

USING SYSTEM DYNAMIC APPROACH TO FORECAST SALES OF INNOVATIVE PRODUCTS

陳國輔、陳偉星

E-mail: 9126816@mail.dyu.edu.tw

ABSTRACT

Demand forecasting is an important work in demand management, and diffusion model had been used to forecast the demand of innovation products for several years. Bass diffusion model describes the empirical adoption curve by using two important factors, namely, the coefficients of innovation and imitation. In 1975, R-L model incorporated the decision variable price into diffusion model. A generalized Bass model incorporated price and advertising policies into the original Bass model to analyze empirical new product diffusion process. A system dynamics diffusion model was constructed to model the dynamical diffusion process of a new product in this research. In addition to the four factors, the effect of product brand was added into the system dynamic model, and use fuzzy theory to fuzzify some subjective parameters. In this thesis, a graphic user interface and a dynamic link file that include fuzzy control mechanism are programmed with Microsoft Visual C++. The model was tested and results revealed that the prediction capability of the proposed system dynamics model is better than those of Bass diffusion model, R-L model and generalized Bass model.

Keywords : demand management ; diffusion model ; system dynamics ; fuzzy theory

Table of Contents

CHAPTER 1 INTRODUCTION--P1	1.1 BACKGROUNDS AND MOTIVATION--P1	1.2 OVERVIEW OF DIFFUSION MODELS--P6	1.3 RESEARCH OBJECTIVES--P7	1.4 CONSTRAINTS OF RESEARCH--P8
CHAPTER 2 LITERATURE REVIEW--P9	2.1 DIFFUSION MODEL--P9	2.2 SYSTEM DYNAMICS--P25	2.3 PARAMETER ESTIMATION--P29	2.3.1 PRIOR DATA UNAVAILABLE--P30
	2.3.2 PRIOR DATA AVAILABLE--P31	CHAPTER 3 SYSTEM DYNAMICS DIFFUSION MODEL--P34	3.1 MODEL DESCRIPTION--P34	3.2 TIME HORIZON--P36
	3.3 BASIC DIFFUSION VIEW--P37	3.3.1 MARKETING EFFECTS SECTOR--P40	3.3.2 INNOVATIVE ADOPTERS SECTOR--P41	3.3.3 IMITATIVE ADOPTERS SECTOR--P42
	3.3.4 ADOPTION SECTOR--P44	3.4 PRICE AND COMPETITION BALANCE VIEW--P46	3.4.1 PRICE EFFECT SECTOR--P48	3.4.2 COMPETITION EFFECT SECTOR--P49
	3.5 ADVERTISING EXPENDITURES AND REPLACEMENT VIEW--P50	3.5.1 ADVERTISING EXPENDITURES SECTOR--P52	3.5.1.1 NORMALIZED ADVERTISING EXPENDITURES SECTOR--P54	3.5.1.2 ADVERTISING EFFECT SECTOR--P56
	3.5.2 REPLACEMENT SECTOR--P57	3.5.2.1 VIEW OF "POSSIBILITY"--P58	3.5.2.2 VIEW OF "PROBABILITY"--P59	3.6 ACTUAL DATA VIEW--P60
	3.6.1 RELATIVE ACTUAL DATA SECTOR--P62	3.6.2 STATISTIC ERRORS SECTOR--P63	3.7 PARAMETER ESTIMATION--P65	3.7.1 PRIOR DATA AVAILABLE--P65
	3.7.1.1 MODEL FITNESS--P66	3.7.1.2 MODEL FORECASTS--P76	3.7.2 NO PRIOR DATA AVAILABLE--P81	CHAPTER 4 POLICY ANALYSIS--P83
	4.1 PRICE FLUCTUATION--P85	4.1.1 POLICIES FOR PRICE CHANGES--P86	4.1.2 CHARACTERISTICS OF THE EFFECTIVENESS OF PRICE IN DIFFUSION MODELS--P91	4.1.3 METRICS FOR EVALUATING THE PRICE FLUCTUATION UPON DIFFERENT MODELS--P93
	4.1.4 ROOM AIR CONDITIONERS (PRICE FLUCTUATION)--P93	4.1.5 COLOR TV (PRICE FLUCTUATION)--P94	4.1.6 CLOTHES DRYERS (PRICE FLUCTUATION)--P96	4.1.7 CONCLUSIONS FOR PRICE FLUCTUATION --P97
	4.2 ADVERTISING EXPENDITURES FLUCTUATION--P99	4.2.1 POLICIES FOR ADVERTISING EXPENDITURES--P100	4.2.2 CHARACTERISTICS OF THE EFFECTIVENESS OF ADVERTISING EXPENDITURES OF DIFFERENT DIFFUSION MODELS--P106	4.2.3 METRICS FOR EVALUATING THE ADVERTISING EXPENDITURES FLUCTUATION UPON DIFFERENT MODELS--P108
	4.2.4 ROOM AIR CONDITIONERS (ADVERTISING EXPENDITURES FLUCTUATION)--P108	4.2.5 COLOR TV (ADVERTISING EXPENDITURES FLUCTUATION)--P110	4.2.6 CLOTHES DRYERS (ADVERTISING EXPENDITURES FLUCTUATION)--P111	4.2.7 CONCLUSIONS FOR ADVERTISING EXPENDITURES FLUCTUATION--P113
CHAPTER 5 SYSTEM DYNAMICS INTEGRATION SYSTEM--P114	5.1 STRUCTURE OF SDIS--P114	5.2 FUNCTIONS OF SDIS--P117	5.3 GENERAL FUNCTIONS--P119	5.3.1 LOAD SYSTEM DYNAMICS MODEL--P119
	5.3.2 EXIT PROGRAM--P121	5.4 SYSTEM DYNAMICS MODEL CONTROLLERS--P121	5.4.1 MODEL STRUCTURE OVERVIEW--P122	5.4.2 SIMULATE MODEL--P123
	5.4.3 ANALYZE MODEL--P126	5.4.4 SENSITIVITY ANALYSIS--P128		

