Chapter 2
Analytical Modeling Research Methodologies for Fashion Business Operations Management

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Abstract In this paper, we examine the analytical modeling research methodologies for operations management in fashion business. We first concisely examine the related literature on analytical modeling research methods for operations management. Then, we propose the research frameworks for conducting analytical modeling operations analysis in fashion business. To be specific, by classifying the frameworks into economic modeling and engineering modeling, we propose the respective steps for conducting rigorous analytical modeling operations management studies in fashion business. For each step, some related important remarks specific to fashion business operations are discussed. Comparisons between these two categories of analytical modeling research methods are also presented.

Keywords Research method · Analytical modeling research · Mathematical models · Fashion business · Economic models · Engineering models · Optimization models

2.1 Introduction

Nowadays, operations management is a very important field of studies, and it is a spin-off from operations research and management science. In the fashion industry, operations management covers topics such as supply chain management, product design, quality control, production and capacity management, inventory control, sourcing, pricing and revenue management, and retail visual merchandising. Proper operations management for fashion businesses requires the support from scientific methods, in particular, the development of mathematical analytical models.

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In the literature, Ackoff (1956) is among the first group of operations researchers who develop a specific framework for conducting scientific analytical modeling research in operations. He proposes the well-known six-phase model which can systematically explore operations management problems ranging from inventory control, resource allocation, queueing, and routing, to replacement processes. Lathrop (1959) discusses science in operations research and comments that more scientific work in operations is necessary for the development of operations research and management science. Morris (1967) examines the art of analytical modeling research. He proposes three hypotheses on the proper approach in developing analytical models for management science studies. Among them, he believes that it is helpful to start with simple models even though they are quite distinct from reality and then move evolutionarily toward the more realistic models. This approach helps to avoid frustration which is very likely to appear when one considers a rich and complex model at the very beginning. Gass (1990) discusses the issues associated with analytical modeling research in which users act as modelers. He suggests that the proper model development methods and processes must be employed in order to yield high-quality insights and decision supports from the analytical models. Willemain (1994) interviews twelve modeling experts and reports some findings on the modeling practices and challenges. Many of the findings provide guidance and tips to proper analytical modeling for operations analysis. More recently, there are proposals on adopting multiple methodologies to examine operations management problems (Boyer and Swink 2008; Carter et al. 2008; Singhal and Singhal 2012a, b; Tang 2015). In particular, Van Mieghem (2013) examines the "3Rs," namely research, relevance, and rewards, of operations management studies. He argues that to have a sustainable future, operations management research must be relevant, both internally (to researchers) and externally (to practitioners). So he advocates the incorporation of rigorous empirical studies into analytical modelling to yield rewarding and fruitful research results in operations management. Echoing Van Mieghem's (2013) view, Simchi-Levi (2014) suggests ways to conduct operations management studies from a data-driven perspective. He proposes that real-world data-driven operations analysis presents a great opportunity and opens a new avenue to cultivate innovative and creative research in operations management. Gallien et al. (2015) explore the practice-based research in operations management. They argue that the real-world practice relevant operations management studies are driven by two dimensions of generalizability and validity. They discuss the related challenges and suggest ways to encourage more researchers to engage in practice-based operations management research. Most recently, Choi et al. (2016) examine the research trend of employing the multi-methodological approach in operations management. The authors discuss the strengths and weaknesses of the multi-methodological approach. They also present some specific multi-methodological approaches which can enhance the research rigor of operations management studies. As a remark, Choi et al. (2016) comment that the multi-methodological approach in operations management is in fact consistent with the classical framework proposed by Achoff (1956).

In this paper, based on the well-established analytical modeling research methods proposed by Achoff (1956), Morris (1967), and Gass (1990), we present how analytical modeling research can be conducted to explore fashion business operations management problems. We classify the fashion business operations management studies by dividing them into two different categories, namely the economic studies and the engineering studies. For each category, we introduce the respective steps of conducting analytical modeling research and show the related published research in the literature.

