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Exploitation vs. exploration: choosing a supplier in an environment of incomplete information☆

Rina Azoulay-Schwartz[a,1], Sarit Kraus[a,b,*], Jonathan Wilkenfeld[b,c,2]

[a] *Department of Computer Science, Bar-Ilan University, Ramat-Gan 52900, Israel*
[b] *Institute for Advanced Computer Studies, University of Maryland, College Park, MD 20742, USA*
[c] *Department of Government and Politics University of Maryland, College Park, MD 20742, USA*

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Abstract

An agent operating in the real world must often choose between maximizing its expected utility according to its current knowledge about the world and trying to learn more about the world, since this may improve its future gains. This problem is known as the trade-off between exploitation and exploration.

In this research, we consider this problem in the context of electronic commerce. An agent intends to buy a particular product (goods or service). There are several potential suppliers of this product, but they differ in their quality and in the price charged. The buyer cannot observe the average quality of each product, but he has some knowledge about the quality of previous goods purchased from the suppliers. On the one hand, the buyer is motivated to buy the goods from the supplier with the highest expected product quality, deducting the product price. However, when buying from a lesser known supplier, the buyer can learn about its quality and this can help him in the future, when he will purchase more products of this type.

We show the similarity of the suppliers problem to the *k*-armed bandit problem, and we suggest solving the suppliers problem by evaluating Gittins indices and choosing the supplier with the optimal index.

We demonstrate how Gittins indices are calculated in real world situations, where deals of different magnitudes may exist, and where product prices may vary. Finally, we consider the existence of suppliers with no history and suggest how the original Gittins indices can be adapted in order to consider this extension.

Keywords: Electronic commerce; Decision making; Incomplete information; Choosing a supplier

1. Introduction

An agent in an electronic market often has to choose among several suppliers of a product or a service. The suppliers differ in the mean quality of the products they sell. The agent does not know with certainty the mean quality of each supplier, but he has some knowledge about qualities of previous items sold

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* Corresponding author. Department of Computer Science, Bar-Ilan University, Ramat-Gan 52900, Israel. Tel.: +972-3-5318762; fax: +972-3-7360498.

E-mail addresses: schwart@cs.biu.ac.il (R. Azoulay-Schwartz), sarit@cs.biu.ac.il, sarit@umiacs.umd.edu (S. Kraus), jwilkenf@gvpt.umd.edu (J. Wilkenfeld).

[1] Tel.: +972-3-9324167; fax: +972-3-7360498.

[2] Tel.: +1-301-3147703; fax: +1-301-314-9256.

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by each suppliers. We consider situations where the agent needs to repeatedly buy items and he would like to buy high quality items for the lowest possible prices.

The problem of unknown quality of items appears also in traditional markets, but is much more pronounced in e-commerce since the buyer cannot view the product before purchasing it and cannot form a personal impression of the supplier [10,13]. When automated agents represent the buyer, this problem is even more pronounced. Thus, there is considerable uncertainty about the quality of the goods, delivery time and the reliability of the supplier.

The price of the goods cannot identify its quality, since unknown suppliers may exist, which may sell goods of high quality, but charge low prices since they are not known. Consider, for example, the market for books. The largest online supplier of books is Amazon [1], but there are other online suppliers that may sell the same books at a reduced price and may also provide a better quality product, if quality is measured as delivery time, since a smaller company has fewer transactions, while the well-known supplier may be backlogged with orders, and delivery may sometimes be delayed. Similarly, empirical tests [4] show that price differences exist in the electronic market of airline ticket offerings.

In situations where the unknown supplier may sell superior goods at a lower price, the agents have to use an intelligent strategy in order to choose the most beneficial deals. Under these circumstances, the history of past transactions with this supplier is crucial information in evaluating the quality of the products or services it sells.

On the one hand, the best option for the agent is to chose the supplier which maximizes his expected utility, i.e., with a low price and high average quality. However, there may be situations in which the agent will prefer to buy from an unknown supplier, in order to explore the quality of this supplier, and this may provide future benefits by buying from better suppliers.

The dilemma of the buyer is whether to choose the best known supplier or to try other suppliers in order to learn about their quality, in order to improve future gains. This dilemma is called in the literature the trade-off between exploitation and exploration. For this kind of problems, Gittins [5] suggests a method for calculating an index for each alternative, which considers the expected gains from choosing it, taking into account future gains from obtaining additional information. Gittins proves that the alternative with the highest calculated index is the optimal choice. However, there are several adaptations that are necessary in order to apply Gittins indices to real world situations such as those in the above examples. In this paper, we consider the problem of applying the Gittins technique to real problems of choosing among alternatives and we demonstrate it on the problem of choosing an online supplier.

The paper is organized as follows. In Section 2, we discuss related work and, in Section 3, the formal model is presented. A theoretical background about Gittins indices is presented in Section 3.1 and how to solve the supplier problem using Gittins indices is explained in Section 3.2. Finally, in Section 4, we provide conclusions and suggestions for future extensions.

2. Related work

The issue of product quality is considered in industrial organization literature [12]. Goods are classified into three different types: search goods are goods with a quality ascertained by consumers before a purchase, but the consumers differ in the way they value this quality; experience goods are goods with a quality that is learned after the goods have been bought; and credence goods have a quality that can rarely be learned, even after consumption. In our model, we assume experience goods. Customers in our model differ according to their information about the firms, but we assume that two consumers will give the same evaluation to the goods if both have the same knowledge about their quality.

The quality of experience goods is learned only after an item is bought, and the question is how customers learn the quality of the goods and what incentive firms have to supply high quality. If a one shot relationship is considered, then a problem of moral hazard exists, and the firms have an incentive to cut quality to the lowest possible level, because the market price cannot respond to the unobservable quality.

If repeated interactions are considered, as in our case, then there is an incentive to provide high quality goods. In this case, a firm can change the price in the short run, in order to signal its quality to the buyers. It may signal low prices, since it is able to lose money in order to earn it back in future interactions. However, a