Professional MBA
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Mass Innovation - a competitive strategy for High-Tech B2B SMEs

A Master's Thesis submitted for the degree of
"Master of Business Administration"

supervised by
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Vienna, August 13, 2014

Affidavit

I, **Dr. Corneliu Catalin Neacsu**, hereby declare

1. that I am the sole author of the present Master's Thesis, "Mass Innovation - a competitive strategy for High-Tech B2B SMEs", 88 pages, bound, and that I have not used any source or tool other than those referenced or any other illicit aid or tool, and
2. that I have not prior to this date submitted this Master's Thesis as an examination paper in any form in Austria or abroad.

Vienna, 13.08.2014

Signature

Always remember that you are absolutely unique.
Just like everyone else.

Margaret Mead

Abstract

Innovation strongly relates to successful business: growth, competitiveness, uniqueness, higher sales volumes, profitability, and higher market value. In their strive for growth, Small and Medium Enterprises often face serious challenges regarding the adoption of their innovations. While many ideas succeed and gain market share or even create new markets, other very promising innovations never reached the adoption threshold to make it on the mainstream markets. This constitutes a deep chasm that needs to be crossed for the company to fully leverage its technological competence and truly enjoy the fruits of innovation. Furthermore, today's knowledge intensive society, companies' boundaries become blurred and users expect tailored solutions to fit their individual needs. In this context, traditional business models like mass production prove insufficient for long term success, especially when the subject of innovation is High-Tech of a non-consumer type.

In the present work a strategic framework is developed as enabler for High-Tech B2B SMEs to successfully cross the chasm to the mainstream market. The concept of Mass Innovation is introduced as synergetic combination of Open Innovation, Mass Customization and Duality oriented organization design. This is intended as empowering and dynamic infrastructure for those companies required to sell innovations rather than products, under the pressure of their customers. The necessary company capabilities are identified, as well as the success factors.

The Mass Innovation strategic framework is exemplified on Photon, one company falling under the High-Tech B2B SME category. Photon is coming form the pure customizer side of the exploration-exploitation continuum, and is currently struggling to cross the chasm. A thorough analysis of the company, its capabilities and market is provided, and conclusions are drawn regarding the level of readiness of the organization and offerings for Mass Innovation. Clear suggestions and offered on how to improve the company's capabilities and therewith performance.

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1 Introduction

With the advent of the distributed knowledge society, it becomes apparent that the times when the customer can buy the car painted in any color as long as they it is black[1] and Nicola Tesla being the archetypal (mad) inventor are at an end.
Modern technological, cultural and societal shifts led to behavioral changes of the consumers: they became more knowledgeable, richer, interconnected and time-starved. Consequently, the established understanding and the corporate business model of mass production & consumption and mass media marketing became a poor producer–consumer fit. The consumer became *prosumer*[2]*,* who instead of destroying value is now part of its co-creation[3]. Today's users expect tailored solutions to fit their individual needs, which is beyond the scope and possibilities of mass production.

Innovative Small and Medium Enterprises often face a strategic chasm during their economic development from the early market to the mainstream one, as they need to:
remain innovative and provide one-of-a-kind offerings to individual users
and
simultaneously extend the customer base sustainably and profitably.

The leadership of such companies struggle with striking the right strategic balance between the two facets of successful innovation: exploration and exploitation. They have to make good use of existing advantages (*e.g.*, agility, responsiveness, tightly knit corporate culture) while reducing the adverse effects of inherent disadvantages (*e.g.*, lesser resources, no economies of scale).

Open Innovation and Mass Customization are new and promising paradigms well developed to successfully tackle these issues in today's dynamic business environment. MC seem to be currently used by Large(r) Enterprises in order to tap into the new trends of addressing individual customer needs while still keeping profits at (close to) mass production levels. Open Innovation constitutes an excellent bridge when it comes to connecting the mass customization strategy with innovation.

[1] Henry Ford (1922), My Life and Work, Chapter IV, p. 71: "Any customer can have a car painted any color that he wants so long as it is black."

[2] Alvin Toffler, *The Third Wave* (Bantam Books, 1980).

[3] Stefan Michel, Stephen W. Brown, and Andrew S. Gallan, "Service-Logic Innovations: How to Innovate Customers, Not Products," *Calif. Manage. Rev.* 50, no. 3 (2008); Rafael Ramirez, "Value Co-Production: Intellectual Origins and Implications for Practice and Research," *Strategic Management Journal* 20, no. 1 (1999): 49–65.

However, both put pressure on the organization itself, with the company required to dynamically balance the stability and change parts of the business equation. In the midst of the knowledge society and economy a firm cannot afford to disregard one aspect to exclusively focus on the other one: not only it looses significant advantages, but almost surely this sooner or later we will have a boomerang effect, from either side. When dealing with organizations and organizing innovation, one does not have the luxury to remain fixated for too long on neither exploitation, nor exploration. The system behaves dynamically in time and any boundaries are increasingly permeable to environmental conditions that can change anytime.

Innovative organizations in general, and especially small(er) ones need to recognize and accept the dual nature of the exploration – exploitation apparent paradox: the tension between stability and change is natural and legitimate, that each side of the paradox has merit[4], and ambiguity is an asset. This is a different and at times confusing state of mind required from the modern leadership.
Hence, for innovative SME organizations to strive and grow in the contemporary highly competitive and interconnected environment it is necessary to strategically implement the new business models of Open Innovation, Mass Customization and Duality in an interlinked manner. Here, this synergy is introduced as Mass Innovation.