The rest of this paper is organized as follows. First, we present the economic analytical modeling framework, propose the respective steps, and review some related studies in Sect. 2.2. Then, we introduce the engineering analytical modeling research framework, explore the respective steps, and examine some related research in Sect. 2.3. We conclude this paper in Sect. 2.4.

2.2 Economic Models

In economics, an economic analytical model can be described as a theoretical construct expressed in mathematics, which is usually a simplified framework (compared to the real-world scenario), to demonstrate the complex economic processes. Operations management, as an important field of modern business studies, aims to generate important managerial insights by a scientific approach, and it requires the support of a solid methodology. The economic analytical modeling approach hence serves this need. As argued by many pioneering management scientists such as Morris (1967), it is wise and important to start the analysis by focusing on some simpler models. In particular, if we aim at deriving theoretically sound closed-form analytical tractable solutions for the operations management problems under studies, we usually have to employ simple models and impose some needed assumptions. With these points in mind, the steps for conducting economic modeling research in fashion business operations management are proposed as follows:

Step 1: *Formulating the problem*: Fashion business operations management is related to the fashion industry. It is thus of the upmost importance to identify the industrial needs. For example, is the problem related to some widely observed industrial problems and challenges in fashion business operations? These real-world industrial needs provide the needed "motivation" for conducting this piece of research. In addition, if high-quality (accurate and systematic) real datasets (e.g., demand data, inventory data, and lead time data) are available, we should carefully collect them and make use of them for the whole study. Similar to other kinds of business research, it is important to search the literature and conduct a comprehensive literature review on the related problems. Some related problems, models, research findings, and under-explored issues should be identified

from the literature review. Then, we can formally define the scope of the problem (e.g., is it a supply chain inventory management issue? A dynamic pricing and revenue management issue? etc.) and proceed to Step 2.

Step 2: *Constructing the analytical model*: From Step 1, the specific research issues, the problem scope, and some related models should have been identified. In Step 2, we proceed to construct the specific analytical model by using standard mathematics. For example, we can construct an optimization model for the decision-making problem (e.g., on inventory management) and define the analytical objective function (e.g., maximizing the expected profit), the decision variable (e.g., the ordering quantity), and the constraints (e.g., on some realistic conditions such as budgeting, and the other model assumptions). As a remark, the proper way to establish the right economic analytical model is more art than science and there are no simple rules of thumb to help. However, some basic guidelines, as listed below, should be observed: 1. Start with a simple model and then proceed to refine it gradually with respect to the given data and the observed real-world practices. 2. Revise and adopt the model assumptions which are reasonably real world supported and can lead to analytical tractable results. 3. Choose the model understandable by the whole team of modelers. For more details, we refer readers to Morris (1967). Notice that in order to obtain analytically tractable closed-form solution, the economic analytical model developed in Step 2 is usually relatively simple. This point deserves much attention because most real-world fashion business operations are complex, while for conducting economic analytical modeling research for the respective operations problem, we have to confine ourselves to relatively simple models by setting the respective assumptions.

Step 3: *Deriving the solution*: After establishing the analytical model in Step 2, we need to identify the respective solution. Observe that the common methods for economic analytical modeling in operations management include optimization modeling and game theoretical modeling. Thus, in Step 3, if we have developed a standard optimization model in Step 2, our goal is to identify the optimal solution; if we have established a game theoretical model in Step 2, our goal is to determine the equilibrium solution. For economic operations management studies, we aim at deriving the closed-form solution. In many cases, we want to identify the unique solution (e.g., the unique equilibrium in the game theoretical analysis), which is especially helpful to derive managerial insights in Step 4. Notice that it is critically important to verify whether the solution makes sense by checking whether the solution is reasonable and in line with the reality (i.e., the practices observed in the fashion industry).

Step 4: *Generating managerial insights*: After determining the solution, we need to go deeper in generating insights from the solution. Standard studies, which include (i) the structural property analysis which aims to show the

features of the solution (e.g., on solution uniqueness and special cases) and (ii) the sensitivity analysis which helps reveal how a change of model parameters affects the optimal solution (which also implies the rational decision of the related party) or the equilibrium, can be conducted. As a remark, the insights developed should be very practical and understandable by the fashion practitioners. As what Raman (1999) commented, managers in the fashion industry are not familiar with management science tools, and hence, we cannot expect they are able to appreciate the complex theoretical insights. They treasure simple and direct managerial advices.

