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The use of modelling in purchasing/supply management research

Aristides Matopoulos [a,*], John E. Bell [b,1], Emel Aktas [c]

[a] Aston University, Aston Logistics and Systems Institute, Aston Triangle, Birmingham, B47ET, United Kingdom
[b] Department of Marketing and Supply Chain Management, Haslam College of Business, University of Tennessee, TN, United States
[c] Cranfield School of Management, Cranfield, Beds, MK43 0AL, United Kingdom

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ABSTRACT

The purpose of this research to explore the use of modelling in the field of Purchasing and Supply Management (P/SM). We are particularly interested in identifying the specific areas of P/SM where there are opportunities for the use of modelling based methods. The paper starts with an overview of main types of modelling and also provides a categorisation of the main P/SM research themes. Our research shows that there are many opportunities for using descriptive, predictive and prescriptive modelling approaches in all areas of P/SM research from the ones with a focus on the actual function from a purely operational and execution perspective (e.g. purchasing processes and behaviour) to the ones with a focus on the organisational level from a more strategic perspective (e.g. strategy and policy). We conclude that future P/SM research needs to explore the value of modelling not just at the functional or operational level, but also at the organisation and strategic level respectively. We also acknowledge that while using empirical results to inform and improve models has advantages, there are also drawbacks, which relate to the value, the practical relevance and the generalisability of the modelling based approaches.

1. What is modelling and what are the generic types of modelling?

Modelling is a simplified and usually mathematical representation of a process or a system to support decision-making or to simply understand the actual situation better. In terms of the purpose of the modelling exercise, models can be categorised into three types: descriptive, predictive, and prescriptive.

Descriptive models provide insight into the past including what happened, and more usefully, why it might have happened. Such models usually constitute a base-case that can be used as a benchmark to make and test suggested improvements.

Predictive models are aimed at understanding the future including what could happen given what we know about a system. Regression is one of the well-known predictive models along with time series forecasting models that are used to predict the future behaviour of a variable of interest. These predictive models represent what could happen in the future, rather than what should be done to reach a desirable outcome, which is addressed by *prescriptive models*.

Optimisation models (e.g. linear programming, integer programming, multi-objective mathematical programming) prescribe the decision maker the best course of action in order to achieve the set objective (e.g. profit/welfare maximisation, cost/time minimisation). Such models are comprised of mainly three building blocks: objective function(s), decision variables, and constraints.

Simulation models can be used for descriptive, predictive and prescriptive purposes. They are very useful in understanding the current situation of a system, and they are also a cost-effective way of experimenting with multiple designs and the variation that can occur in a system.

In terms of the input data and model parameters, it is possible to develop either deterministic or probabilistic models. Deterministic models assume that the parameter values are known with certainty, whereas probabilistic models may incorporate stochastic properties in the parameters and decision variables. Both deterministic models and probabilistic models have proven to be quite useful since the start of the management science discipline; however, choosing the appropriate type of model could also be a modelling exercise.

2. Why do we need models?

The problems faced in both the public and private sector are quite complex, necessitating rigorous and representative models. Models are often needed to understand a system, to predict the behaviour of a system, or to identify points of intervention in order

* Corresponding author.
E-mail addresses: a.matopoulos@aston.ac.uk (A. Matopoulos), bell@utk.edu (J.E. Bell), emel.aktas@cranfield.ac.uk (E. Aktas).
[1] Tel.: +1 865 974 8397.

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to change a system in the desired direction. Most often, it is impossible to arrive at a desired system status by trial and error. It is not only costly but simply impractical to make an arbitrary decision and then assess whether or not is was the right decision. Therefore, models are needed to accurately formulate a problem and to develop meaningful solutions to that problem. In the formulation of the problem, a critical aspect of the model building is the parameterisation of the model.

However, models that are not based on practical observation may lack explanatory power. Therefore, empirical data are required to determine the values of the parameters in a decision model. A model takes its power from the representation of the real situation and therefore relies on various methods of empirical data collection and analysis. There are a plethora of models that can be applied in the purchasing/supply management domain, ranging from models for strategic decisions such as supplier network design and outsourcing strategy to models for tactical decisions such as capacity planning or operational decisions such as a contract negotiation or e-procurement. Modelling is a versatile tool applicable to many supply management problems, and its sole purpose is to help make better decisions for the firm and the related supply chain.