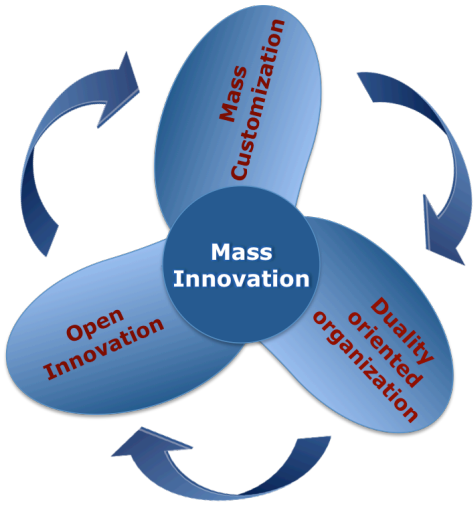
In the era of "Google" and abundant online information on anything, it is rather too easy to find one or even more strategies that, at a first glance, seem to fit an existing problem and provide a solution. Furthermore, to a large extent the available literature is seemingly more concerned with standard (and large) producers and/or B2C online businesses, and less with brick-and-mortar small companies coming from the customizer side in need to effectively implement the "mass" part of the equation. Although tempting, it is in most cases not sufficient to just apply these *mot-a-mot* as panacea. Prior to finding the solution to, *e.g.*, "how to deal with radical or disruptive innovation", it is the comprehensive understanding of the problem itself, its specific context and environment, of the organization's goals, and of the theoretical concepts that are prerequisites to solving the problem.

[4] Fiona Graetz and A. C. T. Smith, "Duality Theory and Organizing Forms in Change Management," *Journal of Change Management* 9, no. 1 (2009): 9–25.

1.1 Objectives

The main objective of present work is to identify and establish a competitive and strategic pathway for brick-and-mortar High-Tech SMEs to cross the early to mainstream market chasm in B2B type industries.

Based on Open Innovation, Mass Customization, and Duality oriented organization design, the concept of Mass Innovation is introduced as dynamic framework and comprehensive strategic enabler. It provides the infrastructure for harvesting the unique opportunity that is the heterogeneity of needs.



This works aims not at establishing a specific, complete and comprehensive toolkit for enabling a superior leverage of innovations. It rather aims at understanding the situation of this type of companies, analyzing the advantages as well as the pitfalls and comprehending the consequences. An encompassing literature review provides the necessary background knowledge.

The questions to be answered here are why and what to do, as opposed to how to do. The discussion is kept on strategic and conceptual level, as to evaluate the readiness of the organizational fit to the proposed strategy, and not on the implementation details.

The assessment of Mass Innovation applicability is illustrated on the specific case of Photon, a highly innovative SME active on the Scientific Research market. The aim here is to provide a solid understanding of the business under scrutiny, its business model, position on the market and identify the strategic development directions towards increased success.

The deployed research method here is the conceptual analysis. The work is mainly based on a qualitative approach, where established and/or new concepts are treated in a holistic manner.

1.2 Structure of the thesis

This thesis is divided in five chapters, with the first one (present one) containing the introduction.

Chapter 2 provides a literature overview of Innovations, starting with the definition and relevant taxonomy. The two main innovation paradigms (Closed and Open Innovation) are described, followed by critical remarks. The important question "is innovation *per se* a product" is consequently positively answered. The chapter concludes with a change in perspective, where innovation is viewed form the adopter vantage point along the adoption curve, and the main adopter types are presented.

Chapter 3 introduces the concept of Mass Innovation. The discussion starts by amending the innovation adoption curve with the chasm between the early and mainstream markets. Mass Customization is then theoretically presented as possible vehicle to cross the aforementioned chasm, and its capabilities and possible approaches are described following the existing literature. The necessary strategic organizational management is treated from the Duality perspective: the interplay of exploitation and exploration, or alternatively stability and change, is explained and their mutually enabling relationships presented. The three main theoretical concepts of Open Innovation, Mass Customization and Duality are thereafter united under the notion of Mass Innovation: a comprehensive strategic framework to enable High-Tech B2B SMEs to cross the mainstream market chasm by using their existing capabilities and developing new ones.

Chapter 4 connects the theoretical framework of Mass innovation with the case of an SME active in a High-Tech B2B industry. Photon is a typical customizer High-Tech SME active on a somewhat atypical market, that of Scientific Research: most of the products are innovations or custom offerings, and all users are innovators themselves. The market conditions are presented, and the customers are categorized along the innovation adoption curve. Following an analysis of the innovation selling business model and the particularities of the company (SWOT), it is concluded that in Photon's case, Mass Innovation is the right vehicle towards crossing the mainstream market and improving the company's technology leverage. The existing Photon capabilities in this framework are discussed, and improvements are suggested.

Chapter 5 concludes this work by summarizing the findings, addressing its limitations and offering and outlook.

A number of Appendices provide more detailed additional information on various themes deemed necessary throughout the thesis.

2 Innovation - theoretical overview

This work draws on a number of theoretical concepts, *e.g.*, Innovation, Mass Customization, and Duality Theory. The first of them is introduced and addressed in the present chapter to the extent necessary.

2.1 Definition and taxonomy of innovation

Innovation strongly relates to successful business: growth, competitiveness, uniqueness, higher sales volumes, profitability, and higher market value. Consequently, it is an important concept to grasp, and a means to use in any business environment.

The "what is innovation" question can also be reformulated: *is every new(er) idea an innovation*?

