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Application of Evolutionary Game Theory to Strategic Innovation

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Abstract

Evolutionary game theory may help us know the right decision to make in situations where our choices are affected by the choices of others whether actors are rational or not. In this study we highlight the rise in importance of bandwagon pressure developing the generation and evolution of strategic innovation in terms of evolutionary game theoretical perspective. According the results, derived from model redefining the business will only be valuable if there are adaptation processes in related industry. Both redefining and adaptations simultaneously are not profitable. Correspondingly, we establish a significant point in strategic management that essence of strategic innovation is bounden with respect to limited level of adaptation; not too much none.

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1. Introduction

Many situations of interest in strategic management include strategic interactions with respect to competition advantage among rivals and therefore require game theoretical modelling. Since most of the business strategy

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decisions involve interdependent outcomes, use of game theoretical modelling would be accepted to apply to business strategy.

To understand game theory we should know the core idea behind it. Most people think economics is about accounting, money and banking, public policy and the markets. In economic model the key tool in the analysis is competition as game theoretic models work similarly. The core of economics is actually very simple; it is the science behind why people make the decisions they make. In other words, economics is the field of science, social science in fact, behind human decisions. In neo-classical economic model competition is searched with respect to many assumption and condition, it is determined like using folk as if in game theoretical way it is determined like using chopstick to balance between simultaneous strategies (Camarer,1991).

Game theory is a mathematical analysis of any social situation in which one player or actor, but possibly a firm or nation—tries to figure out what other players will do, and choose the best strategy given those guesses about others. Most game theory describes the fictional behavior of an ideal, hyper calculating, emotionless and, as a result, is not always a good guide to how normal people who don't plan too far ahead will actually behave. Behavioral Game Theory describes hundreds of different experimental studies which show where game theory predicts well and predicts poorly, and suggests some new kinds of theory.

2. Literature Review

2.1. Strategic innovation

Increasing competitive pressures and new customer wants/needs require finding new ways of competitive game for firms. Therefore the firms need to create new game so as to gaining and sustaining competitive advantage. In this context, strategic innovation is key concept for the firms. Because strategic innovation provides rethinking business, redesigns industries and recreates value proposition. Therefore strategic innovation affects competitive position of the firms directly due to imitation of strategic innovation is hard for rivals. According to Affuah (2009) “The winner of a new game can be a first mover or follower; that is, the winner of a new game can be the firm that moved first to change the rules of the game, or a firm that came in later and played the game better. The important thing is that a firm pursues the right new game strategy to create and capture value.”

Strategic innovation has different definitions in literature. Many types of these descriptions emphasize on breaking current game rules and creating new game rules for industries. These descriptions are not only related with industry environment but also resources, organizational culture, processes, people and core competence. Some definitions of strategic innovation present below;

- Strategic innovation can be defined as breaking the game rules and thinking new way of competing. The firms must define business strategically and surprise competitor in order to changing the game rules. Changing the game rules require new idea that is developing and playing different game (Markides, 1997).
- Strategic innovation leads to a dramatically different way of playing the game in existing business (Markides, 1998).
- According to Markides (2003) strategic innovation is different way of competing in an existing business.
- Strategic innovation can be explain as reshaping market and redefining business model by breaking current game rules and changing current competitive nature (Schlegelmich et. all 2003).
- A strategic innovation is a game-changing innovation in products/services, business models, business processes, and/or positioning vis-à-vis coopetitors to improve performance (Afuah, 2009).

Strategic innovation facilitates to achieve dramatic value improvements for customers and high growth for companies. Dramatic value improvements for customers are related with current business. On the other hand, high growth is connected with industry. Thus the firms can redefine business for customers and redesign industries for high growth (Markides, 1997). The firms create strategic innovation by identifying gaps in industries. These gaps emerge by external changes or proactively by firms (Markides, 1998). According to Markides (1998) new customer segment, customer needs and new production are the gaps. But nowadays different new gaps exist in current business environment.

Strategic innovation is cornerstone concept for the firms in order to changing game rules. It has three elements. These are fundamental redefine of the business model, reshaping of existing markets and dramatic value improvements for customers. Strategic innovation constitutes five steps. These are redefine the business, redefine the, redefine the what, redefine the how and start the thinking process at different points.

