hardcore J_2-type bankers/financiers. Henceforth, J engages to the left, rushing into decision-making. All events occur dynamically.

It appears as though the *illusion area* corresponds to what Tverksy and Kahneman (1972) have labeled representativeness. Most likely, J engages in this area thinking it has similar properties to the real Ψ area (near identical slope with smooth progression), and that it reflects an opportunity for measured, controlled growth, yet, it is exactly the opposite that takes place, which J will realize once panic takes over.

Past the *illusion area*, J enters into a Greed area as he moves further up to the left of his Utility Predatory curve: he becomes excited with the chance to make money and becomes increasingly oblivious to market risk σ_m, which augments rapidly. He believes the odds are on his side[31]. As he moves further along the left side of his Utility Predatory curve, he accumulates assets (non-essential resources or extra houses), increasingly discounting the value of information *I* (his knowledge of the market) (see Abreu and Brunnermeier, 2003). Because the marginal rate at which J keeps buying homes in the Greed area increases continuously, this means that J probably dismisses past failures while, boosted by excess optimism, he finds in recent successes reason to celebrate and a vivid proof that his new found strategy to accumulate wealth is working[32].

J's perspective has changed in two ways by being primed by the *illusion area*. When he was operating in a dynamic POE market (with all predatory behaviors in check), he took for granted that the odds of making money by investing in real estate (accumulating houses he did not need for survival, i.e., by adding more and more assets) were related to the probability that the market was strong as compared to the probability that his weaknesses were *not* to impact his financial decision.

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[31] Recall that this curve stems from the original Utility Predatory curve which displays the fact that at all points in time, J is equal to himself. So, even though J seems greedy at times, and he appears to become increasingly irrational, the bottom line from his perspective is that he endeavors to remain equal to himself, given the information *I* he has.

[32] This would be in line with De Bondt-Thaler (1985) findings on the "winner-loser" effect. This phenomenon cannot be explained by risk σ, but by Ψ as it gets powered by predatory acts.

In other words, J played a balancing act by estimating the chances that the market would remain strong and in his favor, that is, that the market would not beat him[33] (for example, a market would beat him if he were not able to sell the extra houses in time, and/or he could not get the extra value he wanted because of competition) and the probability that he did not have what it took to face the market (his weaknesses). In other words, J thinks the market is calling him and that had he known before, he would have definitely responded to the market's siren call[34] earlier. In the Illusion area, J is led to think that the probability of return is quite reasonable, with some probability of the market beating him at times, but some probability that he could mitigate this possible event by overcoming his weaknesses (which is what subprime mortgages do – they artificially overcome the handicap vulnerable individuals suffer from[35]).

Furthermore, the Illusion area serves as an *a priori* basis for upcoming odds (an anchor or reference point of sorts): if J has been able to beat the market a reasonable amount of times during the *illusion area*, there are no reasons why he can't continue to do so (especially if the market remains strongly in his favor). J's estimates of the odds playing in his favor are related to an assumed probability that the market will not beat him now considering the probability that he could have beaten the market before. He is fully confident[36]: perhaps, he could not beat the market before, but now he thinks the market cannot beat him. This is a self-fulfilling prophecy, which is typical of greed; it explains why once engaged in the greed area, J can't stop buying and flipping houses.

The odds are telling him, with evidence coming from his experience built-up in the Illusion area, that he can beat the market. In other words, J is chasing the market and forgetting the most fundamental rule of finance: one cannot beat the market. J is an irrational investor in the making.

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[33] That he does not become a prey to market forces. Hence, J has truly entered into a predator/prey dynamic by way of J_2's predatory actions.

[34] Reference is made, of course, to Ulysses.

[35] They are often illiterate, poor, from a disadvantaged ethnic background, and older.

[36] De Bondt (1993) study indicates that over confidence leads to a narrower focus, so that J is increasingly limited, by the reduction in width and depth of his portfolio. He may for example focus solely on residential homes, and residential homes of a certain type, as opposed to investing in various venues to spread the risk. Odean (1998) posits that overconfidence reduces the perception of real risk. J is becoming increasing blind, because he has trusted and keeps trusting J_2.