Step 5: *Extending the model?* Since in Step 2, the analytical model being studied is relatively simple, one may extend it in Step 5 by considering a more general or complex situation. Usually, Step 5 involves relaxing some assumptions from the model explored in Step 2. Once the extended model is developed, similar analyses from Step 3 and Step 4 should be conducted. Of course, this proposed Step 5 is not necessary if the model developed in Step 2 is reasonably comprehensive, and the derived findings are sufficient. In the fashion industry, we have different kinds of operations (local versus global), different product types, and different kinds of product tiers (higher end noble brands versus lower end mass market brands). To extend the model, one can actually consider these differences and extend the analysis from one scenario to another scenario, with the goal of yielding generalizable managerial insights and theories.

Step 6: *Real-world validation*: Operations management in fashion should be related to the real industrial practices. As a scientific study, economic analytical modeling research should check the real-world situations and validate if the findings generated by the mathematical analysis are logical and consistent with real-world practices. This step on real-world validation has been highlighted in various classic studies and textbooks (e.g., Gass 1990; Taha 2002). We should also examine whether the findings can well explain real-world situations and phenomena. In fact, the goal of conducting economic analytical modeling research for fashion business operations management is to provide scientifically sound insights which can enhance the respective managerial practices. Empirical case studies, both qualitative and quantitative, industrial interviews, and surveys are all some relevant approaches to adopt in Step 6. Undoubtedly, in the fashion industry, the operations are usually rather complex. However, economic models are all, by definition, simplified versions of the real world. Thus, the findings based on the simplified economic models have to be validated with real-world practices in fashion in order to be convincing and scientifically solid.

Table 2.1 summarizes the steps involved in conducting economic analytical modeling research in fashion business operations management; some important remarks are also added. As shown in Table 2.1, even though economic analytical

Table 2.1 The steps included in the economic analytical modeling research framework

Steps	Key activities	Fashion business specific remarks
1. Formulating the problem	Literature review is critically important. Real-world practices and cases help to motivate the research	Fashion business operations management should be highly related to the fashion industry. Specific fashion company cases and data should hence be employed
2. Constructing the analytical model	Consider simple models first	Fashion business operations can be very complex, and it is wise to start from simple models
3. Deriving the solution	The existence of a unique closed-form solution is desirable	Verifying whether the solution makes sense to fashion is critically important
4. Generating managerial insights	The sensitivity analysis and the structural property analysis, both analytical and numerical, are commonly employed	The insights should be as practical as possible and should be understandable by practitioners in the fashion industry who are in general not experts in analytical modeling research
5. Extending the model?	Generalize the findings (e.g., relaxing assumptions) by exploring the extended model(s)	It is wise to extend the model by following the fashion business practices and industrial setting, from one scenario to another one
6. Real-world validation	Validate the research findings with respect to real-world practices	This is very critical as the findings derived from simplified economic models need not be applicable to the real industrial setting in fashion. This validation helps to make the research solid and scientifically sound

modeling research focuses on the mathematical analysis, real-world practices, data, and empirical industrial inputs are crucial in order to provide the complete picture of the whole fashion business operations management study.

In the literature, we can also find many examples employing the economic analytical modeling approach for fashion business operations management. For example, Iyer and Bergen (1997) study the quick response policy in a two-echelon apparel supply chain. The authors model the problem by considering a newsvendor type of product. Using the Bayesian conjugate pair demand distribution under the normal process, they reveal the impacts brought by quick response to the supply chain and its agents. In order to achieve Pareto improvement, they propose various measures such as service level commitment, volume commitment, and price commitment. Finally, the authors extend the model analysis to study the case with multiple items and also validate the findings by real-world industrial practices. Eppen and Iyer (1997) investigate the backup agreement in fashion buying. The authors construct the analytical model based on the observed industrial practice. They focus on exploring the value of upstream flexibility and generate important insights. By running a retrospective test of the model solution against the real buyer decisions, they find that backup agreements can enhance expected profits and may