Strategic innovation has four benefits for the firms (Ortega and Schoettl, 2005). These are new market spaces and/or reconstruct market boundaries, changing the rules of the market game, create a higher value for the customer of a lower cost, leads to highly profitable growth. On the other hand, barriers of strategic innovation are inertia of success; prevent current strategic position, bad organizational culture and negative institutional support (Markides, 1998).

2.2. Game theory

Game theory is simply analyzing decisions that will affect other people's decisions. Game theory is the mathematically formalized theory of strategic interaction. Game theory (Fudenbegand Trole, 91:112, Gibbons, 1992:45) is a discipline aimed at modelling situations in which decision makers have to make specifications that have mutual, possibly conflicting, and consequences. It is the study of the ways in which *strategic interactions* among *actors* produce *outcomes* with respect to the *preferences* (or *utilities*) of those agents, where the outcomes in question might have been intended by none of the agents. It has been used primarily in economics, in order to model competition between companies.

Game theory was created as a subset of economics because while economics was good at describing why people made decisions that only affected the individual (microeconomics) or a mass of people (macroeconomics), it was lacking when it came to understanding decisions that involved multiple people where one person's decision would affect the other person's decision. Game theory was created to fill that gap.

At its core, game theory is about analyzing decisions that will impact other people's decisions. Game theorists call these types of decisions "strategies." The simple premise behind game theory is that you can calculate the right decision to make even in multi-person (or multi-player) situations, before needing to make it. If you think about the most decisions you make, it's likely that they have some affect, either large or small, on the decision of others.

2.3. Evolutionary game theory

Evolutionary game theory has grown into an active area of research that brings together the concepts from biology, evolution, non-linear dynamics, and game theory. This theory determines the relations between evolutionary stable strategies and Nash equilibria. The theory also identifies replicator dynamics as a static game factor.

Fisher (1930: 10-30) first developer of evolutionary game theory, tries to describe the approximate equality of the sex ratio in mammals. Though he does not formulize it in those terms, it is the first way of equations that can be understood game theoretically nowadays. After him Lewontin makes the first explicit application of game theory to evolutionary biology in his book "Evolution and the Theory of Games" (1961). After Maynard Smith (1972 and 1973) defined and explained the concept of an evolutionarily stable strategy (ESS), the concept of an ESS is begun to be popular. Since then, there has been a phenomenal rise of interest by economists and social scientists in evolutionary game theory.

Evolutionary game theory has provided a crucial framework to examine companies' strategic innovation behavior. What is powerful about evolutionary game theory is that cooperation strategies are chosen by bounded rational actors and success for a strategy is defined in terms of the number of copies of itself (Hofbauer and Sigmund, 1988).

Two main approaches to evolutionary game theory are developed: the first one explains the concept of evolutionary stable strategies, and another one analyzes the frequency of different strategies and studies the evolutionary dynamics of populations. The first approach derives from the work of Maynard Smith and Price (1973) and employs the concept of an evolutionarily stable strategy (ESS) as the principal tool of analysis. ESS is equilibrium where agents that have different strategies do not be constructed by unsatisfactory ones. ESS explains us whether mutant (changed) strategies can be accepted by population. The second approach constructs an explicit model of the process by which the frequency of strategies changes in the population and studies properties of the evolutionary dynamics within that model (Zeeman, 1980; Taylor and Jonker, 1978; Hines, 1987; Schlag, 1998).

3. Mathematical Modelling

3.1. Model

Game-theoretic reasoning is a kind of cognitive trial. Sensible game theorists try to converge to equilibrium by their self-observation (Aumann, 1990; Binmore, 1990). Besides introspection, there are other kinds of forces that might produce equilibration in games such as adaptation (Camerer, 1991) Adaptation is defined as learning which strategy to play in a particular game. In fact, adaptation is the most effective and common equilibrating force. Increases in the number of organizations that adopt an innovation influence the number of remaining organizations so that they will subsequently adopt this innovation (Mansfield, 1961). At least two types of theories explain this phenomenon: rational efficiency theories and theories of fads (Abrahamson, 1991). Proponents of rational-efficiency theories suggest that organizations rationally choose to adopt an innovation. As a result diffusing based on updated information about the innovation's technical efficiency or returns. Conversely, proponents of theories of fads assume that organizations choose to adopt an innovation based on what other organizations have adopted it, rather than its technical efficiency or returns. Rational efficiency theories do not readily explain the widespread diffusions of technically inefficient innovations or innovations that produce losses. Also these theories do not explain why organizations reject technically efficient or profitable innovations. On the other hand, fad theories use the term bandwagon pressure to denote a pressure to adopt or reject created by the sheer number of adopters or rejecters. They determine that; "a bandwagon occurs when certain organizations adopt an innovation because of such pressures, rather than their individual assessments of the innovation's efficiency or returns. A counter-bandwagon occurs when organizations reject an innovation because of bandwagon pressure, rather than their updated assessments of the innovation's efficiency or returns" (Abrahamson and Rosenkopf, 1993).