He is increasingly relying on noise rather than on valuable information I, a fact that meets J_2's goal of confusing his prey.

There is an additional reason why J becomes so eager to beat the market: he is convinced that the market is homogeneous, that is, he assumes that the market is composed exclusively of risk-takers like him with no risk-averse and no risk-neutral individuals in sight[37]. As such, he is that much more motivated to act fast; again, time is of the essence, so he rushes his decisions to invest with complete disregard for the fact that the market is, in fact, originally heterogeneous. In a bubble market, however, his belief eventually proves to be quite true: a herding effect leads all the J's in the US market to chase each other because everybody else is considered a direct competitor and actually turns out to be as such[38]. The market thus becomes extremely volatile, so that σ_m keeps increasing, justifying J in his quest for quick and high returns on his non-essential assets (the extra houses). By making multiple mortgages readily available, J_2 plays right along this scenario; this is even truer from the fact that market risks σ_m and vulnerabilities σ_J are kept muted through the magic of securitization.

As J_2 is the holder of critical information *I*, the asymmetry of information between J and J_2 keeps rising. But as J eagerly plugs along, with less and less time to make thoughtful investment decisions, he truly becomes irrational, because he ignores whatever information *I* he has access to. The uptrend cannot possibly reach infinity – by definition, the model is constrained by time. When finally the apex of delusion is reached, panic kicks in and J slides down the curve exhibited in Figure 9 (on the left of the dynamic Point of equilibrium) at an accelerated rate and in the opposite direction, towards the right, towards the Point of Equilibrium where safety is assumed: panic has kicked in.

Note that as the market becomes more homogeneous as all the J's in the US market move to the left of their Utility Predatory curves, and as the J_2's in the US market gain an unfair advantage by having information *I* on the market that J does not have, does not want to have, is not capable

[37] This entails that the market is filled with investors fearing to miss the opportunity to enter the market.
[38] De Bondt (1993) study points towards a similar observation: disagreement among investors is stronger in bear markets than in bull markets.

of understating, or chooses to disregard, a few remarkable events occur. First, the perceived win-win situation that J based his action upon is longer true, so the relationship between J and J_2 is no longer a zero-sum game, and there is no longer perfect information. Second, as more and more J's target the same assets (extra houses), the chances of the same event (buying a particular house and selling this same house) reoccurring increase many folds. This tends to skew the probability of this event because it no longer follows a linear path. In other words, the market is becoming more and more chaotic. The time average for the transaction keeps diminishing, decisions to invest become less and less grounded in fundamental values: in the worst case scenario, anyone can buy and flip a house at any point in time, so long as he comes first in line, regardless of his knowledge of the market and regardless of market risk σ_m. Put in Fama (1965)'s terms, the market is becoming inefficient because prices do not reflect intrinsic, fundamental values; they reflect a positive bias Ψ boosted by J_2's predatory behaviors. J measures his wealth by the accumulation of houses and his expectations of their future values so that his judgment is quite simple: amass as many houses as possible just like in a Monopoly game, trust the uptrend market, flip the houses and pocket the money. For J, the sheer number of non-essential resources (extra houses) and his own biased expectations of future prices are the only two parameters that determine his current wealth. J's wealth offers no safeguard (e.g., no diversification, no safety deposits, etc.): he has made himself completely vulnerable, which is what J_2, as a good predator, was aiming for. J has made himself the slave of a Ψ boosted by predatory acts.

Compare this dynamic, which was fostered by the predatory actions of J_2 onto his vulnerable prey J, to what happens to the right of the equilibrium (Figure 9). There is an area called the real Ψ area because J is probably justified to be optimistic. He is not being lured but is rather alert. He behaves rationally. Past this area, he can freely engage in investments while remaining quite consistent – there is an upward 5% slope that doesn't show any accelerating tendencies or kinks. It is in this total normal trading area consisting of the real Ψ area and of the activity area that the CAPM formula and the stylized CAPM formula we have presented operate. These functions are valid given a certain type of market; one where there are no predators, or, more exactly, one where dynamic POE's are not transgressed.