Fortunately, innovation has always been a buzzword, which has inspired philosophical discussions, but also an extensive and comprehensive body of business literature.

Schumpeter coined the first definition of innovation (1934) as "setting up a new production function[5]". He attributes the following characteristics to innovations:

- Creation of products or qualitative improvements in existing ones;
- Use of a new industrial processes;
- New market openings;
- Developing of new raw-material sources or other new inputs;
- New forms of industrial organization.

Schumpeter also gives a more poetic definition of innovation, in the context of his creative destruction theory[6]: *Innovations are creative destructions*. They continuously destroy the existing structure while simultaneously creating a new one[7].

The Encyclopedia of Technology and Management of Innovation [8] offers a more contemporary definition: "*innovation is a new idea, method, or device that creates a higher level of performance for the adopting user*".

The existence of various sources of innovations, innovation outcomes and even methodologies leads to partially different and sometimes ambiguous definitions of the

[5] Joseph A. Schumpeter, *The Theory of Economic Development. An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle* (Harvard University Press, 1934).

[6] Joseph Schumpeter, *Theorie Der Wirtschaftlichen Entwicklung*, Reprint of the original version, 1912 (Dunckner & Humblot - Berlin, 2006).

[7] The German text: "Innovationen sind schöpferische Zerstörungen. Sie zerstören unaufhörlich die alte Struktur und unaufhörlich eine neue".

[8] V. K. Narayanan and Gina Colarelly O'Connor, *Encyclopedia of Technology & Innovation Management* (John Wiley and Sons, 2010).

term within the academic literature. Innovation can be treated both as an action as well as an outcome. Nevertheless, it appears that at least one paramount characteristic founds common ground among modern scholars: the clear distinction between *invention* and *innovation*. Brenner [9] rationalizes that while invention might be a prerequisite for innovations, it is only the commercial exploitation of the former that results in innovation. Hence, it is widely accepted to conceptualize **Innovation as the combination of Invention and Exploitation**.

However high the temptation to substantiate the above definition via a mathematical expression, an equation capable to encompass the concept of innovation seems unlikely to survive the rigors of generality: although only two terms seem to play a role (invention & exploration) and are connected through a logical "and" which suggests multiplication, they also strongly depend on external factors, on the exact situation under scrutiny, and on a number of temporal dynamics. Furthermore, the very definition of the two terms is still under debate[10], which renders any effort towards equating the above definition rather futile. Albeit unfortunate from a generalization point of view, this author's inability to mathematically describe the definition underlines yet again the lack of a "universal recipe" and hence the need to treat the details of a particular innovation individually.

It is also important to substantiate the difference between Research and Development (R&D) and Innovation: while the former is concerned with the allocation of resources towards the development of new products, services, and/or processes, innovation is more encompassing, as it includes the commercial (or social) exploitation of the new products, services, and/or processes.

A complete taxonomy of innovation is a rather arduous endeavor. The main reason is that when discussing any innovation, many perspectives as well as levels of knowledge are (or can be) involved, resulting in different classifications as well as an increasing refinement in differences. For simplicity, a bi-level[11] innovation typology is normally used, but a finer categorization is possible and sometimes necessary. The afore mentioned Encyclopedia[12] gives an overview of innovation categories with increasing refinement level, some of which I exemplify in Table 2-1:

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[9] Reuven Brenner, *Rivalry In Business, Science, among Nations* (Cambridge University Press, 1990).

[10] Anil K. Gupta, Ken G. Smith, and Christina E. Shalley, "The Interplay between Exploration and Exploitation," *Academy of Management Journal* 49, no. 4 (2006): 693–706.

[11] By-level is to be understood here according to the either–or principle in mathematical logic.

[12] V. K. Narayanan and Gina Colarelly O'Connor, *Encyclopedia of Technology & Innovation Management*.

Bi-level categorization
• Discontinuous / continuous innovation • Instrumental / ultimate innovation • Variations / reorientations • True innovation / adopted innovation • Original / reformulated innovation • Innovations / re-innovations • Radical / incremental innovations • Evolutionary / revolutionary innovations • Sustaining / disruptive innovations • Business model / radical
Tri-level categorization
• Low / medium / high innovativeness • Incremental / new generation / radically new innovation • Platform / design / component innovation
Higher level categorization
• Systematic / major / minor / incremental / unrecorded innovation • Reformulated innovations / new parts / new improvements / new products /new user / new market / new customers • Improvements / new product lines / additions / new-to-the-world products / cost reduction process developments / repositioning • Research/breakthrough/platform or incremental/step-out or break-out

Table 2-1: Categories of innovations with increasing refinement

As apparent from the table above, innovation is indeed a interplay between Exploitation and Invention, where the two are the sides of a continuum spanning through incremental / radical, or improve / new-to-the world.

In the following, only those innovation categories will be explained and followed which are relevant for the present work.

2.1.1 Incremental versus radical innovation

Drawing on the definition above, innovations can be distinguished according to their degree of novelty: incremental innovations mainly based on and aimed at exploitation, and radical innovations incorporating a much higher exploratory (invention) component, and hence aimed towards newness.

Incremental innovation encompasses refinement and improvement of already existing products or services. It can be viewed as an optimization of a known product in a known

market[13] as a result of slight cost reduction, or slight performance improvement. Incremental innovation is mainly competence enhancing and reinforcing, with the required knowledge building on existing (technological) knowledge. Hence, this type of innovation is widely employed by incumbent firms as to strengthen the dominant design, as it relates to reliability, predictability and low risk.