increase the amount of committed quantity. It is also encouraging to see that backup agreements may also benefit the manufacturer in maintaining its expected profit. Donohue (2000) examines supply contracting in a fashion supply chain with two production modes and forecast updating. The author considers the wholesale pricing with returns supply contract and proves that it can achieve supply chain coordination. In terms of theoretical contribution, her paper is among the first which explores supply chain coordination in the presence of forecast information updating. Jain and Paul (2001) study the operations reversal problem, which involves switching two consecutive stages in a manufacturing process for fashion products. The authors consider both customer heterogeneity and customer preference unpredictability in their model. They identify the analytical conditions in which operations reversal can lead to reduced production volume variability in the manufacturing process. Raman and Kim (2002) explore the impacts of inventory holding cost and the capacity management issue in apparel manufacturing. The authors focus on a real case study with a school uniform manufacturer. Based on many practices of this case, they construct the formal analytical models and then conduct analysis. Their findings reveal that apparel manufacturers with high inventory holding costs should set high stockout costs and achieve low capacity utilization. Choi (2007) studies the preseason inventory ordering and pricing problem in fashion retailing. The author makes several important industrial observations and establishes the stylish model. With multiple Bayesian information updating, he derives the ordering and pricing policy. By an extensive numerical sensitivity analysis, insights on the impacts brought by demand uncertainty and the value of information are generated. The author further extends the model with the consideration of different objective functions for determining the optimal retail price. Cachon and Swinney (2011) study the fast fashion supply chain with strategic consumers. The authors first observe the features of fast fashion supply chains and identify the core elements of them. Then, they explore how these features, such as quick response and enhanced design, relate to the operational performance of the fast fashion supply chain in the presence of forward-looking strategic consumers. They find that if a fast fashion company adopts both quick response and enhanced design strategies together, it will receive a higher profit compared to the sum of profits for the cases when it adopts either strategy alone. Chiu et al. (2011) study the supply chain coordination challenge with the use of "price, returns, and rebates" contract. The authors first report the industrial survey on the presence of the price, returns, and rebates supply contract in various companies, including many fashion-related brands. They then construct formal analytical models and explore the achievability of supply chain channel coordination by using the price, returns, and rebates contract when demand is price dependent and stochastic. Choi (2013) discusses the optimal product returns policy under the fashion mass customization program. Motivated by the observed mass customization industrial practices in various fashion brands such as Nike, the author builds a simple analytical model to explore the optimal consumer return service charging policy for fashion mass customization products. An extensive analytical sensitivity analysis is conducted to generate many important managerial insights. The author further extends the model

Table 2.2 The steps adopted by the related studies in economic analytical modeling research

Steps	Related studies									
	Iyer and Bergen (1997)	Eppen and Iyer (1997)	Donohue (2000)	Jain and Paul (2001)	Raman and Kim (2002)	Choi (2007)	Cachon and Swinney (2011)	Chiu et al. (2011)	Choi (2013)	Lee et al. (2015)
1	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
2	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
3	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
4	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
5	✓	✓	✓		✓	✓	✓		✓	✓
6	✓	✓			✓		✓		✓	

to the case when the fashion company possesses a risk-averse objective function. Finally, some real-world industrial practices are employed to verify the research findings derived from the analytical model. Most recently, Lee et al. (2015) study a supply chain with strategic and loss-averse consumers. The authors propose fast fashion inspired industrial measures such as quick response, enhanced design, and customized design strategies to enhance the agility and overall performance of the supply chain system. Table 2.2 lists the above reviewed studies in the scope of economic analytical modeling research related to fashion business operations management and shows the respective steps adopted in the analysis. As we can observe from Table 2.2, not all steps of our proposed framework are adopted in every cited reference. In particular, Step 6 seems to be overlooked by many studies.