When this is not the case, however, we need to account for the fact that predatory actions take place. To do this, we introduce a new variable, which we call the fear factor, identified by the Greek letter φ. We thus introduce φ into the equations we have seen so far and give it a value of 1 when the market is in a state of dynamic POE's and above 1 when this is not the case, so that φ becomes the designation of the fear factor. We thus propose[39]:

$$DI = E(r_a)\,\psi^{\varphi} \text{ where } E(r_a) = r_f + \beta_a^{\varphi}\,[E(r_m) - r_f] - \varepsilon$$

(Eq. 11)

3.1 Value of Ψ

We know that σ_J is the standard deviation for J's behaviors; this represents J's odds of beating the market, or put differently, the odds that events are playing in his favor. He interprets a (standardized) σ_J of 3, for example, as the fact that he is above 99% the rest of the population of J's. This is why he takes risks; he is overconfident and he will push this overconfidence to the extreme. In other words, the extreme values of σ_J are zero (when J blends in the market filled with J's-like investors) and 3, where J thinks he is above the crowd.

Ψ can thus be expressed as follows:

$$\psi = \frac{\sigma_j}{3}$$

(Eq. 12)

The lower bound of *Ψ* is 0, which means that it nullifies equations 11 and 12. J thinks he doesn't stand a chance so that he doesn't invest at all.

[39] Our analysis might be viewed as complementary to Dawson (2015).

3.2 Value of φ

We have seen that the positivity bias is boosted by a fear factor. This fear factor imposes a risk on J. We can translate this factor by means of the σ's[40].

When J is overconfident (in a state of blind trust or put differently, fearless), he thinks he can push himself to the limit[41] of $\sigma_J = 3$. The higher his standard deviation is *versus* that of the market, the more he gambles because he firmly believes he can beat the market. This is expressed as follows:

$$\varphi = \frac{\sigma_j}{\sigma_m}$$

(Eq. 13)

When J thinks he cannot beat the market, $\varphi = 0$ (his fear of missing out is null, since he has given up), so that Ψ equals 1: that's the best he can achieve (he remains positive but certainly not over-confident). When J_2 motivates J to believe that he can beat the market at all times, $\varphi \to \infty$. We have:

$$\Psi^{\varphi} = \left(\frac{\sigma_j}{3}\right)^{\frac{\sigma_j}{\sigma_m}}$$

(Eq. 14)

The inflammatory effect of greed and predatory behaviors are well underlined in this formula. Without predatory behaviors, J can safely manifest a certain amount of overconfidence; however, when under the influence of predatory behaviors, J can quickly become irrational[42].

[40] Recall that the Utility Predatory curve contrasts σ_m and σ_J and includes the constant $k = 1.3$

[41] At the absolute limit, σ would be over 3.3, but then, at that point, there would be nobody left in the market, and hence, no market at all.

[42] For an application of the proposed stylized model, see Appendix 1.