Radical innovation is defined as an innovation creating an entirely new set of performance features, improvements in existing known performance features of five times or greater, or a significant (>30%) reduction in costs[14]. Although the exact figures in the definition are debatable, this innovation type involves fundamental discoveries and offers substantially new benefits to the user. It needs to be noted here that radical innovations do not necessarily imply a new technology: they include as well the use of existing ideas/innovation for new purpose, either directly or in an integrated fashion. They can either transform existing markets, or even result in the creation of new ones. As radical innovation is by definition new to the company, it might lead to competence obsolescence within the organization: the knowledge used for existing offerings might prove insufficient or even inappropriate for the new offerings. This is a real threat especially for technological knowledge. Direct and negative consequences can be resistance towards the acceptance of the radical innovation in question within the organization, or even the need to employ or re-qualify people. However, the above and other possible pitfalls can be successfully overcome if timely recognized and dealt with by the management.
Radical innovations are more rare in occurrence than incremental innovation, but they have a much heavier impact.

2.1.2 Sustaining versus disruptive innovations

C. M. Christensen developed another dimension along which innovations are classified[15]: sustaining and disruptive innovations.
Sustaining innovation targets demanding, high-end customers with better performance than previously available[16]. It is important to note that performance is measured here against the attributes valued by the most profitable existing customers. This type of innovation aims at sustaining and improving profitability, customer satisfaction and

[13] Robert A. Burgelman, Clayton M. Christensen, and S. C. Wheelwright, *Strategic Management of Technology and Innovation*, 5th edition (McGraw-Hill, 2009).

[14] Ibid.

[15] Clayton M Christensen, *The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail* (Boston, Mass.: Harvard Business School Press, 1997).

[16] Clayton M. Christensen and Michael E. Raynor, *The Innovator's Solution: Creating and Sustaining Successful Growth* (Harvard Business Press, 2003).

competitive advantage. It usually happens within an existing market and Value Network (VN), with the latter being defined as the context within which a firm identifies and responds to customer's needs, solves problems, procures input, reacts to competitors and strives for profit [17]. Sustaining innovations can be incremental as well as radical/breakthrough in nature.

On the other hand, disruptive innovations do not aim at bringing better performance to existing customers on existing markets. They disrupt that trajectory by introducing offerings (services or products) that are actually inferior to available ones, but offer other benefits, *e.g.*, simpler, less expensive, or more convenient. According to Christensen, the characteristics of a disruptive technology are[18]:

- simpler, cheaper and lower performing
- generally promising lower margins, not higher profits
- leading firms' most profitable customers generally cannot use them
- they are first commercialized in emerging or insignificant markets.

Disruptive innovations are either introduced in new markets, or at the low end of existing markets – incumbents considers none of these as being critical. In both cases, new Value Networks are created. The process of disruption is summarized in Figure 2-1.

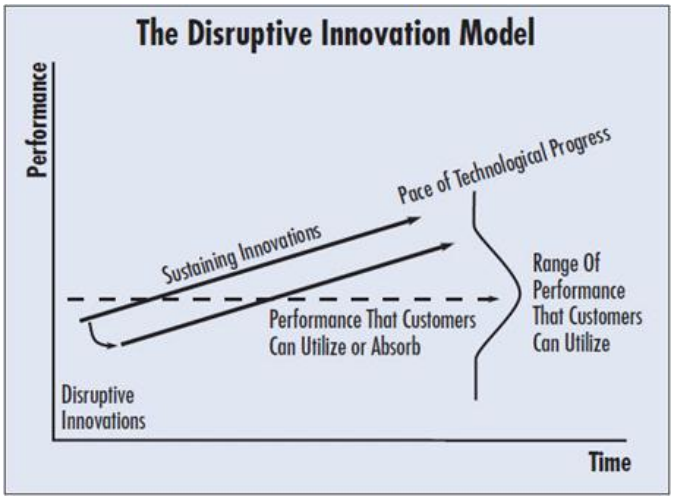

Figure 2-1: The elements of the disruptive innovation process[19]

Although introduced below the performance that customers can utilize and absorb (dotted line), the disruptive innovation improves and reaches this performance at a later time[20].

[17] Christensen, *The Innovator's Dilemma*.

[18] Ibid.

[19] Clayton M. Christensen and Michael E. Raynor, *The Innovator's Solution: Creating and Sustaining Successful Growth*.

[20] Although Figure 2-1 depicts both sustaining and disruptive innovation improving at equal rate, this is not necessarily the case. Actually, it turns out that disruptive innovations improve at a higher rate than sustaining ones.

Once the disruption crosses the line of performance that customers can utilize or absorb, it tends to ultimately crush or paralyze the incumbents (Christensen offers numerous such examples[21]). The latter are motivated to go up-market, design their resources allocation processes towards sustaining innovation (profit creation), and seem unable to respond to disruptions by defending low-end and/or new markets.
Albeit counterintuitive, it is good management towards striving to meet and exceed the high-end customer's expectations as well as mitigating risk-taking that eventually lead to the defeat of incumbents. On the other hand, incumbents generally triumph when it comes to sustaining innovations. A possible solution to the disruption dilemma is offered in[22]: incumbents are encouraged to actively seek and create disruption in a strategic manner.

Disruptive innovation is not to be confused with radical innovation: while the latter always involve new knowledge and significant improvement in performance, the former is not necessarily based on new technologies. Nevertheless, disruptive innovations can involve radically new technologies.