3. The P/SM Discipline: key themes/research areas

The academic disciplines of supply chain management (SCM) and purchasing and supply management (PSM) have grown significantly in the last twenty years, and this is reflected not only in the number of journals covering these fields but also in the growth of the respective professional bodies (e.g. CIPS, ISM, CSCMP). Despite the fact that academia is not always closely aligned with industry and practitioners, it could be argued that in SCM, particularly from a PSM perspective, there are seven main key themes (and sub-themes) in research and practice that keep academics' and practitioners' attention. They include: Supplier Relationship Management (e.g. Supplier Development, Supplier Co-ordination/Association), Developing and Managing Contracts (e.g. Negotiation, Contract Management, Conflict Resolution), Purchasing Processes and Behaviour (e.g. Needs Assessment/Commissioning, Data Analysis/Business Intelligence, Supplier Evaluation and Appraisal, Sourcing and Tendering), People and Skills in the Purchasing and Supply Organisation (e.g. Leadership and Promotion of Procurement and Supply Management, Change Management, Purchasing and Supply Team Governance), Strategy and Policy (e.g. Category Management, Make-or-Buy/Outsourcing Strategy, Procurement Policy Development), ICT (e.g. e-Sourcing/e-Procurement Systems, e-Auctions/Reverse Auctions) and Risk/Mitigation (e.g. Counterfeit, Fraud and Transparency, Risk Analysis and Management).

Some of these seven themes (e.g. purchasing processes and behaviour) focus more on the actual function from a purely operational and execution perspective, while others (e.g. strategy and policy) focus more on the organisational level from a more strategic perspective. Not surprisingly, there are themes (e.g. supplier relationships management) that have got both operational and strategic implications or other themes (e.g. people, skills and the purchasing/supply organisation) with implications for both the function and the organisation. Regardless, empirically driven models can be applied in each of these areas and can help with supply and purchasing decision making for the function or organisation from strategic to operational level. In Fig. 1, a classification of these seven main themes is provided. The classification reflects our views and understanding (informed by years of interactions with P/SM scholars, managers and companies) of the discipline and it is not based on any objective and/or quantitative data analysis.

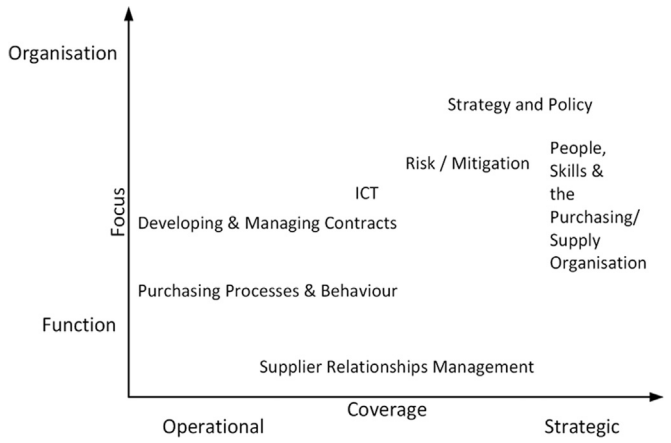

Fig. 1. P/SM themes classification.

4. The match/mismatch

4.1. Why do models make sense for P/SM research?

There are a number of opportunities to build and apply models in P/SM research. Additionally, combining an analytical model with empirical methods in a multi-method approach can create several advantages and has been called for in the SCM literature (Sanders and Wagner, 2011; Cheng et al., 2012; Sanders et al., 2013; Choi et al., 2016). There are several reasons why P/SM researchers should consider empirically informed analytical models. For example, exploratory empirical methods, such as case studies and surveys, have the potential to generate relevant results from current business practice that can then be used to drive the design and inputs for a rigorous analytical model. In doing so, the experimental results of the model have the potential to be more externally valid and generalisable to practice, since the underlying tenants and parameters of the model are based more closely on actual real world data (Choi et al., 2012; Simchi-Levi, 2014; Sodhi and Tang 2014).

Another approach may be utilised where results from an empirical study are then extrapolated or subjected to sensitivity analysis by either an optimisation model or simulation model. Such post-hoc analysis allows the research to further explore the relationships and sensitivity of the results in a controlled experimental setting where the analytical model is used to generate new results in addition to those gathered in the initial empirical stage (Choi et al., 2016). Additionally, when empirical data are difficult to collect or are not a sufficient sample size, analytical methods offer an option for generating additional data to ensure the rigour of the analysis. System simulations that use distribution-fitting techniques offer this ability, and they are one possible technique for applying a secondary analytic method after an empirical effort determines the initial range of inputs for variables (Evers and Xiang, 2012).

The use of analytic methods can be used to extrapolate and forecast results for conditions that do not currently exist, and therefore they do not rely solely on the use of historical data as the input. Therefore, P/SM studies that combine an initial empirical study that creates a historical baseline for the phenomenon can be followed with an analytical study that extends the results based on anticipated changes in the parameters of the business environment. Such an approach has the potential to create a powerful predictive capability.

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