4. Conclusion

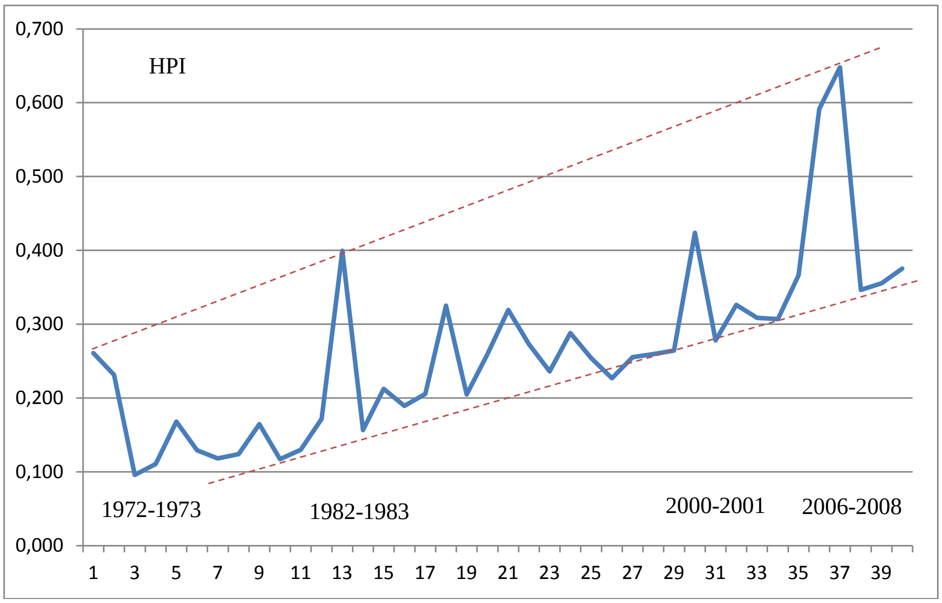
Our analysis of market agent's behaviors during the episodes of the subprime boom and crash was based on predator-prey dynamic. This model assumes a set of fixed parameters and is articulated around a constant k = 1.3 (with boundaries at 2.3). Knowing this, we examined the market and found that we could well explain the behaviors of both the naïve investor J and the predatory banker/financier J_2. We were able to put values on the different functions and concepts we introduced because we had set boundaries for the analysis (e.g.: 2.3 for the Edgeworth box). We have reconsidered some of the main functions found in standard financial analysis and used a stylized format of the CAPM model and the Sharpe ratio by introducing a measure of the positivity bias, of chaos and particularly of predation. All analyses are set in function of time: J and J_2 both have limited time to either enter or exit the market. However, when a predator like J_2 chooses its prey J, J ends up trapped in J_2's hidden agenda, thus changing the course of his own time direction. Markets would not boom or bust if there were no predatory acts; the reality, however, is that the financial market may be influenced by predatory acts.

Our approach points toward the necessity of implementing strong regulations aimed at curbing the opportunity to commit predatory acts. Clearly, the 2007-09 crisis was fueled by the lack of proper regulation and of enforcing measures when predatory acts were detected. This is especially true given that investors, large and small, tend to develop a positivity bias that fuels their greed, which inevitably leads, sooner rather than later, to a panic phase, that is, to a financial crisis.

Appendix 1 – Example of an application of the proposed stylized model

The analysis we have provided for the 2007-09 subprime crisis must be included in a larger view of the US market and of predatory opportunities. An index with respect to historical predatory episodes has been developed by examining at socioeconomic data[43] including house values. Figure 10 is a rendition of this Index for the US market (Mesly, 2015).

Figure 10– The US Historical Predatory Index (HPI)



When measuring the fear factor φ for the period covered by the HPI (1971-2012), we found that it is equal to 1.18; and 1.38 if we take the peaks and lows out of the measurement (considering them as outliers). In other words, on average, φ tends towards the constant $k = 1.3$. When taking the extremes out (peaks and lows), the correlation coefficient between internal and external risks is 60% (or, in k terms, $20(k\text{-}1)$)[44]. Hence, in normal conditions (in dynamic POE markets), φ is assumed to be equal to k. For the years 2003-2007, it is equal to 1.07 and for 2008, 0.80, which shows that there was a dramatic change in the overall level of risk assessment. It is the difference

[43] It is based on information's three fundamental characteristics: time line (horizon and cycles); gamma (γ) and lambda (λ) curves (not discussed in this paper – see Mesly, 2015); and risk (internal and external). The HPI was calculated for the years ranging from 1971 to 2012 in the US market (see Mesly, 2015).

[44] Note: when testing on the database we used to develop the CMFP, k=1.35 for some 1,700 individual participants; and when taking extremes out, k = 1.13 and the correlation coefficient = 37%.

between φ and k that is symptomatic of problematic markets: the larger the spread, the more volatile the market appears to be.

