Proceedings of the 2022 Winter Simulation Conference
B. Feng, G. Pedrielli, Y. Peng, S. Shashaani, E. Song, C.G. Corlu, L.H. Lee, E.P. Chew, T. Roeder, and P. Lendermann, eds.

TOWARD DEVELOPING AN AGENT-BASED MODEL OF EUROPEAN PHARMACEUTICAL TRADE MARKET

Ruhollah Jamali
The Mærsk Mc-Kinney Møller Institute
University of Southern Denmark
Campusvej 55
Odense 5230, Denmark

ABSTRACT

Agent-based modeling and simulation offer a bottom-up platform to research the European pharmaceutical trading market by enabling us to investigate macroeconomic dynamics emerging from microeconomic behaviors and interactions of players in the market. Players such as manufacturers, wholesalers, parallel traders, and hospitals are involved in the pharmaceutical trading market, and their activities in the market are called microeconomics behaviors and interactions. The main objective of this research is to develop an agent-based model of the pharmaceutical trading market based on an available game-theoretic model of the market and discuss applications of the represented model for economists and players involved in this market to study and predict the market.

1 INTRODUCTION AND BACKGROUND

Parallel trade of pharmaceuticals happens when parallel traders buy pharmaceutical products from a country with lower prices than the destination country, and they sell the products in the destination country to make a profit. This movement of pharmaceutical products is strictly regulated, and repackaging them should comply with local and national legislation and linguistic needs. Further, parallel traders sell products at a lower price than the standard local price of the destination country and start a price competition for the product with the manufacturer or other parallel traders.

Game theory offers a systematic framework to formalize business situations and interactions to analyze them. A simple game theory model of pharmaceutical parallel trade market consisting of two countries developed by Pecorino (Pecorino 2002) and his works followed by two other research(Guo, Hu, and Zhong 2013; Grossman and Lai 2008). However, game theory has limitations in modeling business situations. For example, as the number of players involved in a game increases, it will be challenging to model the game using game theory. Considering the limitations of game theory, agent-based modeling and simulation could be a superior tool for studying the pharmaceutical trade market. In an agent-based model, multiple autonomous agents with different characteristics interact with each other, and the environment (Dawid and Gatti 2018). Due to our literature review, there has been no effort to model the pharmaceutical parallel trade market employing agent-based modeling.

2 AGENT-BASED MODEL

Toward developing an agent-based model of the pharmaceutical parallel trade market, we considered two countries (E and I) involved in a pharmaceutical parallel trade market. In this market, a pharmaceutical manufacturer named F produces a patented medicine in E and sells it in both countries. However, to sell the medicine in I, they should negotiate the price of the medicine with the country's government. Since negotiation between F and the government of I could cause a lower price for the medicine in I than E, parallel traders start buying the medicine in I and re-importing it to E to make a profit.

In our model, we considered the countries and their markets as the environment of our model. Each country has a variable attribute, the price of the medicine, and a fixed attribute called market size. Our model has three types of agents: government, manufacturer, and parallel trader. Government has a fixed attribute called bargaining power. Manufacturer has a fixed attribute called bargaining power which is equal to 1 minus the government's bargaining power. The manufacturer also has two variable attributes, one of them is the market share in E, and the other one is their step revenue. A parallel trader has three attributes: A fixed attribute called transfer cost, market share in E, and step revenue which are variable attributes. Transfer cost for a parallel trader is the price that a parallel trader should spend to move the medicine from I to E and repackage it.

Every step of our model starts with price negotiation between the government in I and F to set the price of the medicine in I, considering their bargaining power. After setting the medicine price in I, parallel traders check the price in I to see if it is profitable for them to buy the product there and sell it in E. Then there are two possible scenarios. The first scenario is that parallel traders will not participate in the market. In this case, F acts as a monopolist in E and sets its desired price to maximize its profit. In the second scenario, parallel traders buy medicine in I, move it to E and sell it there to make a profit. In this case, F and parallel traders compete in the market of country E by adjusting their market share in the market of E. Since both manufacturer and parallel traders are selling the same product, the price of the medicine in E is settled considering the total share of F and parallel traders and the demand function of the medicine in E. So in every step, parallel traders and F adjust their market share in E toward maximizing their profit by considering the demand function in E. After adjusting the market shares, the model sets the medicine's price according to the medicine's demand function and the total market share of F and n parallel traders.

3 CONCLUSIONS AND FUTURE WORK

An agent-based model of the pharmaceutical parallel trade market allows us to simulate different scenarios considering multiple conditions and feature adjustments. Resulting in a better understanding of the market for economists and also for players involved in the market. Our current model is the basis of our future work, where we want to model the whole European pharmaceutical trade market. We will involve more agents' characteristics and also other agents such as wholesalers and hospitals. Additionally, we will employ available pharmaceutical trading market historical data to evaluate our model. Moreover, we can estimate agents' features by taking advantage of the historical data, resulting in a more realistic market representation.

ACKNOWLEDGMENTS

This work is partly funded by the Innovation Fund Denmark (IFD) under File No. 9065-00207B.

REFERENCES

Dawid, H., and D. D. Gatti. 2018. "Agent-based macroeconomics". *Handbook of computational economics* 4:63–156.

Grossman, G. M., and E. L.-C. Lai. 2008. "Parallel imports and price controls". *The Rand journal of economics* 39(2):378–402.

Guo, S., B. Hu, and H. Zhong. 2013. "Impact of parallel trade on pharmaceutical firm's profits: rise or fall?". *The European Journal of Health Economics* 14(2):345–355.

Pecorino, P. 2002. "Should the US allow prescription drug reimports from Canada?". *Journal of Health Economics* 21(4):699–708.