5.4.5 EXTERNAL FUNCTION LIBRARY--P131 5.5 FUZZY CONTROLLERS--P132 5.5.1 SELECT FUZZY VARIABLES--P132 5.5.2 FUZZY SETS CONTROL--P135 5.5.3 FUZZY RULES--P138 5.5.4 DEFUZZIFIED OUTPUTS--P139 CHAPTER 6 CONCLUSIONS--P142 6.1 CONCLUSION--P142 6.2 RECOMMENDATIONS FOR FUTURE RESEARCH--P143 REFERENCE--P144 APPENDIX--P149

REFERENCES

1. BASS, F. M. (1969), "A NEW PRODUCT GROWTH MODEL FOR CONSUMER DURABLES," *MANAGEMENT SCIENCE*, 15, 215-227.
2. BASS F. M., KRISHNAN T.V. AND JAIN D.C. (1994), "WHY THE BASS MODEL FITS WITHOUT DECISION VARIABLES," *MARKETING SCIENCE*, 13, 3,203-223.
3. BAYUS, B.L., HONG, S., LABE, R.P. (1989), "DEVELOPING AND USING FORECASTING MODELS OF CONSUMER DURABLES: THE CASE OF COLOUR TELEVISION," *JOURNAL OF PRODUCT INNOVATION MANAGEMENT*, 6, 5-19.
4. CHRISTOPHER PALMBERG (2002), "SUCCESSFUL INNOVATION - THE DETERMINANTS OF COMMERCIALIZATION AND BREAK-EVEN DURATIONS OF INNOVATIONS," *VTT GROUP FOR TECHNOLOGY STUDIES*.
5. DOCKNER, E. AND JORGENSEN, S. (1988), "OPTIMAL PRICING STRATEGIES FOR NEW PRODUCTS IN DYNAMIC OLIGOPOLIES," *MARKETING SCIENCE*, 7 (FALL), 315-334.
6. FORT, L. A. & WOODLOCK, J. W. (1960), "EARLY PREDICTION OF MARKET SUCCESS FOR GROCERY PRODUCTS," *JOURNAL OF MARKETING*, 25, 10, 31-38.
7. FRANK H. M. (1998), "NEW PRODUCT DIFFUSION MODELS IN INNOVATION MANAGEMENT - A SYSTEM DYNAMICS PERSPECTIVE," *SYSTEM DYNAMICS REVIEW*, 14, 4, 285-308.
8. GEROSK, P.A. (2000), "MODELS OF TECHNOLOGY DIFFUSION," *RESEARCH POLICY*, 29, 603-625.
9. JAMES M. L. (2000), "SYSTEM DYNAMICS FOR MARKET FORECASTING AND STRUCTURAL ANALYSIS," *SYSTEM DYNAMICS REVIEW*, 16, 1, 3-25.
10. JINHONG XIE, X. MICHAEL SONG, MARVIN SIRBU AND QIONG WANG (1996; JULY), "KALMAN FILTER ESTIMATION OF NEW PRODUCT DIFFUSION MODELS".
11. J.S. METCALFE, MARIA D. FONSECA, R. RAMLOGAN (2000), "INNOVATION, GROWTH AND COMPETITION : EVOLVING COMPLEXITY OR COMPLEX EVOLUTION," *COMPLEXITY AND COMPLEX SYSTEMS IN INDUSTRY CONFERENCE 19 TH -20 TH SEPTEMBER*.
12. KALISH, S. (1983), "MONOPOLIST PRICING WITH DYNAMIC DEMAND AND PRODUCTION COST." *MARKETING SCIENCE*, 2, 135-159.
13. KALISH, S. (1985), "A NEW PRODUCT ADOPTION MODEL WITH PRICE, ADVERTISING, AND UNCERTAINTY," *MANAGEMENT SCIENCE*, 31, 1569-1585.
14. LAWRENCE, K. D. AND WILLIAM H. L. (1981), APPLICATION OF DIFFUSION MODELS: SOME EMPIRICAL RESULTS IN NEW PRODUCT FORECASTING, Y. WIND, VIJAY MAHAJAN, AND RICHARD C. CARD-OZO, EDS. LEXINGTON, MA: LEXINGTON BOOKS, 529-541.
