Analysis of Geoinformation Pricing Using Game Theory

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SUMMARY

Game theory is a theory of decision-making and models dynamic and flexible economic relationships. In this paper we demonstrate how it can be implemented in a geoinformation trade situation. We set up a business game model where two producers of geoinformation produce and sell their products. The producers are rational in the sense that they are trying to maximize their profits, and they can set either a high or a low price for their geoinformation products. We focus on the implementation of different pricing strategies and show the resulting payoffs in the form of the profits gained by the geoinformation producers. According to our analysis, setting a low price is a strictly dominant strategy. A dominant strategy is the best choice for a player for every possible choice of the other player. We conclude the paper with a discussion of the analysis results and suggestions for further research.

KEYWORDS: *geoinformation, price, trade, game theory, decision-making*

INTRODUCTION

Neoclassical economics takes the structure of the markets as fixed. The buyers are considered as simple rational stimulus-response machines, products and prices are assumed to be fixed, and the production and consumption are optimised accordingly. It provides well established models describing the mature markets and the trade on these markets (Browning 1999, Deaton 1980, Frank 2000, Mansfield 1993). However, it fails to capture buyer's and seller's creativity in finding new ways of interaction and trade. Analysis tools given by neoclassical economy do not provide appropriate models which could help us to explain the situation on a geoinformation market. Game theory, on the other hand, is a different way of looking at the world. According to this theory, the economy and economic relationships are dynamic and flexible. The players create new markets, take on multiple roles, their preferences are not defined in advance and the products or prices are not given and fixed (Brandenburger 1996, Davis 1983). Game theory is a logical analysis of situations of conflict and cooperation (Axelrod 1997, Straffin 1993), and provides a framework for the rapidly changing world. At the same time it is a theory of decision making; it considers how one should make decisions, but to a lesser extent, how one does make it (Morton 1983, Heap Shaun 1992). It can help to understand and investigate the strategic behaviour, which arises when two or more individuals interact and each individual's decision turns on what that individual expects the others to do (Baird, Gertner et al. 1994).

Game theory models decision-making situations in form of a game. A game is defined by specifying its structure; the players in the game, the strategies available to the players, and the payoff each player receives for each possible combination of strategies. The most often cited and studied game is the Prisoner's Dilemma, introduced first in 1950 by Tucker at a seminar at Stanford University. This game captures the key tensions between individual and collective actions and the outcomes which are the consequence of these actions. There is a strong temptation to behave selfishly and exploit the partner, but both persons are hurt if they behave selfishly. This game was later extended by von Neuman and Morgenstern (1944). They included a larger number of participants in every game forming a n-person dilemma model.

In this paper we apply some elements of game theory in a geoinformation trade situation. This situation is economically specific due to the special characteristics of geoinformation as an economic good. Complications on the geoinformation market arise due to the zero or close to zero marginal cost of geoinformation reproduction and incomplete information the buyers usually have about the geoinformation product prior to purchase (Krek 2002). Incomplete information, e.g. situations in which the information is not known or difficult to acquire (Baird, Gertner et al. 1994) are one of the central problems in game theory.

We start the paper with a short introduction of the basic concepts and game theory terminology which we need for the purpose of our analysis. Then, we set up a simple model including two geoinformation producers producing and selling geoinformation products. We focus on their pricing strategy, geoinformation production costs and the possible outcomes of the trade game. The producers can set a high or a low price for their products. The price is high or low in a relative sense comparing it with the prices of similar or equal geoinformation products on the same market. We explain the rules of the pricing game and observe the payoffs resulting from the trade of geoinformation. The analysis is in detail explained in three different cases where we vary the parameters such as the cost of producing geoinformation and the pricing strategies applied by the geoinformation producers. Setting a low price is a strictly dominant strategy in all three case studies, which is the best possible choice for the player of the geoinformation trade game. This implies that the geoinformation producer is better of setting a low price for his product for every possible choice of the other player. However, we do not claim that the price of geoinformation must be either low or high in an absolute sense. In our analysis, the price is taken to be high or low in comparison to the price of the similar or equal geoinformation products on the market. We conclude the paper with a discussion of the results and directions for further research.

