Proceedings of the 2020 Winter Simulation Conference
K.-H. Bae, B. Feng, S. Kim, S. Lazarova-Molnar, Z. Zheng, T. Roeder, and R. Thiesing, eds.

FACILITATING RESILIENCE OF DOMESTIC PORK SUPPLY CHAINS THROUGH HYBRID SIMULATION MODELING

Christian Fikar

Institute for Production Management
WU Vienna University of Economics and Business
Welthandelsplatz 1
Vienna, 1020, AUSTRIA

Yvonne Kummer
Klaus-Dieter Rest
Patrick Hirsch

Institute of Production and Logistics
University of Natural Resources and Life Sciences
Feistmantelstraße 4
Vienna, 1180, AUSTRIA

ABSTRACT

This work develops a simulation-based decision support system for governmental organizations to facilitate resilient pork supply chains. The focus is set on a sudden outbreak of African swine fever (ASF) and its impact on food security as well as the identification of resulting bottlenecks in related logistics and disposal operations. The problem is modeled as a hybrid simulation considering various farm types and production and logistics facilities of the supply chain. Discrete-event elements represent production steps, while agent-based ones consider farmers' decision making processes over time. Based on real-world data from Austria, various crisis scenarios are simulated tracking animal populations and contacts among individual animals over time. Results highlight the importance of better knowledge of relevant bottlenecks to react fast to such a crisis as well as major benefits of improved visibility within the supply chain.

1 INTRODUCTION

Within agri-food supply chains, resilience is of particular importance due to increased supply chain volatility resulting from population growth, dietary transition and climate change (Stone and Rahimifard, 2018). The focus of this work is on a domestic pork supply chain and the sudden outbreak of African swine fever (ASF). ASF is a viral hemorrhagic disease which affects domestic pig and Eurasian wild boar populations. The disease is characterized by high lethality and wide-ranging socio-economic impacts, requiring, among others, early detection, epidemiological tracing and stand-still measures (Blome et al., 2020). To evaluate such measures, a simulation-based decision support system for governmental organizations is developed in this work. Simulations are commonly used to study various aspects of agri-food supply chains as such models are able to deal well with both uncertainties and dynamics present in this industry (Utomo et al, 2018; Leithner and Fikar, 2019).

2 METHOD

To investigate the problem setting in detail, the Austrian pork supply chain is modeled. In the first step, relevant data was collected and various process steps identified through business process modeling in close cooperation with expert from industry, research and food safety agencies. The identified processes were implemented in a hybrid simulation model, i.e. a simulation which combines at least two simulation techniques (Brailsford et al, 2019). Discrete-event simulation techniques are used to model the lifecycle of pigs and logistics processes within the supply chain. In contrast, famers' decisions are integrated through agent-based modeling to consider various potential reactions to the outbreak of ASF. Based on input

provided by the decision maker, various risk scenarios are calculated with results presented in a graphical user interface. An overview of the decision support system is shown in Figure 1.

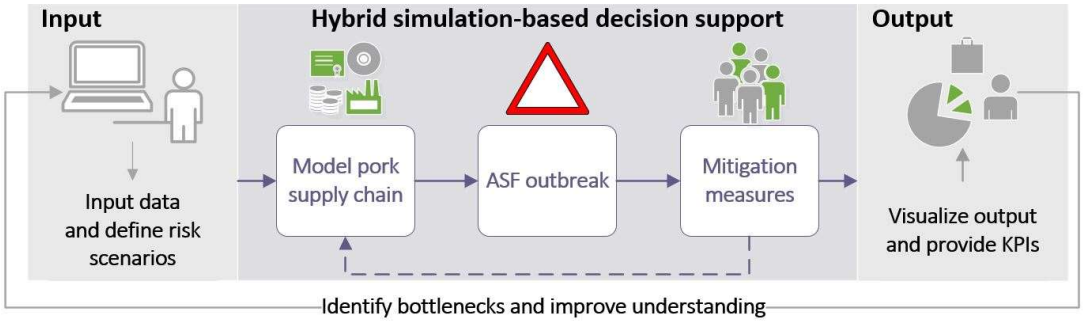

Figure 1: A decision support system to facilitate resilient pork supply chains

3 FINDINGS AND DISCUSSION

The presented simulation model enables one to investigate domestic pork supply chains in detail to identify bottlenecks and improve understanding of the underlying system in a flexible and risk-free environment. Each run starts with one initially infected farm, which spreads the virus throughout the region due to transports of living animals. Depending on supply chain visibility and selected countermeasures, the further development varies over time. As results of first computational experiments highlight, such knowledge is particularly important when dealing with ASF due to its substantial impacts on animal populations and required logistics and disposal capacities. By identifying bottlenecks and testing various mitigation strategies, the severity of outbreaks can be reduced and food security facilitated.

Future works focuses on expanding the analyzed risk scenarios based on real-world settings defined by various experts on food safety, ASF and pork supply chains. Additionally, benefits of improving supply chain visibility through new technologies, particularly distributed ledger technologies, will be investigated in detail to facilitate safe and resilient pork supply in the future.

ACKNOWLEDGEMENTS

We thank the Austrian Federal Ministry for Agriculture, Regions, and Tourism (KIRAS: 867015) as well as the German Federal Ministry of Education and Research (FKZ: 13N15070-13N15076) for funding the project NutriSafe (https://www.nutrisafe.de/en/) within the civil security research programs.

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