2.1.3 Critical remarks

An important point deserving the full attention of an innovator is the effect the particular innovation has on the customer/user, as well as on the complementary existing business ecosystem. Any innovation represents a change. It is not only a change in products or service available, but it might also require changes in the customer/user behavior, as well as the infrastructure of supporting businesses which provide complementary products/services. The amount of change required strongly depends on the type of innovation: incremental innovations are expected to lead to an insignificant customer behavioral change and low change in the complementary infrastructure. Radical innovation is associated with a higher degree of changes necessary, while disruptive innovations almost always require very significant changes. The latter innovation type can lead not only to the disappearance of the existing competitive offering, but also to total obsolescence of other products/services involved in the existing value network. Simply put, with the advent of the disruption, the customer might give up not only the incumbent offering, but also other offerings used in conjunction with the incumbent, which gives rise to discontinuities.
In general, we are creatures of habit: we usually do not want to change our ways in order to take advantage of innovations. Hence, the innovator has to consider behavioral

[21] Christensen, *The Innovator's Dilemma*.

[22] Clayton M. Christensen and Michael E. Raynor, *The Innovator's Solution: Creating and Sustaining Successful Growth*.

elements when introducing innovative offering, as they can be barriers in the way of success.

The classification of innovations along the dimensions detailed above (or any other dimension) does not necessarily mean that there is "bad innovation" and „good innovation", or that companies deal with only one type of innovations. *De facto*, firms simultaneously work with different types of innovations in their portfolio, and it proves difficult to keep innovations in separate categories. The discreet classification of innovations proves to be mainly an academic endeavor that happens *a posteriori* and aims at understanding and generalizing certain observed behaviors.
Companies with an effective innovation management aim at balancing their portfolio(s) as to match their market and technology capabilities and competencies. Furthermore, innovating is a dynamic process which happens over a finite and non-zero period of time in which internal as well as external conditions will change. Consequently, ideas towards product improvement might result in radically new developments and vice versa.

Academic literature abounds with innovation classifications as well as strategies to manage even the most challenging types of innovations: radical innovations are treated *in extenso* in [2324252627], disruptive innovations in [2829303132], architectural innovation in [33] and references therein, etc.

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[23] Richard Leifer et al., *Radical Innovation: How Mature Companies Can Outsmart Upstarts* (Harvard Business School Press, 2000).

[24] Marc Gruber, Ian C MacMillan, and James D Thompson, "Escaping the Prior Knowledge Corridor: What Shapes the Number and Variety of Market Opportunities Identified Before Market Entry of Technology Start-Ups?," *Organ. Sci.* 24, no. 1 (2013).

[25] Rita McGrath and Ian MacMillan, "The Entrepreneurial Mindset" (President and Fellows of Harvard College, 2000), 301–35.

[26] MW Johnson, Clayton M. Christensen, and Henning Kagermann, "Reinventing Your Business Model," *Harvard Bus. \dots*, no. December (2008): 50–60.

[27] D J Treece, "Profiting from Technological Innovation: Implications for Integration, Collaboration, Licensing and Public Policy," *Res. Policy* 15, no. 6 (1986): 285–305.

[28] Clayton M. Christensen and Michael E. Raynor, *The Innovator's Solution: Creating and Sustaining Successful Growth*.

[29] Constantinos D. Charitou and Constantinos C. Markides, "Responses to Disruptive Strategic Innovation," *MIT Sloan Manag. \dots*, no. Winter (2003): 55–64.

[30] Joseph L Bower and Clayton M Christensen, "Disruptive Technologies : Catching the Wave," *Harv. Bus. Rev.*, no. February (1995): 43–54.

[31] Maxwell Wessel and Clayton M Christensen, "Surviving Disruption," *Harv. Bus. Rev.* December, no. December (December 2012): 58.

[32] Michael E. Raynor, *The Innovator's Manifesto: Deliberate Disruption for Transformational Growth* (Crown Business, 2011).

It is rather too easy to find one or even more strategies that, at a first glance, seem to fit an existing problem and provide a solution. Although tempting, it is in most cases not sufficient to just apply these *mot-a-mot* as panacea. Prior to finding the solution to, *e.g.*, "how to deal with radical or disruptive innovation", it is the deep and comprehensive understanding of the problem itself, its specific context and environment, as well as the organization's goals that are prerequisites to solving the problem.

Here I am concerned with High-Tech B2B SMEs as innovators. Here, the above remarks become particularly important:

- Most of the innovation in High-Tech require significant behavioral changes everywhere but the most incremental of innovations. The reason for this is three fold: (i) High-Tech innovations are easy to implement technically in the computer era, so innovators tend to simply "go for it" as means for market differentiation and additional USPs; (ii) High-Tech became such an integral part of our life, that even the smallest changes and revisions necessitate an avalanche of indirect alterations; (iii) there is an increasing knowledge gap between the user and the innovator, which in itself creates fear for change.
- Behavioral changes in B2B need to be treated with at least as much respect as in a B2C type business: it is simply a matter of the relative importance of individuals in the process of acceptance of innovation.
- Many innovation strategy studies are done on large organizations, which are fundamentally different to SMEs. Hence, simply applying such ready-made models on small companies will not bring the desired effects without careful considerations of the particular environmental and initial conditions.

It is the aim of this work to state and understand the innovation-related challenges of the SME described later on as a case study and establish a framework of possible solutions, with the exact details of the implementation only covered in general terms.