15. LEKVALL, P. AND WAHLBIN C. (1973), "A STUDY OF SOME ASSUMPTIONS UNDERLYING INNOVATION DIFFUSION FUNCTIONS," *SWEDISH JOURNAL OF ECONOMICS*, 75, 362-377.
16. MAHAJAN, V., MULLER E. AND SHARMA S. (1986), "SIMPLE ALGEBRAIC ESTIMATION PROCEDURE FOR INNOVATION DIFFUSION MODELS OF NEW PRODUCT ACCEPTANCE," *TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE*, 30 (DECEMBER), 311-346.
17. MAHAJAN, V., MULLER E. AND BASS F.M. (1990), "NEW PRODUCTION DIFFUSION MODELS IN MARKETING: A REVIEW AND DIRECTIONS FOR RESEARCH," *JOURNAL OF MARKETING* 54, 1, 1-26.
18. MAIER, F. (1995), "DIE INTEGRATION WISSENS- UND MODELLBASIERTER KONZEPTE ZUR ENTSCHEIDUNGSSUNTERSTUTZUNG IM INNOVATIONSMANAGEMENT," BERLIN: DUNCKER & HUMBLOT.
19. MALCOLM WRIGHT, CLINTON UPRITCHARD AND TONY LEWIS (1997), "A VALIDATION OF THE BASS NEW PRODUCT DIFFUSION MODEL IN NEW ZEALAND," *MARKETING BULLETIN*, 8, 15-29.
20. MANSFIELD, E. (1961), "TECHNICAL CHANGE AND THE RATE OF IMITATION," *ECONOMETRICA*, 29,10, 741-766.
21. MANSFIELD, E., RAPOPORT J., SCHNEE J., WAGNER S., AND HAMBURGER M. (1981), "RESEARCH AND INNOVATION IN THE MODERN CORPORATION:CONCLUSION, IN CORPORATE STRATEGY AND PRODUCT INNOVATION," ED. R.R. ROTHBERG, NEW YORK, LONDON: THE FREE PRESS, 416-427.
22. MARKETING INTELLIGENCE SERVICE, LTD. (2002), MARKETING INTELLIGENCE SERVICE'S INNOVATION RATING.
23. MIDGLEY, D.F. (1976), "A SIMPLE MATHEMATICAL THEORY OF INNOVATIVE BEHAVIOR," *JOURNAL OF CONSUMER RESEARCH* 3 (JUNE) 31-41.
24. MILLING, P. (1986), DIFFUSIONSTHEORIE UND INNOVATIONSMANAGEMENT.,IN TECHNOLOGIE INNOVATIONSMANAGEMENT, ED. E. ZAHN. BERLIN: DUNCKER & HUMBLOT: 49-70.
25. MILLING, P. (1996), "MODELING INNOVATION PROCESSES FOR DECISION SUPPORT AND MANAGEMENT SIMULATION," *SYSTEM DYNAMICS REVIEW*,47- 12, 3, 211-234.
26. NAMWOON KIM, EILEEN BRIDGES, AND RAJENDRA K. S. (1999), "A SIMULATION MODEL FOR INNOVATIVE PRODUCT CATEGORY SALES DIFFUSION AND COMPETITIVE DYNAMICS," *INTERNATIONAL JOURNAL OF RESEARCH IN MARKETING*, 16, 95-111.
27. OLSON, J. AND CHOI, S. (1985), "A PRODUCT DIFFUSION MODEL INCORPORATING REPEAT PURCHASES," *TECHNOLOGICAL FORECASTING AND SOCIAL CHANGE* 27,385-397.
28. PARDUE J. H., THOMAS D. C. JR. AND GRAHAM W. W. (1999), "MODELING SHORT- AND LONG-TERM DYNAMICS IN THE COMMERCIALIZATION OF TECHNICAL ADVANCES IN IT PRODUCING INDUSTRIES," *SYSTEM DYNAMICS REVIEW*, 15, 1, 97-105.
29. PARKER P., GATIGNON H. (1994), "SPECIFYING COMPETITIVE EFFECTS IN DIFFUSION MODELS: AN EMPIRICAL ANALYSIS," *INTERNATIONAL JOURNAL OF RESEARCH IN MARKETING*, 11, 1, 17-39.
30. PATRICK D. FLECK

