

RESEARCH WITHIN REACH

Cracking the code – the maths behind consumer choice

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All businesses face the same challenge – choosing the right product to sell, to the right customer, at the right time, for the best price. New research by Melbourne Business School academic sheds light on how managers can choose the right combination to maximise revenue for their business.

Revenue management is a set of practices to decide what products to offer and at what price by considering consumer choice behaviour. From supermarkets to insurance providers, the product range, price and timing of the offers are crucial to success. Choose the wrong product mix and not only is capital spent on unproductive inventory but the business loses customers to competitors that are seen to be more aligned to customer needs.

Over the past five decades, the field of revenue management has evolved to a finely tuned discipline, using data and analytics, which aids managers to predict consumer behaviour and demand.

“The concept of revenue management actually started in the airline industry,” explains Associate Professor Gerardo Berbeglia who specialises in Operations Management at Melbourne Business School.

“Following the Airline Deregulation Act of 1978, airlines had much more flexibility on setting prices. They began to understand how to anticipate consumer demand and predict what customers were willing to pay for the same product.

“It allowed them to segment the market and to introduce flexible pricing models, which was particularly important as the product (in this case the seats) had to be sold before a certain point in time (before the flights departed).”

Over time, businesses saw that it was applicable to most industries. Over the past two decades, with the availability of large amounts of consumer data, applied with mathematical models developed in other areas, researchers have shown that it is possible to make quite accurate predictions of consumer preferences.

“But what the research hasn’t done so far is to compare the various choice-based mathematical models to see which is the most accurate in different situations. For example, in settings where consumer preferences are very similar versus settings in which they are quite different; and where the firm has access to large transaction datasets versus small ones. This is what we set out to do with this research paper,” says Associate Professor Berbeglia.

“With this information, data analysts will be better equipped to choose the right mathematical model to better predict consumer choice.”

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Discrete choice models in retail operations

Mathematics can be used to predict outcomes. The circumstances are far and wide, ranging from traffic management to demand for university courses.

“Given that mathematical models underpin almost every aspect of our lives, it’s not hard to see how this would have made its way into the field of business,” says Associate Professor Berbeglia.

Choice-based demand estimation is a fundamental task in retail operations and revenue management. What products consumers choose and how their choice is impacted by the product range being offered has consequences for inventory control and pricing optimisation.

With co-researchers Agustín Garassino from the University of Buenos Aires and Professor Gustavo Vulcano from the School of Business, Universidad Torcuato di Tella in Buenos Aires, Associate Professor Berbeglia conducted a study of nine different choice-based demand models (also known as discrete choice models) and their respective estimation algorithms. Their paper, A Comparative Empirical Study of Discrete Choice Models in Retail Operations, was recently accepted for publication at Management Science – one of the leading journals in the field.

“We had two real datasets – 17,000 bookings from five hotels in the US, and preferences from 5,000 individuals

It is possible to make quite accurate predictions of consumer preferences.

“This task is particularly difficult where product availability varies over time and customers may substitute buying other products,” says Associate Professor Berbeglia. “What I mean by that is what happens if the buyer’s first choice is not available and they go with their second preferred option. The more options there are, the more variables there are.”

of different sushi types,” explains Associate Professor Berbeglia.

“Against these two datasets, we tested nine discrete choice models for both demand and revenue predictions. The results obtained were also validated using two synthetic datasets.”

What the researchers found has the potential to simplify the task of revenue management going forward.

Research by



Gerardo Berbeglia

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After completing his PhD at the Université de Montréal, Gerardo was a Senior Scientist at ExPretio Technologies Inc and, later, a Postdoctoral Fellow at McGill University.

Gerardo’s research has been published in leading journals and conference proceedings, including Management Science, the European Journal of Operational Research, Transportation Science, Algorithmica and the ACM conference on Economics and Computation among others. His recent research focuses on revenue management and quantitative models that account for social influence in online markets (such as iTunes or Google Play).

Gerardo teaches Operations, Optimisation and Decision Making, and Supply Chain Analytics on the MBA and Master of Business Analytics programs. Gerardo is a member of the Centre for Business Analytics. He is one of the recipients of the 2020 MBS Teaching Excellence Award.

Superior models

In a nutshell, two models stood out in terms of prediction accuracy and revenue performance – the Markov chain model and the Exponential choice model.