2.3 Engineering Models

In Sect. 2.2, we have examined the economic analytical modeling approach for research in fashion business operations management studies. Even though real-world practices are considered in the economic modeling analysis, we usually do not expect to implement the model directly into any real-world application (e.g., a decision support system) because the objective is to identify the valuable managerial insights. However, if one aims to look at an operations management problem and identify an implementable solution scheme for real-world deployment (e.g., developing a software tool), then the engineering analytical modeling approach should be adopted.

Under the engineering analytical modeling approach for fashion business operations management, the focal point is on solving a realistic problem by incorporating as many real-world-related features and constraints into the model as possible. In other words, we plan to develop very realistic and "rich" optimization models which naturally would be highly complex. As a result, we do not intend to derive closed-form analytically tractable solutions; instead, we aim to identify the "best possible" solution for the realistic problem. Many methods such as the

multi-criteria decision-making methods, the evolutionary algorithms, and the efficient heuristics would be applied to solve the related optimization problem.

Similar to the economic analytical modeling approach, we propose a six-step framework for the engineering analytical modeling approach as follows. Notice that the following framework follows the classic frameworks proposed by Ackoff (1956) and Hillier and Lieberman (1990).

Step 1: *Formulating the problem*: The goal is to identify the real problem from the respective fashion company and define it clearly. Thus, it is critically important to consider the related organizational behaviors in the fashion company, which can be learned by conducting extensive surveys and interviews with the people in the company. As a formal research study, it is also important to check the literature and identify related models and applications. Last but not least, data collection and management is very critical. In fact, for engineering analytical modeling research, data are the lifeblood as it directly drives the model development, the analysis, the testing, and also the implementation of the optimization tool. Poor data management will ruin everything. In the fashion industry, since not many companies are familiar with scientific operations management tools (see Raman 1999), we cannot take for granted that high-quality data are available. It is thus essentially important to collect the needed data and make sure the collected datasets are properly managed for model construction and further analytical studies.

Step 2: *Constructing the mathematical model*: This step is similar to Step 2 in the economic analytical modeling research we proposed above. However, the focal point here is to construct the mathematical model which is as realistic as possible. Having a complex optimization model is hence expected here. For many modelers, they would start establishing the model by considering a specific numerical instance of the observed operations problem. This would help them better understand the assumptions, constraints, and objectives and also let them have a taste of the problem complexity. As a remark, the completed analytical model in Step 2 should preferably be related to practices, supported by the literature, transparent (intuitive and understandable), robust, and scalable (can be extended and elaborated in the future when needs arise). Furthermore, it is important to seek advice from the practitioners in fashion for their comments on the model. This helps to enrich the model, facilitate its future implementation, and enhance the chance of success as well.

Step 3: *Deriving the solution*: Since the optimization model developed in Step 2 can be very complex, the solution may only be found numerically. In some cases, finding the globally optimal solution is computationally too expensive (e.g., for the NP hard problems) and hence one may be satisfied by finding the near-optimal or "satisfying solution." Heuristics and evolutionary algorithms are some widely applied approaches for solving realistic yet complex optimization problems. Notice that it is critically

pertinent to verify whether the solution makes sense and is consistent with the fashion industrial practices (as many fashion companies are not using systematic measures in their operations practices).

Step 4: *Testing the model and solution*: Although we emphasize on the fact that the model we constructed in Step 2 is as realistic as possible, we have to understand that the model is "never more than a partial representation of reality" (Ackoff 1956). Thus, before deployment, we have to see how well the model and its solution perform. To do so, one can conduct a retrospective analysis (i.e., "creating the past"—using historical data to test the model and the solution) via, e.g., simulation studies. To be scientific, computational results from the simulation-based retrospective analysis should be verified by standard statistical tests (e.g., t test for comparing means). In Step 4, an essential task is to verify and validate the solution. Verification here refers to checking whether the solution scheme (e.g., the computerized algorithm) runs smoothly as planned. Validation means that whether the model and the derived solution are consistent with the reality. Observe that for the testing in Step 4, we should employ the real data collected from the fashion companies. The testing results, if positive, can hence provide convincing support to the model and the solution under tests.