2.2 Sources of innovation

The main question to be answered in the present section is: how does innovation happen? Two general paradigms are detailed below, Closed Innovation and Open Innovation (CI and OI, respectively).

[33] Rebecca M Henderson and Kim B Clark, "Architectural Innovation : The Reconfiguration of Existing Product Technologies and the Failure of Established Firms," *Adm. Sci. Q.* 35, no. Special Issue: Technology, Organizations, and Innovation (March 1990): 9–30.

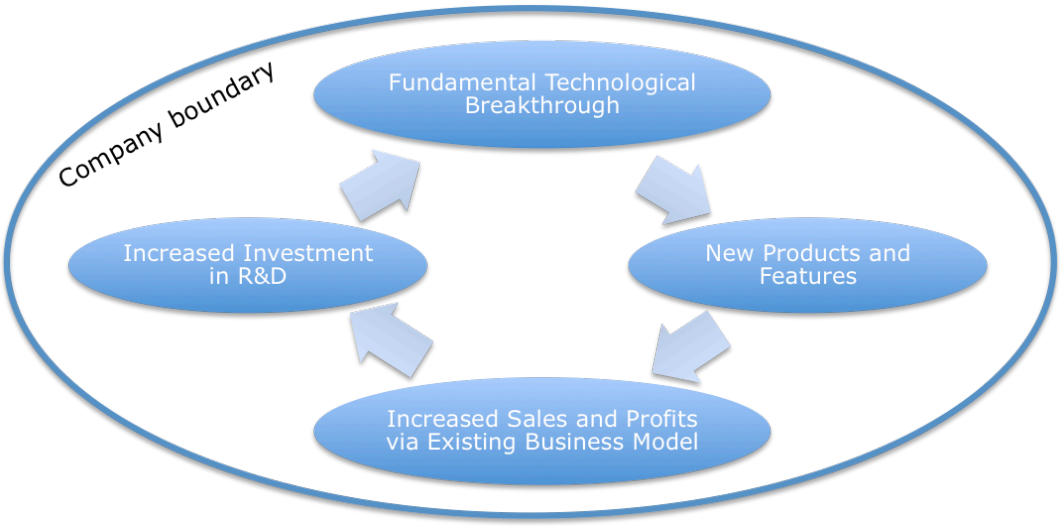

Figure 2-2: The virtuous circle of Closed Innovation (rendering following[34], page xxi).

2.2.1 The closed innovation paradigm

Prior to the Industrial Revolution, the difference between producer and consumer was slim to non-existent. Commerce existed, but its purely economic[35] consequences were relatively small, with most of products and services being consumed by the producers themselves[36]. The Industrial Revolution brought the clear differentiation producer - consumer, mainly since almost nobody was self-sufficient anymore[37]. In this context, the Consumer is treated in the mainstream economic understanding as "destroyer of value"[38] created by producers (*e.g.*, accounting systems started depreciating the value to zero over a period of time, with the value created being only the price paid for the product).

Traditionally, innovation by companies was the realm of the company itself (the classical successful examples here would be Xerox and its PARC center, or the Bell Laboratories). This is what H. Chesbrough calls *Closed Innovation*: "*companies must generate their own ideas and develop them, build them, market them, distribute them, service them, finance them and support them on their own*"[39]. In other words, the company has complete control over the innovation and this leads to success. Chesbrough depicts the CI paradigm via a virtuous circle, which is completely contained within the company boundaries (Figure 2-2).

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[34] Henry W. Chesbrough, *Open Innovation* (Harvard Business School Press, 2003).

[35] This is not to say that the cultural and societal consequences of pre- Industrial Revolution commerce are insignificant.

[36] Alvin Toffler, *The Third Wave*.

[37] Ibid.

[38] For a comprehensive survey of the etymology of the "value" and "customer" notions as well as alternative views on the role of the consumer, the reader is directed to Ramirez, "Value Co-Production."

[39] Henry W. Chesbrough, *Open Innovation*.

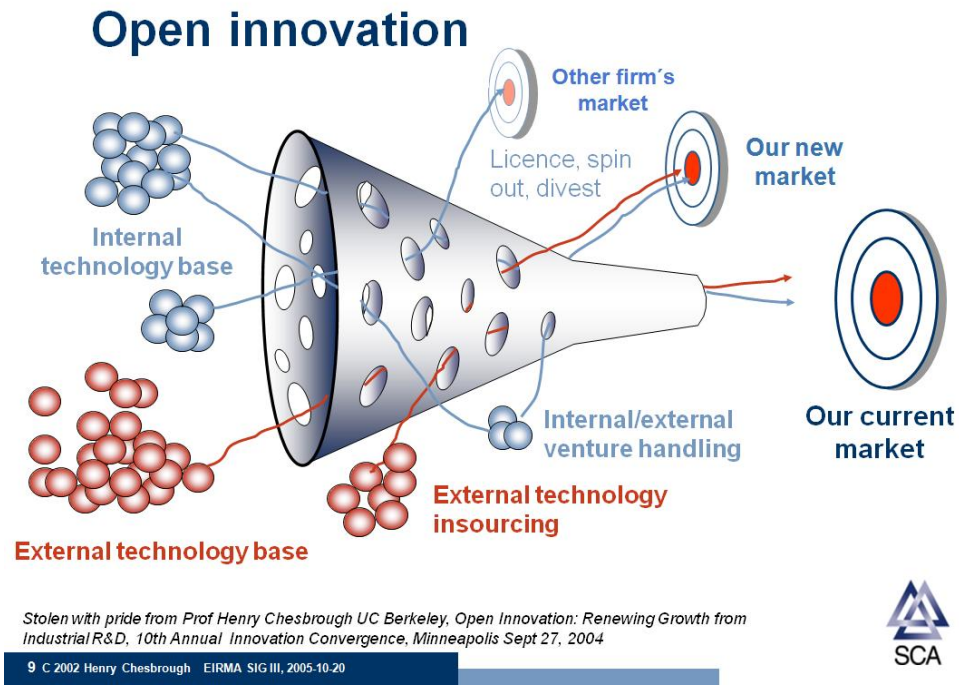

Figure 2-3: The Open Innovation funnel[40]: permeable company boundaries, internal and external sources of innovation, and existing and new markets.

