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The Value of Information Updating in New Product Development

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To my family

Preface

Ever since I learned to fly airplanes, I am passionate about long-distance gliding in the Alps. Every time I take off in the early morning, I never know exactly which challenges I will have to overcome during the day. Especially the weather conditions are constantly changing, making it impossible to forecast even the thermal behind the next mountain range with certainty. Despite this lack of information, I have to decide whether it is worthwhile to "jump" over the ridge into the next valley towards my target. To obtain the experience how to instantly study the new conditions, reassess the previous plan, and adjust the route accordingly was a tough process, ending several times in an acre instead of my home airport. But most other times, when it worked out, I was rewarded with great moments and majestic impressions.

New product development projects resemble long-distance flights in many aspects. They are also exposed to numerous uncertainties and require continuous adjustments of the development efforts in order to successfully launch the product. While decision making during a flight is relatively straightforward and can be based on experience, it is far more complex for development projects. The basic principle, however, remains the same. Additional information obtained during the process has to be considered in the decisions for the remaining periods. Although this process is intuitive and follows the natural way of making decisions, it has hardly been formalized for development projects so far. It became the goal of this work to develop a decision model that explicitly takes information updates into account in order to better manage uncertainty. I hope it will be instrumental to managers and academics alike when facing difficult decisions in complex new product development projects. This work was submitted in fulfillment of the requirements for the doctoral degree at WHU, Otto-Beisheim School of Management, in the department of Production Management, chaired by Professor Dr. Arnd Huchzermeier.

I would like to thank Arnd Huchzermeier for his guidance and the inspiring environment he creates at his department, including the opportunity for me to study and research at Stanford University. I am deeply indebted to Rainer Brosch for the great intellectual and personal support during all these years, and for the many unforgettable moments. Furthermore, my thank goes to Daniela Schmitz-Wiehenbrauk and Christoph van Wickeren, who have been great colleagues and friends, making my time enjoyable not only at WHU. I also thank Stefan Spinler who was ready to help whenever necessary. I owe special gratitude to Georg Strasser who has been a dear friend since studying together in Karlsruhe. Driven by his expertise and enthusiasm, he added different perspectives and ideas in the many enriching discussions I had with him. Moreover, I appreciate the financial support from the German Ministry of Education and Research that funded this dissertation.

Finally, I am most grateful to my parents, Helmfried and Marlene, who have always encouraged and supported me throughout my life. And to my brothers and sister, Volker, Petra, and Marko, who are always with me. You all have consistently helped me keep perspective on what is important in life and added a lot of joy. This work is dedicated to you.

Immenstadt, August 2008 *Christian Artmann*

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List of Abbreviations, Variables, and Functions

*	(indicates optimality)
α_t	Improvement cost at stage t
a_t	Managerial action (i.e., continue, improve, or abandon) chosen at stage t
c_t	Continuation cost at stage t
cf.	confer (compare)
d	Market performance requirement
$E(\cdot)$	Expectation operator
e.g.	exempli gratia (for example)
Eq.	Equation
et al.	et alii (and others)
$f(\cdot)$	Distribution density function
f., ff.	following
γ_t	Cost of market performance requirement update at stage t
G	Gamma distribution
I	Initial investment cost
IG	Inverse Gamma distribution
i.e.	id est (that is to say)
$k(a_t)$	Expected performance state improvement if action a is selected at stage t
μ	Mean of market performance requirement distribution
M	Upper bound of profit margin
m	Lower bound of profit margin
N	Normal distribution
N_k	Multivariate normal distribution (k dimensions)
NPD	New product development
NPV	Net present value
OV	Option value

$\Pi(x)$ Expected market payoff if launched product has performance level x

$\Pi(x, z)$ Expected market payoff after update with signal z if launched product has performance level x

P Market payoff

$P_t(x, z)$ Posterior project value in state x at stage t if prior managerial policy is applied

$P_t^\tau(x)$ Expected project value in state x at stage t for an update at τ if prior managerial policy is applied

p., pp. page(s)

$\Phi(\cdot)$ Cumulative probability function of a distribution

post (superscript) Posterior value, i.e., after update with signal z

prior (superscript) Prior value, i.e., before update with signal z

QFD Quality Function Deployment

QR Quick Response

r Discount rate

R&D Research and Development

Σ Covariance matrix

σ Standard deviation of market performance requirement distribution

ξ Prior standard deviation of market requirement mean

St Student's t distribution

St_k Multivariate t distribution (k dimensions)

τ Updating point in time

θ Unknown parameter of market performance requirement distribution (true market performance requirement)

T Project duration

$tr(\cdot)$ Trace of a matrix argument

$V_t(x)$ Project value in state x at stage t (no updating possibility)

$V_t(x, z)$ Project value in state x at stage t after update with signal z (posterior project value)

$V_t^\tau(x)$ Project value in state x at stage t in expectation of information update at time τ ($t < \tau$) (expected project value)

$V_t^I(x, z)$ Value of information update with signal z in state x at stage t

$V_t^{I,\tau}(x)$ Expected value of information in state x at stage t for update at time τ ($t < \tau$)

Wi_k Wishart distribution (k dimensions)

X_t Performance state of project at beginning of stage t

ω_t Development uncertainty at stage t

z Observed market performance requirements in follow-up study (signal)