Step 5: *Establishing controls:* In the optimization model for a real-world-related fashion business operations management problem, there are various model parameters. We have to be cautious on the fact that the solution of the optimization model is valid only when the model parameters are fixed like what we assume. However, in reality, the parameters may not be fixed or their values may deviate from our estimations. Thus, in Step 5, we have to establish control by taking some measures. For example, following the proposal by Ackoff (1956), we can do the following: For each parameter, we define the range of significant change. Then, we set up a sense-and-respond procedure to detect the occurrence of the significant change and provide reactive proposals on how the optimal solution should be revised if there is a significant change of a parameter. The sensitivity analysis will be helpful to identify the "significant change" in the optimization model. Note that similar to Step 4, the analysis conducted in Step 5 should be based on real data from fashion companies. In addition, as a lot of fashion companies have not established systematic data management and data quality auditing schemes, when we try to establish controls, we have to pay special attention to the issues associated with "data."

Step 6: *Implementing the solution*: After completing Steps 1–5, we proceed to explore the implementation and deployment of the solution. Special attention should be paid to the fact that the users of the solution are usually managers and business executives in the fashion company. They may not be analytically strong. Thus, it is important to make the tool easy to use and the solution easy to understand. Providing full documentation on the whole model, the implementation process and the related analyses

can help, too. As a remark, some performance projections (e.g., on profit or cost) and performance metrics (for future checking) on adopting the proposed solution should also be provided.

Table 2.3 summarizes the steps of the engineering analytical modeling research framework for exploring fashion business operations problems and some related useful remarks. As we can see from the proposed steps, real-world practices, realistic models, and solution implementations are all focal points in the engineering analytical modeling research framework.

In the literature, there are many studies employing the engineering analytical modeling research framework. For instance, Fisher et al. (2001) explore the optimal inventory replenishment policy for fashion retailing. The authors formulate the

Table 2.3 The steps included in the economic analytical modeling research framework

Steps	Key activities	Fashion business specific remarks
1. Formulating the problem	Focus on the real company problem and scenario	Data collection and data quality control are most critical because they directly affect the model construction. In addition, expectedly, the final solution will be implemented to enhance practice, which also requires the support by using data
2. Constructing the analytical model	Consider the most realistic optimization model. Model verification and validation are essentially important	Get comments from fashion practitioners if possible. This helps to enrich the model and enhance the feasibility of having an applicable tool and solution
3. Deriving the solution	Find the efficient way of identifying the best possible solution	Verifying whether the solution is consistent to the fashion industrial practices and fashion practitioners is critically important
4. Testing the model and solution	Conduct the retrospective test	The tests should be based on real data and the results should be understandable by fashion practitioners
5. Establishing controls	Identify and define the significant change and impose procedure to detect and respond to it	This requires the real industrial data from fashion business operations. Since many fashion companies may not have very systematic data management and quality control, special attention should be paid to the "data"
6. Implementing the solution	Pay special attention to users	It is important to well document the whole model, the implementation process, and the related analyses and details so that fashion practitioners can trace back and check whether problems arise

problem as a two-stage stochastic dynamic programming optimization model and develop an important heuristic to solve it. They derive the conditions under which the proposed heuristic can efficiently determine the optimal solution. They apply the heuristic in a catalog retailer case and find that their proposed procedure significantly outperforms the existing practice. They further comment that their proposed method can be used to identify the optimal reordering time and select the optimal replenishment contract. Motivated by the observed challenges in the knitted fabric production process, Laoboonlur et al. (2006) study the respective production scheduling problem. They focus on a specific kind of knitted fabric dyeing and finishing process. By building the formal optimization model, they solve the problem and discuss the respective applications. Caro and Gallien (2010) study the inventory management challenges of the fast fashion retailer "Zara." The whole study is based on Zara's industrial practices and operations challenges. Realistic models are constructed. The authors report the real-world implementation of their proposed inventory management model and the respective inventory allocation process. Their experiments reveal that the new inventory allocation process can yield a good improvement of sales, increase the proportion of time of product display, and reduce transshipment in Zara. Yeung et al. (2010) investigate the optimal scheduling problem in a single-upstream-supplier and single-downstream-manufacturer supply chain system. Their model and optimization problem are inspired by various observed industrial practices in apparel production in China. After constructing the optimization model and uncovering the structural properties, an efficient algorithm is developed to help identify the optimal production schedule. Real datasets from an apparel manufacturer are also employed to further verify the performance of the proposed algorithm. Other recent studies employing the engineering analytical modeling research approach include the following: the study on clearance pricing in the fast fashion company Zara (Caro and Gallien 2012), the facility location planning problem for carpet recycling operations (Bucci et al. 2014), the fast fashion sales forecasting decision supporting systems (Choi et al. 2014), and the panel data-based fashion sales forecasting models (Ren et al. 2015). Table 2.4 lists the above reviewed papers and indicates the corresponding adopted steps (with respect to our proposed engineering analytical modeling research