2.2.2 Open innovation & customer co-creation

However, towards the end of the 20th century, technological, cultural and societal shifts (mainly based on the informational technology advances) led to behavioral changes of the consumers: they became more knowledgeable, richer, interconnected and time-starved. Consequently, the established understanding and the corporate business model of mass production & consumption, as well as the mass media marketing became a poor producer–consumer fit. The consumer became *prosumer*[41], who instead of destroying value is now part of its co-creation[42]. Today's consumers and users expect tailored solutions to fit their individual needs, which is beyond the scope and possibilities of mass production. The afore-mentioned co-creation extends to the innovation process as well.

Simultaneously with the advent of the *prosumer*, the abundant knowledge suddenly available (the Knowledge Age) rendered the Closed Innovation paradigm no longer sustainable. This led to a paradigm shift[43] towards Open Innovation (term coined by in [44]), which assumes that:

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[40] Graphics found online under: http://pakbec.blogspot.co.at/2013/01/innovation-through-collaboration.html

[41] Alvin Toffler, *The Third Wave*.

[42] Stefan Michel, Stephen W. Brown, and Andrew S. Gallan, "Service-Logic Innovations: How to Innovate Customers, Not Products"; Ramirez, "Value Co-Production."

[43] Term introduced by T. Kuhn to describe the non-monotonous progress in Science. See Thomas S. Kuhn, *Structure of Scientific Revolutions*, Third (The University of Chicago Press, 1996).

"firms can and should use external as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology".

Here the whole innovation process transcends the company's boundaries, which becomes permeable towards outside influences (ideas on one side and markets on the other), as well as to "leakages" towards the outside (e.g., external licensing and start-ups or establishing new markets).

In a nutshell, Chesbrough summarizes the main differences between Closed and Open Innovation as shown in Table 2-2 below.

Contrasting Principles of Closed and Open Innovation

Closed Innovation Principles	Open Innovation Principles
The smart people in our field work for us.	Not all of the smart people work for us* so we must find and tap into the knowledge and expertise of bright individuals outside our company.
To profit from R&D, we must discover, develop and ship it ourselves.	External R&D can create significant value; internal R&D is needed to claim some portion of that value.
If we discover it ourselves, we will get it to market first.	We don't have to originate the research in order to profit from it.
If we are the first to commercialize an innovation, we will win.	Building a better business model is better than getting to market first.
If we create the most and best ideas in the industry, we will win.	If we make the best use of internal *and* external ideas, we will win.
We should control our intellectual property (IP) so that our competitors don't profit from our ideas.	We should profit from others' use of our IP, and we should buy others' IP whenever it advances our own business model.

* This maxim first came to my attention in a talk by Bill Joy of Sun Microsystems over a decade ago. See, for example, A. Lash, "The Joy of Sun," The Standard, June 21, 1999, http://thestandard.net.

Table 2-2: Contrasting principles of Closed and Open Innovation, from[45].

Albeit its novelty and paradigm shifting ansatzes, Open Innovation (in the classical theoretical framework) seems not to be treated as completely detached from the "old/classical" business framework. In its seminal book Open Innovation, Chesbrough is still preaching for a classically framed business model: value proposition, market segment, value chain, cost structure and even the cognitive implications should be controlled and well know by the company from the beginning on[46]. In other words, although the source of the innovation and its market(s) are supposed to be open, the innovation process needs not only be controlled (this is legitimate), but also well established from the beginning on. In my opinion, this can only be an intermediate state of Open Innovation, with the truly

[44] Henry W. Chesbrough, *Open Innovation*.

[45] Henry W Chesbrough, "The Era of Open Innovation," *MIT Sloan Manag. Rev.* 44, no. 3 (2003): 35–41.

[46] Chapter 4 in Henry W. Chesbrough, *Open Innovation*.

open innovation still to be accepted. Steps in this direction already take place, starting with concepts such as Minimum Viable Product, Guerilla Marketing, etc.

A question of paramount importance for OI is **who innovates**? Eric von Hippel categorizes the sources of innovation according to their functional role[47] in the innovation process: producer, supplier, user, competitor, or combinations thereof. He finds that the relative weight of different sources innovating strongly depends on the particular industry. In the Scientific Instruments industry (highly relevant in the context of the present work), over 70% of the innovations originate with the users. In the same study he actually even proposes a causal connection between the source of innovation and the innovation-rent by arguing that "*the functional source of innovation can be predicted on the basis of potential innovators' expectations of innovation-related rents*" (p. 70 in [48]).