THE NATURE OF THE GAME

A game is defined to be any situation in which there are at least two players. A player may be an individual, but it may also be a more general entity like a company, a nation, or even a biological species. Each player has a number of possible strategies, courses of action which he or she may choose to follow. In general, games are played by the sequence of moves. Individual moves are of interest insofar as they contribute to an overall plan of action e.g. the strategy. What characterizes a strategy is that, at every point of a decision, the strategy dictates precisely what the player does (Friedman 1986). A strategy represents only those actions that are physically possible. They determine the overall outcome of the game. Associated to each possible outcome of the game is a collection of numerical payoffs, one to each player. These payoffs represent the value of the outcome to the different players, and tell us the consequences of actions for a player. The nature of the game is defined by the rules. Solving a game is the process of identifying which strategies the players are likely to adopt. In the following part of the section we explain some key concepts and terminology used in game theory needed for a better understanding of our analysis.

Payoff Matrix: A payoff matrix shows the payoffs that each player receives in the game, and they depend on the combined actions of all players. A payoff matrix is used only in the case when there are two players involved in a game. We call it bimatrix.

Dominant strategy: A dominant strategy is the best choice for a player for every possible choice by the other player. A player will choose a strictly dominant strategy whenever possible and will not choose any strategy that is strictly dominated by another.

Nash equilibrium: The combination of strategies that players are likely to choose is one in which no player could do better by choosing a different strategy given the strategy the other chooses. The strategy of each player must be the best response to the strategy of the other. The solution concept based on this principle is known as Nash equilibrium. It was introduced by John Nash in 1950 and has emerged as one of the central concepts of game theory (Baird, Gertner et al. 1994). A strategy combination that is not a Nash equilibrium is unlikely to be the solution of the game.

Rational player: Individuals are rational in the sense that they consistently prefer outcomes with higher payoffs to those with lower payoffs (Baird, Gertner et al. 1994). They do the best given the set of preferences, and believe the others will act rationally as well. A player's actions are the best response, given the player's beliefs and the actions and beliefs of the other players.

Symmetric game: A game is symmetric if one player's payoffs can be expressed as a transpose of the other player's payoffs. If the transpose of the other player's matrix is ordinally equivalent, then the game is ordinally symmetric.

Simultaneous-move game: Players choose strategies simultaneously without observing other's strategy. Rational, perfect foresight implies that simultaneous choice of strategies yields the same outcome as decision-making in real time.

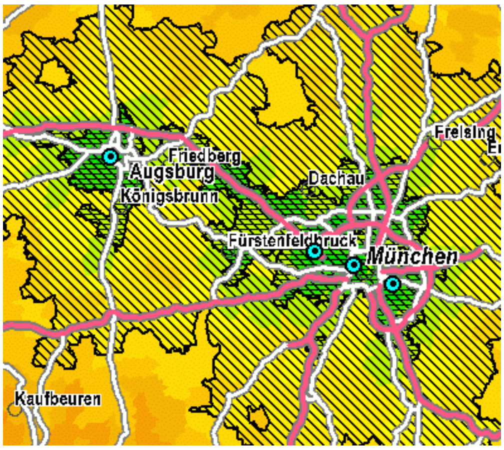
SETTING UP THE MODEL

The games of collective actions can be reduced to two-person games. We set up a simple trade model where we assume that only two geoinformation producers exist on the geoinformation market. This is a simplification of the model, where we concentrate on pricing, cost, and the resulting payoffs. All other political and economic parameters that might influence the price setting environment are given, do not change and influence the price setting environment. The model has a similar structure as the well-known Prisoner's dilemma. The elements of a geoinformation trade game are defined as follows:

- Players of the game

The main players are two producers of geoinformation who compete on the same market. They are rational in the sense that they prefer higher profit to low profit and they want to maximize their market share. We assume that a liberalised market for geoinformation products exists on which two producers produce very similar or even equal, competitive products.

Example 1: Geomarketing service producer
Company: Producer 1
Price of the selected service: 18 €
Map source: http://www.wigeogis.com



We take here an example of two Austrian companies specialised in geomarketing services. Geomarketing allows the user to analyze complex economic and socio-economic relations and visualize the information on accurate maps. For the purpose of such analysis, company data is associated with demographic, economic and spatial data. Geomarketing has long been recognized as a useful tool in the fields of marketing, distribution and sales.

- Strategies for the players

The geoinformation producers can apply different pricing strategies; they can set either a high or a low price for their products. The price is considered to be high or low in comparison to the similar products on the market. In each period, the geoinformation producers simultaneously decide which price to charge.

