UTS UNIVERSITY OF TECHNOLOGY SYDNEY

Extended Sustainable Supply Chain: Pathways to Sustainability through Consumer Behavior Change

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Thesis submitted in fulfilment of the requirements for the degree of

Doctor of Philosophy

under the supervision of Distinguished Professor Alexey Voinov and Doctor Nagesh Shukla

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February 2020

CERTIFICATE OF ORIGINAL AUTHORSHIP

I, Firouzeh Taghikhah declare that this thesis, is submitted in fulfilment of the requirements for the award of Doctor of Philosophy, in the School of Information, System, Modeling, Faculty of Engineering and Information Technology at the University of Technology Sydney.

This thesis is wholly my own work unless otherwise reference or acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

This document has not been submitted for qualifications at any other academic institution.

This research is supported by the Australian Government Research Training Program.

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February 12, 2020

ACKNOWLEDGEMENTS

I am indebted and grateful of my supervisors, Professor Alexey Voinov and Doctor Nagesh Shukla for their invaluable guidance, enthusiastic, encouragement and continuous support. I also have been deeply privileged to work with Professor Tatiana Filatova and would like to add a special note of thanks for her constructive guidance. These brilliant scholars have always been inspiring throughout my PhD journey. They showed great patience and encouragement as I grew in my learning and provided me with many wonderful opportunities to learn both in theory, and in real-world projects. This thesis could hardly have been completed without their insightful guidance, delicate supervisions and sincere devotion. In my future work, I will hope to mirror these qualities.

I have the utmost respect for Professor Iwona Miliszewska and Professor Ghassan Beydoun for their support during the past few years of my endeavours here at the school of Information, Systems, Modeling. Finally, I am very grateful to the Faculty of Engineering and Information Technology, the University of Technology Sydney for offering research scholarships that have enabled me to accomplish this study.

Words fail me to express my appreciation and gratitude to my fiancé, Ivan Bakhshayesh, who has been always there for me during the good and difficult times. My warmest thanks go to my parents, family and friends for their endless support in this long journey.

To all these people, and the many more I haven't named, thank you. I hope I can pass a measure of your support on to those I work with in the future.

LIST OF PUBLICATIONS

Conferences:

Taghikhah, F, Voinov, A, Shukla, N, & Filatova, T., 'Modeling extended agro-food supply chain: pathways to sustainability through consumer behavioral change', 2020, 22nd Conference of the International Federation of Operational Research Societies, Jun 2020, Seoul, South Korea

Taghikhah, F, Voinov, A, Shukla, N, Filatova, T, & Anufriev, M., 'Modelling the impacts of consumer policies on organic farming adoption: Ecological and sociological perspectives', 23rd International Congress on Modelling and Simulation, 1-6 December 2019, Canberra, Australia.

Taghikhah, F, Voinov, A, Shukla, N, & Filatova, T., 'Exploring organic wine purchase behaviour: An agent-based approach', IEEE Systems Modelling Conference. 12 September 2019, Canberra, Australia

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Taghikhah, F, Voinov, A & Shukla, N., 2019, *'Extending the supply chain to address sustainability',* Journal of Cleaner Production, vol. 229, pp. 652-666.

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Taghikhah, F, Voinov, A, Shukla, N, Filatova, T, & Anufriev, M., 2020, *'Integrated modeling of extended agro-food supply chains: A systems approach',* European Journal of Operation Research.

Taghikhah, F, Voinov, A, Shukla, N, & Filatova, T., 2020,' *Shifts in consumer behavior towards organic products: theory-driven data analytics,* Journal of Retailing and Consumer Services, (Revision).

Taghikhah, F, Filatova, T, Voinov, A., 2020, *'From Theoretical to Empirical Agent-based Models: A Comparison Framework',* Journal of Artificial Societies and Social Simulation (Revision).

ABSTRACT

In today's growing economy, overconsumption and overproduction have accelerated environmental deterioration worldwide. Consumers, through unsustainable consumption patterns, and producers, through production based on traditional resource depleting practices, have contributed significantly to the socio-environmental problems. Consumers and producers are linked by supply chains, and as the idea of sustainable development has become seen as a way to reverse socio-environmental degradation, it has also started to sprout in research on supply chains. We look at the evolution of research on sustainable supply chains and show that it is still largely focused on the processes and networks that involve the producer and the consumer, hardly taking into account consumer behavior and its influence on the performance of the producer and the supply chain itself. We conclude that we cannot be talking about sustainability, without extending the supply chains to account for consumers' behavior and their influence on the overall system performance. In Chapter 2, a conceptual framework is proposed to explain how supply chains can become sustainable and how their economic and socio-environmental performance can be improved by motivating consumer behavior toward green consumption patterns, which, in turn, motivates producers and suppliers to change their operations.

