Institution: University of Manchester

Unit of Assessment: UoA 11: Computer Science and Informatics

Title of case study: Intelligent Pricing Decision Support Systems

1. Summary of the impact

Pricing optimisation and revenue management systems represent fundamental progress from the art of pricing to the science of pricing. Our research led the scientific approach in demand modelling and pricing optimization, and produced the first computerised Intelligent Pricing Decision Support Systems (IPDSS) for retail and petroleum, which have led to economic impact and changes in pricing practice. Our research led to spin-off companies that employ over 150 people, with a turnover of £19.2m in 2012, which are the leading providers of IPDSS, used by more than 400 retailers across 80 countries to improve their performance in competitive markets.

2. Underpinning research

The impact is based on research that took place in Manchester from 1993 to date. The key researchers behind these achievements were:

- Professor Madan Singh (1993-2002)
- Dr Jean-Christophe Bennavail (1993-2000: Lecturer)
- Dr Xiao-Jun Zeng (1993-date: PhD student 1993, Developer 1996, Lecturer 2000, Senior Lecturer 2006)
- Ms Nathalie Cassaigne (1996-2005: RA 1996, Lecturer 1997)

Despite substantial and widespread research in pricing, it was regarded as an art, and in practice was dealt with in an *ad hoc* way until the 1980s. As such, a major objective of the team was to develop the underpinning techniques that would place the development of IPDSS on a firmer footing, so that they could utilise all the available data and domain knowledge to make optimal pricing decisions possible and efficient. This required research to establish the necessary framework, algorithms and tools, with the following results:

1. The development of generic pricing decision support systems (as summarised in [1]), which include the following key elements: (i) use of nonlinear adaptive prediction models and learning algorithms for demand modelling (i.e., identifying price-sale relationships from data and domain knowledge); (ii) embedding of market competition and long term strategic goals into short term tactical targets; (iii) application of nonlinear pricing optimization for finding the prices to best achieve the multiple pricing targets; and (iv) provision of systematic decision support capabilities for generic price-setting problems in competitive markets. With such a generic methodology, an IPDSS for a particular industry can be realised by specifying the corresponding variant of the generic pricing technology adapted to that particular industry.
2. The instantiation of the generic framework to provide IPDSS capabilities, software prototypes, feasibility studies, experiments, and pilot verifications with commercial organisations in retail [1, 5], petroleum [1,6], banking [4], and telecommunication [1] industries.
3. The invention and development of knowledge bounded demand modelling methods and learning algorithms [2, 3], which combine domain knowledge and historical data to identify accurate demand models. This overcame the bottleneck problem in applications where there is limited price-sale historical data available for demand modelling and forecasting.

3. References to the research

Key Publications:

1. N. Cassaigne, M. G. Singh, Intelligent decision support for the pricing of products and services in competitive consumer markets, *IEEE Trans. Syst., Man, Cybern. Part-C*, vol. 31, pp. 96–106, 2001 (DOI: 10.1109/5326.923272), Citations: Google Scholar 17.
2. X. J. Zeng, M. G. Singh, Fuzzy bounded least-squares method for the identification of linear systems, *IEEE Trans. Syst., Man, Cybern. Part-A,* vol. 27, no. 5, pp. 824–835, Sep. 1997 (DOI: 10.1109/3468.618261), Citations: Google Scholar 12.
3. X. J. Zeng, M. G. Singh, Knowledge bounded least squares method for the identification of fuzzy systems, *IEEE Trans. Syst., Man, Cybern. Part-C*, vol. 33, no. 1, pp. 24–32, 2003 (DOI: 10.1109/TSMCC.2003.809347), Citations: Google Scholar 13.

Other Publications:

4. M.G. Singh, Decision Technologies for Supporting the Interplay between Qualitative and quantitative aspects of Managerial Decision Making, *Mathematics, Computers and Simulation Journal*, vol. 36, no. 2, pp. 103-114, 1994 (DOI: 10.1016/0378-4754(94)90025-6).
5. M. G. Singh, J.-C. Bennavail,, Price-Strat: A knowledge support system for profitable decision making during price wars, *Inf. Decision Technol*., vol. 19, no. 4, pp. 277-296, 1994.
6. M. G. Singh, Knowledge support for profitable pricing in a competitive environment, in Plenary Paper, *4th Int. Conf. Cognitive Foundations of Econ. Manage*., Paris, France, 1995.

4. Details of the impact

Context

A systematic approach to computerised systems for pricing started in the mid-80s, when yield management systems were developed to support the pricing of perishable resources (such as airline seats or hotel room reservations) to optimise profits. In other sectors, such as retail and petroleum, however, due to their completely different features, there was little success and there were few systems for optimising pricing decision support before our research. Our major research progress was achieved between1993 and 2002, leading to the first systematic approach based on demand modelling and pricing optimisation, and the earliest IPDSS for retail and petroleum.

Pathways to Impact

Integrating Academic Research and Pricing Practice with Computerised IPDSS.

For scientific pricing, the conventional approach from research to applications was not successful, as academic research could not reach and test practically the complexity and dynamics of real pricing environments for the grocery and petrol retail sectors, where there may be tens of thousands of prices for a grocery retailer and different prices across a few hundred petrol stations for a petrol retailer. As a result, a different approach, which integrated academic research and pricing practice, was adopted in 1993 with the launch of KSS Ltd as the commercial arm of the university research group. This new approach took pricing problems from real commercial organisations and went though an iterative research path: research – software prototype – application – feedback – research and finally transfer to IPDSS software products.

