Applied Mathematics and Computation 240 (2014) 175–199

Contents lists available at ScienceDirect

Applied Mathematics and Computation

journal homepage: www.elsevier.com/locate/amc

# An optimal information acquisition model for competitive advantage in complex multiperspective environments

Madjid Tavana [a,b,*], Debora Di Caprio [c,d], Francisco J. Santos-Arteaga [e]

[a] Business Systems and Analytics Department, Lindback Distinguished Chair of Information Systems and Decision Sciences, La Salle University, Philadelphia, PA 19141, USA
[b] Business Information Systems Department, Faculty of Business Administration and Economics, University of Paderborn, D-33098 Paderborn, Germany
[c] Department of Mathematics and Statistics, York University, Toronto M3J 1P3, Canada
[d] Polo Tecnologico IISS G. Galilei, Via Cadorna 14, 39100 Bolzano, Italy
[e] Departamento de Economía Aplicada II, Facultad de Económicas, Universidad Complutense de Madrid, Campus de Somosaguas, 28223 Pozuelo, Spain

ARTICLE INFO

*Keywords:*
Multicriteria decision making
Information acquisition
Decision reversals
Risk
Linguistic reports
Triangular fuzzy numbers

ABSTRACT

The optimal information acquisition process is a major strategic task for sustaining a firm's competitive advantage. We define the optimal sequential information acquisition behavior of a rational decision maker (DM) when allowed to acquire two pieces of information from and observe positive credible signals on a set of multidimensional products. We illustrate how firm reputation affects the continuity of the expected utilities derived from a given search and may generate reversals in the information acquisition incentives of DMs when deciding whether or not to shift their search processes between different signal-induced markets. This study makes a number of important contributions to our understanding of a firm's information acquisition. First, it provides a formal analysis of the information acquisition process when the characteristics defining a product have a continuous set of variants. Second, it allows for the study of risk-averse DMs, while most of the literature concentrates on risk-neutral DMs. Third, it opens the way for strategic scenarios to be considered when analyzing the information acquisition processes of firms and creates a direct link to the game theoretical literature on strategic reporting. Fourth, it can be easily implemented within multicriteria decision making methods such as the analytic hierarchy process (AHP) to study the information acquisition behavior of DMs when the characteristics of the products are unknown.



## 1. Introduction

"The fox knows many things, but the hedgehog knows one big thing," the Greek poet Archilochus once said. Perhaps Archilochus simply meant that the hedgehog's single defense defeats the fox's many tricks. Yet, the hedgehog and the fox were turned into metaphors by many thinkers and writers. We argue that, despite the increasing amount of information available nowadays, decision makers (DMs) within a firm should behave more like the hedgehog – that is, base their acquisition of

* Corresponding author at: Business Systems and Analytics Department, Lindback Distinguished Chair of Information Systems and Decision Sciences, La Salle University, Philadelphia, PA 19141, USA.
*E-mail addresses:* tavana@lasalle.edu (M. Tavana), dicaper@mathstat.yorku.ca, debora.dicaprio@istruzione.it (D. Di Caprio), fransant@ucm.es (F.J. Santos-Arteaga).
*URL:* http://tavana.us/ (M. Tavana).

http://dx.doi.org/10.1016/j.amc.2014.04.074
0096-3003/

information and subsequent decisions on a small but highly relevant amount of information. Formal models generally rely on *ad hoc* heuristic rules to simplify the information acquisition process of DMs within increasingly complex multidimensional environments, but do not consider the *seemingly* straightforward setting where little relevant information determines the behavior of DMs. In other words, foxes constitute the main subject of analysis nowadays while the more focused, though deemed simpler, hedgehog remains outside the scope of the literature.

We propose an information acquisition algorithm that intersects three different research lines linked by their respective analyses of the optimal information acquisition processes of rational DMs. In particular, it relates to the consumer choice literature, the economic one dealing with fads and herding phenomena, and the decision theoretical branch of operations research dedicated to study the optimal choice of technology by firm managers.

### 1.1. Literature review

Consider the problem faced by a rational DM regarding what information to gather given a limited capacity to do so. The consumer choice literature studies this problem mainly from a psychological perspective. In particular, this research line focuses on how the information given to DMs can be strategically designed in a way that some predetermined options appear more attractive than others (see e.g. [1,20,49]). These strategic considerations, together with the limited cognitive ability of DMs to assimilate information, allow for choice modifications to be induced through their information acquisition processes.

The previous research line provides the empirical counterpart to the search theoretical economic models that analyze fads and herds as rational phenomena, following the seminal works of Banerjee [4] and Bikhchandani et al. [7]. These models deal with the influence that signals and the observable choices made by other DMs have on the optimal (sequential) behavior of the remaining DMs. However, this stream of research does not study the influence that information transmission processes, and signals in particular, have on the optimal information *acquisition* behavior and subsequent choice structures of DMs, see [10] for a comprehensive review of the literature. It should be noted that the subject of information sharing and herding, and how it relates to decision making, has recently received ample attention in the game theoretical literature. Previous relevant work analyzing the impact of information sharing within a game theoretical environment is provided by Szolnoki and Perc [58]. In terms of collective phenomena, Chen et al. [14,15] have shown how decision making is affected by the fact that one is never alone in a crowd. Similarly, herding and the relevance of the wisdom of crowds have been studied in [30,57,59].

The design and analysis of algorithmic information acquisition processes remains outside the scope of the previous lines of research but within that of the operations research literature, which, at the same time, tends to overlook the strategic implications that different signaling and preference manipulation strategies have for the information acquisition and choice behavior of DMs.

Indeed, the management/operations research literature has been considering the optimal information acquisition and choice problems of firm managers for quite some time, in particular when analyzing the acquisition of a new technology. In this regard, the seminal models of McCardle [47] and Lippman and McCardle [40] limited their scope to return functions that were both convex increasing and continuous, a constraint removed by the most recent research models within this area, such as [63]. However, and despite the inclusion of Bayesian learning mechanisms into their algorithms, even the most recent models omit the strategic effects inherent to the information transmission process. This research line remains focused on the importance that search costs have on limiting the information processing capacity of generally risk-neutral DMs when determining the introduction or dismissal of a new technology (see e.g. [28,53]).

More precisely, the operational research/management theoretical literature on the demand for new technology can be classified as game theoretic, a research stream started by Reinganum [51], or decision theoretic, following Jensen [28]. Both approaches were initially developed within the economic literature but taken over by the operational research one, leading to two separate and clearly differentiated streams of research. The former approach concentrates on the strategic incentives implicit behind the adoption and *diffusion* of technology but does not deal with the information acquisition processes affecting technology adoption decisions, see [6]. At the same time, the decision theoretical branch of operations research has recently extended its scope to allow for comparisons between different technologies. In particular, Paulson Gjerde et al. [50], as well as Cho and McCardle [16], emphasize the cumulative and interdependent character of technological evolution and its effect on the corresponding adoption (or rejection) of new technologies. However, in both cases, the entire set of technological features is observable and its stochastic evolution defined by a known probability function. Therefore, the strategic effects resulting from signals received regarding the value of unknown technological characteristics as well as those derived from influencing the preferences of DMs remain unstudied.

### 1.2. Main results

The current paper formalizes and studies the optimal information acquisition behavior of a rational DM when acquiring information on and choosing among multidimensional products defined by vectors of characteristics. We analyze in detail the case where the decision process is based on the possibility of collecting two pieces of information before making a choice. This limit is imposed to account for existing information processing costs, either pecuniary or cognitive, and to allow for a simple numerical analysis illustrating the theoretical results obtained. Besides, the literature usually concentrates on a small