In the thesis we focus on agro-food production-consumption, which is an important element of the sustainability agenda. The current intense food production-consumption is one of the main sources of environmental pollution and contributes up to 25-30% of anthropogenic greenhouse gas emissions. Organic farming is a potential way to reduce environmental impacts by excluding synthetic pesticides and fertilizers from the process. Organic food has important environmental and health benefits, decreasing the toxicity of agricultural production, retaining carbon, and improving overall soil quality, and generally the resilience of farming. Despite the recorded 20% growth in organically managed farmland, its global land area is still far less than could be expected, only 1.4%. Increasing consumers' demand for organic food reinforces the rate of organic farming adoption and the level of farmers' risk acceptance when transitioning to organic.

Increasing demand for organic food is an important pathway towards sustainable food systems. In Chapter 3, we explore this consumer-centric approach by developing a theoretically- and empirically-grounded agent-based model. Three behavioral theories – theory of planned behavior, alphabet theory, and goal-framing theory – describe individual food purchasing decisions in response to policies. We take wine sector as an

example to calibrate and validate the model for the case study of Sydney, Australia. The discrepancy between consumer intention and purchasing behavior for organic wine can be explained by a locked-in vicious cycle. We assess the effectiveness of different policies such as wine taxation, and informational-education campaigns to influence consumer choices. The model shows that these interventions are non-additive: raising consumer awareness and increasing tax on less environmentally friendly wines simultaneously is more successful in promoting organic wine than the sum of the two policies introduced separately. The phenomenon of undercover altruism amplifies the preference for organic wine, and the tipping point occurs at around 35% diffusion rate in the population. This chapter provides policy recommendations to help decision-makers in the food sector make informed decisions about organic markets.

Chapter 4 focuses on modeling the interplay between consumer preferences and socio-environmental issues related to agriculture and food production. We operationalize the novel extended agro-food supply chain concept and simulate adaptive behavior of farmers, food processors, retailers, and customers. Not only the operational factors (e.g., price, quantity, and lead time), but also the behavioral factors (e.g., attitude, perceived control, social norms) of food suppliers and consumers are considered in order to foster organic farming. We propose an integrated modeling approach combining agent-based, discrete-event, and system dynamics modeling for the case of a wine supply chain. The model undergoes standard testing procedures including calibration, validation and uncertainty quantification before being used for scenarios analysis and optimization. Findings demonstrate the feasibility and superiority of the proposed model over the traditional sustainable supply chain models in incorporating the feedback between consumers and producers, and analyzing management scenarios that can urge farmers to expand organic agriculture. Results further indicate that demand-side participation in transition pathways towards sustainable agriculture can become a time-consuming effort if not accompanied by the middle actors between consumers and farmers. In practice, our proposed model may serve as a decision-support tool to guide evidence-based policymaking in the food and agriculture sector.

In Chapter 5, we empirically examine purchasing behavior considering planned, impulsive, and unplanned decisions of consumers for an organic wine case study. A comprehensive theoretical framework integrating the theory of planned behavior, the theory of interpersonal behavior, impulsive buying theory, alphabet theory, and goal framing theory helps us to identify possibly influential behavioral factors, including cognitive and affective ones, driving consumers' organic wine choices. Accordingly, we

surveyed 1003 Australian wine consumers living in the City of Sydney. The descriptive analysis presents a gap between intention and behavior where 80% of consumers have a positive willingness to pay for organic products, but only 20% are actual organic wine shoppers. The correlation analysis reports strong correlations between factors confirming the validity of the proposed framework. We then use supervised machine learning method - classification algorithms including random forest, decision tree, logit regression, and support vector machine - to estimate the organic wine preferences as well as unsupervised machine learning method - the DBSCAN clustering algorithm - to segregate consumers based on their similarity. Comparing the results of methods, we notice that consumers' intention and behavior are highly influenced by behavioral factors as well as shopping, and drinking-related patterns while the effects of socio-demographic factors are small. Moreover, the classification algorithm emphasizes the role of hedonic, gain and normative cues in guiding behavior, whereas the clustering algorithm reveals the dual effects of emotions and impulsiveness in choosing organic products. Our findings have direct applications for industry and policymakers aiming at promoting organic food and facilitating demand-side solutions in a transition to sustainable agriculture.

This analysis has direct implications for further research on the topic, which we outline in the conclusion part.

Keywords: Sustainable supply chain, complex systems, organic food, pro-environmental behavior, integrated modeling, machine learning.

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