We can use this HPI to measure the $E(r_a)$ in 2007 and in 2008. Year 2007 represents the peak, and hence the point where chaos is about to start, so that $\varepsilon = 0$. Year 2008 represents chaos, so that $\varepsilon = 4.6$ and $\sigma' = 3.78$ (we keep a value of 3.78 when the market in not yet in chaos, short of knowing its real value)[45]. We assume a stable correlation coefficient of 60% (20 * (k-1)). All other values in the *DI* are known except for $E(r_a)$. We know J is greedy; hence, he would like to make more returns on his assets (his extra houses) than what the most common speculative market return could offer. We choose the NASDAQ index (plus 1% to account for the desire to make more) to represent this $E(r_a)$, as it offers a superior return to S&P in 2007 (Dow Jones: 6.43%; S&P 500: 3.52%; NASDAQ: 9.81%). The r_f is the teaser rate of common predatory mortgages at 1 %. We thus have:

$$\text{Y2007 E}(\mathrm{r_a}) = E(r_a) = r_f + \beta_a\,[E(r_m) - r_f] - \varepsilon$$

$$= 1\% + \beta_a\,[10.81\% - 1\%] - 0$$

where $\beta_a = [k'\,\sigma'_m\,(\sigma_m)\,\sigma'_J\,\sigma_J\,] / \sigma_m^2 = [60\% * 3.78 * 0.54 * 3.78 * 0.59\,] / 0.54^2$

So that $\beta_a = 9.37$.

$$\text{Implying that Y2007 } E(r_a) = 1\% + 9.37\,(10.81\% - 1\%) - 0 = 92\,\% \qquad \text{(Eq.15)}$$

In short, J expected to nearly double his investment during the frenzy period led by predatory mortgages. Thinking to be able to achieve this type of return over the long-term is, truly, irrational: the NASDAQ average return for the period 1975-2012 has been of roughly 14 % (about 10% for the Dow Jones and the S&P 500).

[45] The mathematical reasoning can be provided upon request.

By comparison, J's expected return $E(r_a)$ in 2008 (taking the best of the returns between Dow Jones, S&P 500 and NASDAQ: Dow Jones at -33.84%) was of:

$$\text{Y2008 } E(r_a) = r_f + \beta_a\ [E(r_m) - r_f] - \varepsilon$$

$$= 6.03\ \% + \beta_a\ [-33.84\% + 6.03\%^{46}] - 4.6$$

with $\beta_a = [60\%\ {*}3.78\ {*}\ 0.49{*}3.78{*}\ 0.17] / 0.49^{\,2} = 2.97$

Implying that Y2008 $E(r_a) = 6.03\ \% + 2.97\ (33.84\% + 6.03\%) - 4.6 = -26\ \%$ (Eq.16)

So J has dropped from excessive optimism and over confidence thinking he would double his money (and beat the market) each time he bought and sold a house to realizing he was losing 26 % on his investments, meaning he was putting himself in debt, and possibly bankrupt.

J's decision to invest changed dramatically, as follows:

Y2007 $DI = E(r_a)\ \Psi^{\varphi}$

where $\Psi^{\varphi} = (\sigma_J/3)^{\sigma_J/\sigma_m}$

Implying that Y2007 $DI = 92\ \%\ (0.59/3)^{0.59/0.54} = 0.16$ (Eq. 17)

Y2008 $DI = E(r_a)\ \Psi^{\varphi}$

where $\Psi^{\varphi} = (\sigma_J/3)^{\sigma_J/\sigma_m}$

Implying that Y2008 $DI = -26\ \%\ (0.17/3)^{0.17/0.49} = -0.10$ Eq. 18)

[46] We insert a "+ " sign because J wants to minimize his loss.

The decision to invest in 2008 is actually a decision to disinvest (withdrawal from the market). This is truly a punishing market[47]. The above numbers provide an exemplary demonstration of the effect of predation acts upon a market that should, normally, be a dynamic POE market. This constitutes a strong illustration, we feel, for the necessity to implement and enforce regulations that prevent predatory maneuver by all the J_2's acting in the marketplace.

The HPI suggests that other financial crises will occur[48], and that their degree of harm onto the market will keep increasing. It thus appears important to continue understanding how the J's and J_2 in the US market behave, because this may provide clues to prevent further crises by way of implementing much-needed regulations.

[47] This analysis reports results that are in line with a recent neurobiological study showing that fear of an unknown predator (chaotic market) elicits stronger reactions that fear of a known predator (see Mesly, 2015).

[48] In fact, based on the HPI, the next extreme financial crisis would be anticipated in 2042-43.

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