Both institutional and competitive theories and research on bandwagons assume organizations only adopt an innovation if they assess returns from adopting that exceed a certain threshold during the early stages of diffusion. In addition to this ones that do not adopt an innovation during this early stage may adopt it in a later stage. Because competitive or an institutional bandwagon pressure coerce them to be likeness to the number of adopters (Abrahamson and Rosenkopf, 1993).

Adaptation has a long history in game theory. Although experiments show that adaptation is common (e.g. Van Huyck, et al., 1991), adaptation of this type will only converge if the same game is played repeatedly and players act myopically (Camerer, 1991). An important empirical question for game theory, which strategy empiricists could help answer, is whether the adaptation process adequately will able to expose strategic innovation.

In this study we highlight the rise in importance of bandwagon pressure developing the generation and evolution of strategic innovation. When we intend to highlight the implications of strategic innovation decision, we study the actions of individuals (also organizations) over time with respect to adaptation especial to bandwagon effect.

3.2. Mathematical Model

Abrahamson and Rosenkopf (1993) explain that organizations adopting an innovation can cause a bandwagon pressure, giving rise to other organizations to adopt this innovation. Since non adopters fear appearing different from many adopters, institutional bandwagon enforcement happens.

They modelled organizations' adoption decisions by summing their individual assessment of the innovation's return and the bandwagon pressure. Theories of bandwagons suggest that the strength of bandwagon pressure increases with the number of adopters. The level of ambiguity, however, moderates this main effect. Therefore, we modelled bandwagon pressure with respect to Abrahamson and Rosenkopf (1993) equation in which the product of ambiguity and the number of adopters are added. In sum, assessed returns, ambiguity, and the number of adopters influence organizations' decisions to adopt an innovation according to the equation.

$B_{ik} = I_i + (A_i + n_{k-1})$ where:
B_{ik} = Bandwagon assessment of the innovation in bandwagon cycle k,
I_i = Innovation assessment,
A_i= Ambiguity about innovation,
n_{k-1}= proportion of adapters (Abrahamson and Rosenkopf, 1993).

Considering a system which is consisted of two representatives firms X and company Y. Firms may redefine business and may break the rules in its industry. As a result they may become strategic innovator conversely firms may obey the rules in its industry. So both firms X and Y have two strategies; redefine the business (RB) or not redefine or adopt the business (A).

We assume that;

$\left.\begin{matrix} I_X \\ I_Y \end{matrix}\right\}$ Innovation assessment level of X and Y respectively,

$\left.\begin{matrix} A_X \\ A_Y \end{matrix}\right\}$ Ambiguity about recent innovation with respect to X and Y,

C_R= research and development costs of firms,

C_F= funding costs of firms,

Strategic innovation, significant shifts in market share and wealth occurs not only having competitive advantage but also for changing rules of the game. The thought is not to play the game better than the competition but to develop and play different game (Markides, 1998). Although coming up with new ideas and changing the rules of game profitable, there are numerous examples of firms that tried to strategically innovate but are not succeeded. Therefore, firms may alternatively choose to adopt rather than strategically innovate as it is more risky than adaptation.

If firms assess returns exceed their adaptation threshold, these firms adopt innovations. Firms that did not adopt in early stage consider their innovation assessments and adopt innovation (Abrahamson and Rosenkopf, 1993). As a result bandwagon pressure effect occurs and they do not need to redefine their business.