(2002), "5 INSIGHTS FOR IMPROVING PRODUCT DEVELOPMENT CYCLE SUCCESS," COOPER. 31. PETERSON, R. A. AND MAHAJAN V. (1978), MULTI-PRODUCT GROWTH MODELS, IN: J. SHETH (ED.), GREENWICH, CT: JAI PRESS, RESEARCH IN MARKETING, 1, 201-231. 32. RICHARDSON, GEORGE P. AND PUSH, ALEXANDER L. (1981),"INTRODUCTION TO SYSTEM DYNAMICS MODELING," MASSACHUSETTS INSTITUTE OF TECHNOLOGY. 33. ROBINSON B. AND LAKHANI C. (1975), "DYNAMIC PRICE MODELS FOR - NEW-PRODUCT PLANNING," MANAGEMENT SCIENCE, 21, 1113-1122. 34. SCHUMPETER, J. A. (1961), KONJUNKTURZYKLEN-EINE THEORETISCH,HISTORISCHE UND STATISTISCHE ANALYSE DES KAPITALISTISCHEN PROZESSES,ERSTER BAND. COTTINGEN: VANDENHOEK & RUPRECHT. 35. SRINIVASAN, V., MASON, H. (1986), "ANON-LINEAR LEAST-SQUARE ESTIMATION OF NEW PRODUCT DI -FFUSION MODELS," MARKETING SCIENCE, 5, 169-178. 36. SULTAN, F; FARLEY, J & LEHMANN, D (1990). A META-ANALYSIS OF APPLICATIONS OF DIFFUSION MO -DELS. JOURNAL OF MARKETING RESEARCH, 27, FEBRUARY, 70-76. 37. TANNY, S. M. AND DERZKO N. A. (1988), "INNOVATORS AND IMITATORS IN INNOVATION DIFFUSION MODELING," JOURNAL OF FORECASTING, 7, 4, 225-234. 38. THOMAS, ROBERT J. (1985), "ESTIMATING MARKET GROWTH FOR NEW PRODUCT: AN ANALOGICAL DIFF -USION MODEL APPROACH," JOURNAL OF PRODUCT INNOVATION MANAGEMENT , 2 (MARCH), 45-55. 39. TONY ARNOLD J. R., STEPHEN N. CHAPMAN (2000), INTRODUCTION TO MATERIAL MANAGEMENT, PRE -NTICE HALL. 40. TOWHIDUAL ISLAM, NIGEL MEADE (2000), "MODELLING DIFFUSION AND REPLACEMENT," EUROPEAN JO -URNAL OF OPERATIONAL RESEARCH, 125,551-570.