- Rules of the game

The market for geoinformation products is limited and both producers together can sell maximum ten products. We assume that every geoinformation producer can get 50% of the market share in the case they trade products of equal or similar quality priced at the same price. The producer can sell more products charging a low price, because he is more competitive. If one producer sets a low price and the other one a high price for the same product, the first producer gains the whole market and can sell all 10 geoinformation products. If both producers set a high price, they can only sell 8 products together, each of them 4. We assume that certain amount of price sensitive buyers will not be willing to pay the high price for the product.

PLAYING THE PRICING GAME

To illustrate the geoinformation trade game, we apply the rules of the game to the geoinformation trade situation. The geoinformation products traded are of equal or similar quality, and we assume that it costs 10 € to produce a new version of the geoinformation product. The high price of the product is defined to be 18 €, and the low price is set at 14 €. Charging the low price results in the payoff of 4 €, which is the difference between the price of the product (14 €) and the production cost (10 €). Charging the high price gives the payoff of 8 €. The results of our first analysis are presented in bimatrix 1. The first number in the brackets shows the payoff gained by the Producer 1, and the second number shows the payoff gained by the Producer 2. The payoff is calculated as the difference between the revenue earned by the sale and the cost of geoinformation production. The revenue gained by the sell equals the number of the sold products multiplied by the price of the product.

		Producer 2	
	Price	high	low
Producer 1	high	(32, 32)	(-10, 40)
	low	(40, -10)	(20, 20)

Bimatrix 1: GI Producer's game, many products produced, sold many times

If both producers set the high price, then each of them can sell only four geoinformation products. Selling four products brings the revenue of 72 € (4 * 18 €), and the payoff of 32 € (72 € – 40 €) to each of the involved geoinformation producers. If one of them sets the low price, then he can sell all 10 products, because he is more competitive, given the quality of both products being the same. The calculation of the payoff is the following: revenue of 140 € (10 * 14 €) – production cost of 100 € (10 * 10 €), gives the payoff of 40 €. At the same time, the competing producer incurs 10 € costs of producing the first product, and at the same time not being able to sell anything. If both producers set the low price, then each of them can sell five products resulting them in the payoff of 20 € each (5 products * 14 € / product – 5 * 10 € cost of production). If the Producer 2 charges the high price, the Producer 1 earns 8 € more by charging the low price rather than the high. So, no matter what the Producer 2 does, the Producer 1 earns more by charging the low price. The same holds for the Producer 2, because of the symmetric nature of the game. We can conclude that setting a low price is a strictly dominant strategy for both producers, which is the best choice for a player for every possible choice by the other player. A player will most likely adopt a strictly dominant strategy, and at the same time predict that the other player will adopt such a strategy and will act accordingly. The Producer 1 predicts that the Producer 2 will choose the strictly dominant strategy and will set the low price. In this case, the Producer 1 is better of setting the low price. This situation is called Nash equilibrium, where the geoinformation producers choose the strategy in which no producer could do better by choosing a different strategy given the strategy the other chooses. In the example above, we assume that the producers incur production costs for every geoinformation product they produce. This is usually true for standard economic goods, but it is somehow unrealistic for geoinformation products. Geoinformation data can be collected once and sold many times. The collection costs are usually high and cannot be easily recovered by the sell of one product.

In our second analysis we take an example of two producers offering geomarketing service on a geoinformation market. A geoinformation product in this case is an analysis done with the help of socio-demographic and spatial data which is provided to the user in the form of a map. The producers want to sell the result of their analysis and can decide between charging either 18 € or 14 € for their geomarketing analysis. The high fix cost of production cost is estimated to be 50 €, which is an estimation done by the author of this paper, and was not given by the producers itself. This cost appears only at the beginning when the map product has been created. The marginal cost of reproduction is close to zero and can be neglected. The payoffs of the producers involved in geoinformation trade game are presented in bimatrix 2.

		Producer 2	
	Price	high	low
Producer 1	high	(22, 22)	(-50, 90)
	low	(90, -50)	(20, 20)

Bimatrix 2: GI Producer's game, high fixed cost, one product produced, sold many times

If both producers charge the high price of 18 €, then each of them can sell four products, which results in the revenue of 72 € (18*4 €) for each producer. When we subtract 50 € of the fixed cost of production we get the payoff of 22 € for each producer involved in the geoinformation trade game. In the case they both charge the low price of 14 €, each of them can sell five products. The sell of five products results in the revenue of 70 €, and the payoff of 10 € for every producer. If only one producer sets the low price, then he can sell all 10 products earning the profit of 90 € (10*14 € - 50 €). The other geoinformation producer incurs losses of 50 € investing in the production, but selling nothing due to the high price charged for the geoinformation product. When both producers charge the low price, each of them can sell 5 products. Selling five products results in the payoff of 20 €. Again, no matter what the Producer 2 does, the Producer 1 is better of setting the low price. Setting the low price in this case brings even more profit to the producer than in the first example. Each of them is better of charging the low price, and jointly they are better of charging the low price. This analysis demonstrated that setting even higher price for geoinformation brings losses to the geoinformation producers in the case they both try to charge the high price for their products.