Assumption 1: Firms X identify the gaps of their related industry and decides to fill them and the gaps grow to become the new mass market. If the non-innovator firm's assess returns exceed its adaptation threshold it chooses to adopt rather than filling the gaps of the market. Indeed firm, not adopting in early stage of innovation adopts innovation because of the bandwagon effect. Thus firm Y chooses the options of not to redefine business (NRB) and it only adopts. We determine this situation (RB, A) where firm X redefine (RB) and firm Y decide not to redefine the business (A) and it only adopts. The gain of firm X and Y are assumed as follows:

U_X=I_X+A_X -(C_R+C_F)

U_Y= I_Y-C_R

We determine the reverse situation where (A, RB) is satisfied. At this point firm X decides not to redefine the business (A) and it only adopts firm Y redefine (RB). The gain of firm X and Y are assumed as follows:

U_X=I_X-C_R

U_Y= I_Y+A_Y -(C_R+C_F).

Assumption 2: If both firms X and Y asses returns from adopting greater than adoption threshold and their ambiguity of previous or present innovation small but ambiguity of new innovation high, they will choose to adopt rather than redefine the business. Adaptation was prompted by the added bandwagon pressure not by the firm's assessment of innovation returns. We determine this situation (A, A) where firm X and firmY decide not to redefine the business (A) and it only adopts. The gain of firm X and Y are assumed as follows:

U_X= I_X -C_R

U_Y= I_Y -C_R

Assumption 3: If bandwagon assessments of the innovation do not exceed the adaptation threshold value, diffusion may stop. Both firms X and Y try to find gaps in industrial positioning map. They behave strategically innovative and choose to redefine the business. We determine this situation (RB, RB) where firm X and firmY decide to redefine the business (RB). The gain of firm X and Y are assumed as follows:

U_X=-(C_R+C_F)

U_Y=-(C_R+C_F)

Table I. Payoff matrix of general model

X/Y	RB	A
RB	-(C_R+C_F) -(C_R+C_F)	**I_X+A_X -(C_R+C_F)** **I_Y-C_R**
A	**I_X-C_R** **I_Y+A_Y -(C_R+C_F)**	I_X -C_R I_Y -C_R

3.3. Results

ESS is equilibrium where agents that have different strategies do not be constructed by unsatisfactory ones. According to this model players-actors-companies are identical; their roles in a watch are the same. The situation we have studied is symmetric. In symmetric model conditional evolutionary stable state (ESS) is satisfied if only if it is Nash Equilibrium and for every action of different strategy that is best response to this strategy.

If the following condition is tenable; there are two Nash Equilibriums in our model; fund, share (RB, A) and (A, RB) where one of the actor redefining the business and the other adopts it. If one of the Nash equilibrium (RB, A) exists,

(1)I_X+A_X -(C_R+C_F) $\geq$ I_X -C_R,

$\boldsymbol{A_X \geq C_F}$.

(2) I_Y-$C_R \geq -(C_R$+$C_F)$,
$\boldsymbol{I_Y \geq C_F}$

Another Nash equilibrium exists when where two strategies (A, RB) is chosen,
(3) I_X-$C_R \geq -(C_R$+$C_F)$,
$\boldsymbol{I_X \geq C_F}$**,**
(4)I_Y+A_Y -$(C_R$+$C_F) \geq I_Y$ -C_R
$\boldsymbol{A_Y \geq C_F}$**.**

As conclude, we determine from above mathematical explanation that firms innovation assessment level should exceed their fund costs. In addition to this their fund costs should also be lower than their level of ambiguity about recent innovation.

4. Conclusion

This article focuses on situations in which the bandwagon diffusion of an innovation occurs in a collectivity even though, on average, organizations in this collectivity assess negative returns from adopting this innovation. We also examine the evolution of strategic innovation with respect to game theoretical aspect. When we intend to highlight the implications of strategic innovation decision, we study the actions of individuals (also organizations) with respect to adaptation especial to bandwagon effect.

We simply determine evolutionary stable strategies. An evolutionary stable state of a population occurs where all members adopt an evolutionarily stable strategy (ESS). Even if mutant- curious novel strategies appear in a few members, they cannot prevail and will vanish. This means that natural selection is sufficient to keep the population in ESS equilibria. Therefore they are in a subset of Nash equilibria. In our model choosing adaptation strategy when redefining the business or reverse are ESS. According the results, derived from above model redefining the business will only be valuable if there are adaptation processes in related industry. Both redefining and both adaptations simultaneously are not profitable. Correspondingly, we establish a crucial point in strategic management that essence of strategic innovation is bounden with respect to limited level of adaptation; not too much none.

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