Transfers of Research to Product.

There were two principal research results incorporated into products:

- *Systematic decision support*. Research into generic frameworks for IPDSS [1, 4, 5, 6], with pilot studies in petroleum and retail, provided the foundation for the IPDSS PriceNet for petroleum and PriceStrat for retail. These have evolved into the current products of KSS Fuels and KSS Retail, respectively.

- *Learning demand models*. A remaining bottleneck in the application of IPDSS was learning the demand models with limited historical price-sale data in a dynamic environment. The solution to this bottleneck is the use of knowledge bounded recursive least square learning methods based on the underpinning research reported in [2, 3], which is the principal method behind all IPDSS software systems produced by KSS Fuels and KSS Retail.

Reach and Significance of the Impact

Economic impact

- *Profitable spin-off companies and job creation*: The research was brought to market by the spin-off company KSS. KSS was demerged into KSS Fuels and KSS Retail in 2007. Since 2008, KSS Fuels has been a profitable software company with 2012 revenue of £13.2m [A] and expected revenue for 2013 over £15m [B]. It is the leading global provider of pricing software to fuel retailers (400 clients across 80 countries in 2012 [F]) with more than 100 staff, 40 in the UK and 60 in the USA. In August 2012, a 40% stake in KSS Fuels was sold for £7.2m [D], valuing KSS Fuels at £18m. KSS Retail is also a profitable software company, with 2012 revenue and profit being £6m and £3m respectively [A]. It is a premier global provider in price intelligence and optimization software solutions for general retailers (grocery, convenience, chain drug, etc) with about 60 staff, half in the UK and half in the USA. KSS Retail was sold to Dunnhumby Limited for £12.9m in Dec 2009 [C].
- *Financial impact of KSS Fuels and KSS Retail on clients*: Controlled experiments with a number of oil companies demonstrated average profit improvements of £4k – £10k per fuel retail site per annum [E], without loss of volume, when using PriceNet. With 400 clients estimated to have more than 10,000 petrol stations [H] using PriceNet worldwide, this leads to £40m – £100m improvement in annual profits. Experiments using PriceStrat for setting prices of all goods in convenience stores led to profit improvements of about $75k per store per annum [E]. With an estimated 1000 – 2000 convenience or grocery stores [G] using PriceStrat worldwide, this leads to $70m – $150m profit improvement in annual profits.

Impact on Practitioners

The PriceNet and PriceStrat IPDSS have fundamentally changed pricing process/practice.

- In fuel pricing, IPDSS has helped more than 400 companies [H] to address key aspects of optimal pricing: (i) combining customer knowledge with analytics to better understand customers and competition; (ii) addressing efficient process execution to reduce response times; (iii) and implementing regulatory requirements with guaranteed compliance. A number of testimonials can be found in [F], e.g.: “KSS Fuels and PriceNet helped us revise our pricing process to be more accurate and timely in response to competition. PriceNet alerts us to stores needing attention so the pricing team can spend time where they add most value to the business, making price decisions,” President of Miller Oil, USA.
- In retail pricing, IPDSS has helped more than 30 companies [G] to adopt science-based pricing intelligence, shopper insights, optimization, and modelling solutions for the grocery, convenience store, drug chain and general retail industries. Customers include Kroger (the largest grocery store chain in the USA), Tesco (the largest grocery store chain in the UK), 7-Eleven (the world’s largest convenience store operator), O’Reilly (the third largest auto parts chain in the USA) and Rite Aid (third largest drugstore chain in the USA) [I]. Testimonials can be found in [G], for example: “We strive to deliver the best value for our customers and after an extensive evaluation of customer-demand pricing tools to support this fundamental strategy, selected KSS. By using KSS PriceStrat, we will have advanced insight into our pricing and

promotional decisions and will be able to ensure that we are priced right, on the right items, for our customers. It is important for us … to model, forecast and optimize our regular and weekly promotional pricing." (Joe Hanson, Vice President of Operations at Yoke's Fresh Food Stores, USA).

4. Sources to corroborate the impact

Supporting material is available from the university for the corroborating sources below.

A. FAME - Detailed information on UK and Irish companies, https://fame.bvdinfo.com/version-201367/Home.serv?product=fameneo. Confirms the revenue and profits at KSS Fuels and KSS Retail; supporting material provides the specific entries.

B. Eurovestech plc - Interim report for the six months ended 31 December 2012 on 03/04/13, http://www.eurovestech.co.uk/_downloads/_financial/EurovestechplcInterims31Dec2012.pdf

C. Stockmarket Wire News: http://www.stockmarketwire.com/article/3753849/Eurovestech-sells-KSS-Retail-to-dunnhumby-Ltd.html.

D. Stockmarket Wire News: http://www.stockmarketwire.com/article/4428839/Eurovestech-sells-40pct-stake-in-KSS-Fuels.html

E. THE WALL STREET TRANSCRIPT, MADAN SINGH - KNOWLEDGE SUPPORT SYSTEMS GROUP - (KSS.L), CEO Interview - published 09/25/00

F. KSS Fuels clients' testimonial: http://www.kssfuels.com/About_Us/Client_Testimonial.html

G. KSS Retail client list and testimonial: http://www.kssretail.com/clients/

H. Testimonial letter from KSS Fuels Ltd. Confirms origin of the company as university spin-out. Provides information on the scale of the business and customer base.

I. Testimonial letter from KSS Retail Ltd. Confirms origin of the company as university spin-out. Provides information on the scale of the business and customer base.