Table 2.4 The steps adopted by the related studies in economic analytical modeling research

Steps	Related studies							
	Fisher et al. (2001)	Laoboonlur et al. (2006)	Caro and Gallien (2010)	Yeung et al. (2010)	Caro and Gallien (2012)	Bucci et al. (2014)	Choi et al. (2014)	Ren et al. (2015)
1	✓	✓	✓	✓	✓	✓	✓	✓
2	✓	✓	✓	✓	✓	✓	✓	✓
3	✓	✓	✓	✓	✓	✓	✓	✓
4	✓	✓	✓	✓	✓	✓	✓	✓
5	✓	✓	✓	✓	✓	✓	✓	✓
6	✓	✓	✓		✓	✓		

framework). Similar to the case in the economic analytical modeling research, Table 2.4 shows that not all proposed steps are adopted in each cited study. In particular, as many of these studies are academic in nature, Step 6 on real-world implementation is not completed in many of them.

2.4 Concluding Remarks

We have explored in this paper the research methodology for conducting analytical modeling research in fashion business operations management. We have reviewed the extant literature on analytical modeling research in operations management. We have proposed the research frameworks for two categories of analytical modeling research, namely the economic analytical modeling research and the engineering analytical modeling research. Each proposed research framework includes six steps which provide guidance to researchers and practitioners on the proper way of conducting operations management research in fashion. For each step of the research framework, some relevant remarks specific to fashion business operations are discussed. As a concluding remark, we further present in Table 2.5 the comparisons between the economic analytical modeling research and the engineering analytical modeling research frameworks.

From Table 2.5, we can see that both frameworks are systematic (with six steps) and have a focal point on being scientifically sound. However, they differ in terms of the research goal, model simplicity, solution features, and the popular tools employed for the analysis. Before closing, it is important to understand that the division of fashion business operations management analytical modeling research into "economic models" and "engineering models" is just a way to systematically classify the related works and present the respective research frameworks. However, many related studies may fall in the middle between these two categories

Table 2.5 Comparisons between the economic analytical modeling research and the engineering analytical modeling research frameworks

	Economic analytical modeling research	Engineering analytical modeling research
Goal	Generate valuable managerial insights	Develop applicable models and solutions
Model simplicity	Simple models	Realistic models which are usually complex
Solution features	The globally optimal closed-form solution	The best possible solution
Process	Systematic, with 6 steps	Systematic, with 6 Steps
Scientifically sound?	Yes	Yes
Popular tools	Game theoretic analysis, global optimization	Simulations, evolutionary algorithms, heuristics

of models. Thus, this classification does not imply that the world of fashion business operations management analytical modeling research must be purely "black-and-white," and we have to understand that "gray" does exist.

For future research, it is meaningful to compare the steps of the two proposed analytical modeling research methodologies and generate deeper insights. One may also explore whether the two proposed analytical modeling research methodologies are comprehensive enough. Very likely, some further enhancement is possible. For example, for fashion business operations management studies which incorporate human behaviors into the analysis (Croson et al. 2013), the respective analytical modeling research methodology will probably be different from the ones discussed in this paper. In addition, under the trendy proposal of conducting multi-methodological research in operations management (Choi et al. 2016), it is also interesting to examine and establish the corresponding frameworks for fashion business operations management.

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