For both small and large data environments where there is high consistency in terms of customer preferences, the Markov chain model was one of the stand-out performers.

Examples of small data environments would be a start-up, or a company who has just launched a new product range, whereas large datasets are frequent in more established businesses.

Understanding choice through the lens of non-deterministic choice models can enable retailers to estimate the potential demand more accurately and make better decisions in terms of product selection, their placements in store, and their price.

The strong performance of the Markov chain model was confirmed using a different dataset.

“We also had a sushi dataset provided by researcher who asked 5,000 participants to rank 10 different sushi from most favoured to least. When we tested all nine models against

of the population. Along with the Markov chain model, the Exponential model performed very well here.”

The Exponential model posits that where consumers are well informed about products and their value, they are more willing to substitute for another product where they perceive it provides better value or has characteristics that make them attractive. The opposite of this is where a product has a unique value that can't be easily substituted, for example artwork.

“In our hotel dataset for example, we had customers who needed a room. The purchasing decisions revolved around a combination of attributes such as location, inclusion of breakfast, price, what competitors were offering, each of which could be traded off against the other.

“What is remarkable is that the Exponential model is not really complicated and yet it produced wonderful results. This choice model is also easily adaptable. For example, one can easily incorporate product attributes (known as co-variables) such as price, room size, location and so on.

“This allows product manufacturers and retailers to tweak existing products by modifying product attributes or experimenting with different combinations of attributes to come up with a product range that is appealing to consumers.

“In other words, the costly process of new product development is not always necessary. We have seen this many times, for example in models of cars that do not provide any innovation but are repackaging what is already available.”

“This seems to be counter-intuitive. As humans, we think that our choices are deterministic rather than random.”

“The Markov chain model imagines the process of choosing a product as a random walk,” explains Associate Professor Berbeglia.

“At first, the person walks to their most preferred product (product A). If product A is available, they choose it and that's it. But if it is not available, there is some probability that the person will walk to product B, another probability to product C and so on. If this second product is available, it will be chosen, otherwise the process continues until the person walks to a product that is available.

“This seems to be counter-intuitive. As humans, we think that our choices are deterministic rather than random. But the Markov chain model has a strong random component. The fact that the Markov chain model performed well tells us that at least on the aggregate, consumers' choices can be explained using a simple randomized process.”

this dataset, the Markov chain model performed the best. It was the model that could more accurately predict the fraction of participants that would choose any particular sushi when they were offered a subset of the 10 sushi to choose from.”

The more difficult scenario is what would happen where you had a low degree of consistency in terms of consumer preference.

“In other words, this is where you have more diverse consumers and their preferences are very different – a product that is highly appreciated for some segment might be not appreciated at all by other segments

“The costly process of new product development is not always necessary.”

The impact of this research

“This research is really about choice,” says Associate Professor Berbeglia.

“If you don’t have a model that can predict the choices that humans make, then you won’t be able to properly make important business decisions such as finding the right product mix and the optimal pricing. These impact on your ability to maximise your sales.”

for a company in Montreal looking at implementing a revenue management system to optimize prices for airlines and for high speed trains in Europe.

“Similar to airlines that operate multiple routes and tiered ticketing, you can imagine in a retail environment, with hundreds of categories and multiple choices within each category, the decision-making process around

“If you can predict what your customer wants and the price which they are willing to pay, you will gain an incredible advantage over your competitors.”

Choosing the correct model to estimate demand which then impacts inventory control can have substantial benefits. A study at heavy vehicle manufacturer John Deere & Co found that by reducing the number of configurations by 20-50% while maintaining high levels of customer service would boost profit by up to 18%.

“These issues are relevant not just in Australia but also globally. My corporate background was working

which products to stock can be incredibly complex. Our research has the potential to help firms build better revenue management software, using the most appropriate mathematical model in combination with customer purchasing data, that can help with predicting future demand.

“I’ve observed that this is a field which a lot of people have yet to fully understand. There is so much more that we can do with the tools currently

More information

Research Within Reach is a regular publication from Melbourne Business School designed to explain the latest research by our academic faculty in easy-to-understand language. For more information, please contact:

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at our fingertips. At some point, we want to explore the mathematical models that have been developed in the area of machine learning and compare those complex models with the ones that we have found so far.

“At the end of the day, if you can predict what your customer wants and the price which they are willing to pay, you will gain an incredible advantage over your competitors.”



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