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Combined and mixed methods research in environmental engineering: when two is better than one

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Abstract

Eco-innovation will play a major role in contributing to a sustainable future. Understanding the diffusion is critical, since the diffusion rate is slow and the path unclear. We present the conceptual methodology for eco-innovation diffusion. This methodology combines mixed and combined research methodology to improve the validity and reliability of results. A survey is used as a quantitative method; artificial neural networks and system dynamic are applied as qualitative methods. With this article we aim to contribute to the applications of combined and mixed methods research in the field of eco-innovation diffusion. The application of the presented methodology can be extended for other problems.

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Keywords: artificial intelligence, dynamic simulation, eco-innovation diffusion, technology substitution

1. Introduction

Eco-innovation will play a major role in securing a sustainable future. Eco-innovations are related to sustainable production and consumption; they are increasingly used to substitute existing products or services [1].

Some eco-innovations have already reached a mature state, but they diffuse slowly. A recent review by Karakaya et al. [2] states that understanding the diffusion of eco-innovations is critical, since the diffusion rate is slow and the path unclear. Consequently, eco-innovations have required a long-time period to be adopted. Moreover, there is little known about the importance of various factors on the diffusion process of eco-innovations.

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The use of various simulation models and data analysis tools are a fundamental part in the majority of research problems. Each method has its strengths and weaknesses and therefore growing interest is given to the application of combined and mixed methods or hybrid methods [3, 4, 5].

The study by Vīgants et al. [6] combines quantitative and qualitative research methods to study eco-innovation diffusion. The work studies the influence of various policy tools and the relative importance of internal and external on the diffusion processes of eco-innovations. As the quantitative research methods regression analysis is used in studies by Vīgants et al. [6] on the intention to use micro-fibre clothes, Tonglet et al. [7] on the intention to recycle and Bariss et al. [8] on the intention to adopt energy efficient practices. The highest adjusted deviance explained by these studies was 33.5 %. We aim to improve these statistics with proposal of a novel methodology.

Therefore the goal of this study is to present a conceptual methodology and develop a model for eco-innovation diffusion. We use both mixed and combined research methodology to improve the model of eco-innovation diffusion.

Nomenclature

a_j	actual target output
b_j	predicted output of the neural network
d	number of time-delays
m	number of output data
$erf(x)$	asymptotic series of error function
$erfc(x)$	complementary error function of asymptotic series
i	external neurons ($i = 1,2, \ldots, n$)
k	the neuron
MSE	mean square error as training parameter
R^2	statistical coefficient of determination
t	discrete time step
u_k	output from the summation function
x_i	input signals from external neurons
$x(t)$	input to the network at discrete time step t
w_{ki}	weight between the i^{th} external input and neuron k
$y(t)$	output of the network at discrete time step t

2. Methodology

In this study mixed and combined research methods will be integrated to obtain the model for innovation diffusion, see Fig.1.