Let us take a closer look at the situation we have at the moment on the geoinformation market. Producers know the cost of production and are trying to set a high price for the datasets in order to recover the high data collection and production cost. We develop the second example further, and increase the difference between both prices. The high price the producer can charge is 22 €, and the low price is 14 €. The sell drops because of the high prices and each producer can sell only two products if he charges the high price. He can sell all five geoinformation products if he charges the low price. The fixed cost of producing the first version of the product is 50 €. The marginal cost is neglected, and it is close to zero. The results of this geoinformation trade game are presented in bimatrix 3. Substantial loses appear in the case where both geoinformation producers charge the high price, and in the case one of them charges the high price. These losses appear due to the high fix cost, which is not recoverable through the sell of the highly priced geoinformation products.

		Producer 2	
	Price	high	low
Producer 1	high	(- 6, -6)	(-50, 90)
	low	(90, -50)	(20, 20)

Bimatrix 3: GI Producer's game, high fixed cost, high prices, one product produced, sold many times

Setting a low price is the dominant strategy for both producers also in this case where the producers set even higher price for geoinformation than in both study cases before. This analysis demonstrates that setting even higher price for geoinformation, which is at the same time still lower than the cost of production, brings losses to the geoinformation producers. The losses appear to both producers in the case when they both charge the high price for their products. The logical result of this situation is that they are not able to sell many products and therefore losses incur to them. The situation is even more extreme in the case where only one of them sets the high price. This situation is very simple to the situation in the second study case.

CONCLUSIONS AND FURTHER WORK

Well-known prisoner's dilemma is a metaphor for a collective action problem. It can be a powerful tool, which offers insights into how pricing policy affects buyer's behaviour with the respect to the information he or she has. The value of this paper is in the implementation of game theory in situations, which are specific for the geoinformation market. We observed final payoffs acquired by the producers under different market conditions. We vary the production cost and the pricing strategies in three study cases, and observe the payoffs gained by the geoinformation producers. Our analysis showed that the producers are better of setting a low price for their geoinformation products. Setting a low price is strictly dominant strategy on this market. However, we do not claim that the price of geoinformation must be low or high in an absolute sense. The price in this paper is defined to be high if it is higher than the price, which the competitor would charge for the same or similar product. The same is valid for the definition of the low price.

Now, the most important question is not "What strategy should a rational producer of geographic data choose", but rather "What are the necessary conditions to justify him playing a cooperative strategy?" What are the strategies available to him and what would be the best strategy for him? Will forming a coalition of two or three producers bring additional benefit to them? What is a fair allocation of the cost and benefits along the geoinformation value chain? Let us assume that the Producer 1 values the datasets at 15 €. The Producer 2 is willing to spend as much as 20 € to acquire this dataset. The different values that Producer 1 and Producer 2 impose on the good assure the trade among them. Trade will happen only when both parties believe that it will make them better off. Although each party wants to gain as large share of the surplus as possible it seems likely that they will agree on some division. In the mutually beneficiary trade the gain from trade has to be divided in a certain way. The right division of the gain from the trade gives the parties incentive to cooperate. If only one of the parties enjoys the entire surplus, the other party will not have an incentive to establish trade relationship and cooperation. How will the geoinformation trade parties divide potential gains from the trade? The potential gain in our case is the difference between 20 € and 15 €? For a more extensive form of the game, the alternatives that each party enjoys matter. The geoinformation producers have also an exit option which is the right to break the geoinformation trade game and receive some alternative payoff by the third party. If the value of the exit option is low, this option does not have an effect on the proceeding of the game. The player is better of playing the game than exercising his exit option. This analysis is already part of our further research, where we will work on many products produced and possible divisions of the benefits between them, observing different pricing strategies and their effects along the geoinformation value chain. The analysis presented in this paper is our first step towards this goal.

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