In subsequent studies, von Hippel[49] argues that there is a capital difference between users as innovators and all other categories: if the latter must "sell" the innovation to others in order to profit, the users benefit directly from the innovation[50]. Furthermore, innovating users appear to bear the characteristics of *lead users*: "*they are ahead of the majority of users in their population with respect to an important market trend, and they expect relatively high benefits form a solution to the needs they have encountered*"[51]. The main reason for users innovating appears to be the high heterogeneity of their needs, corroborated with the non-availability on the market of their wanted product/service. The afore mentioned high heterogeneity of need was comprehensively studied by Franke et al.[52] who also found a high user willingness to pay to get what they want.

The lead-user theory was put under scrutiny Franke et al.[53], who confirm not only that lead-users innovate, but also that the lead-user characteristics of the innovator relate to the commercial attractiveness of the resulting innovation (Figure 2-4).

One direct positive consequence of lead users innovating is that the rest of the market (early majority through laggards) is likely to readily accept the innovation, a major added benefit to the innovation manufacturer. Hence, many a company are interested in

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[47] E von Hippel, *The Sources of Innovation* (Oxford University Press, 1988).

[48] Ibid.

[49] Eric von Hippel, *Democratizing Innovation* (MIT Press, 2005).

[50] Ibid., chapter 1

[51] Ibid., chapter 2

[52] Nikolaus Franke, Heribert Reisinger, and Daniel Hoppe, "Remaining within-Cluster Heterogeneity: A Meta-Analysis of the' Dark Side' of Clustering Methods," *Journal of Marketing Management* 25, no. 3–4 (2009): 273–93.

[53] Nikolaus Franke, Eric von Hippel, and Martin Schreier, "Finding Commercially Attractive User Innovations: A Test of Lead-User Theory," *J. Prod. Innov. Manag.* 23 (2006): 301–15.

developing better and more effective ways to involve their customers in the innovation process (co-creation) and New Product/Service Development.

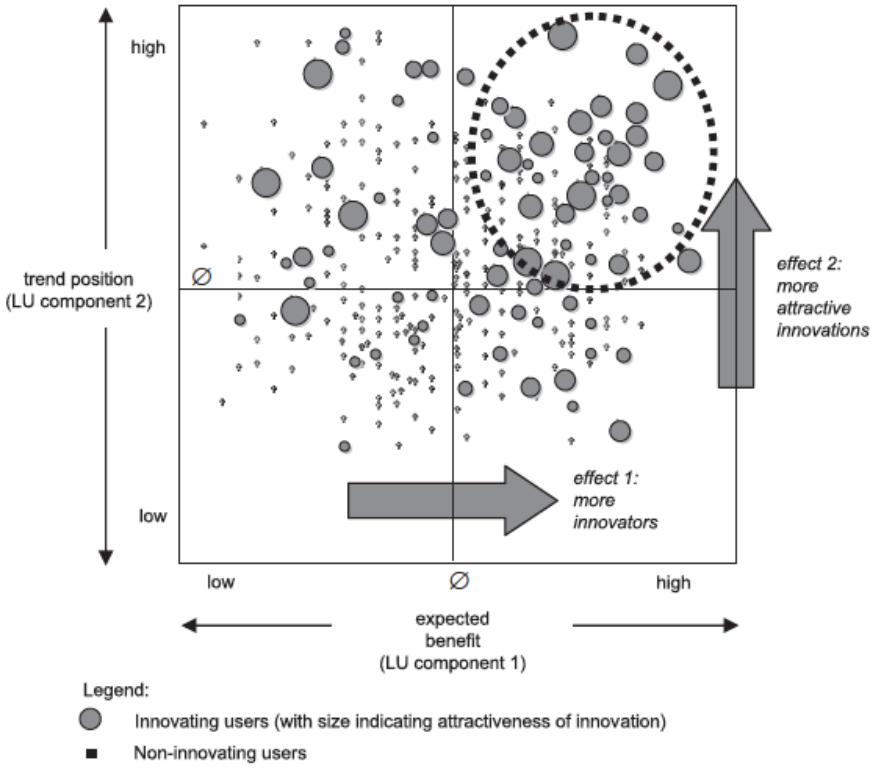

Figure 2-4: Effects of Lead-User Components (extracted from [54]).

2.2.3 Applying Open Innovation

Presently, there is a sizable and increasing body of theoretical as well as practice oriented literature putting forth different models for OI and customer involvement, as well as well developed toolkits to support an organization on the OI path[55], the management of user communities, or for NPD and NSD. The applicability of the models strongly depends on the industry, product vs. service, organization type, organization goals, etc. A useful overview of the techniques can be found in the opening chapters of [56] and references therein. Even more, there are successful companies acting as Open Innovation brokers: Innocentive and Open Photonics[57] are only two examples. There is already a Pan

[54] Ibid.

[55] The following is just an example of commercial software for OI Management: http://innovation.qmarkets.net/?qm_src=gg_im&gclid=CjkKEQjww6SdBRDls9vxsf7EoM0BEiQART_xPoJmTpuoxFeCcVba_hMrx0aGsZvD3__gC0-M9YTP_XPw_wcB

[56] Marcel Weber, "Customer Co-Creation in Innovations: A Protocol for Innovating with End Users" (PhD, Technische Universiteit Eindhoven, 2011).

[57] https://www.innocentive.com/; http://www.open-photonics.com/.

European OI platform to "contribute to the development and knowledge diffusion of the concept of open innovation in the European business community"[58].

All strategies for OI and especially those based on users recognize the importance of users as sources of radically new creative ideas based on their experience. Numerous methods have been developed and put forth for user integration in innovation, and they come with different value propositions.

The lead-user method mentioned above is usually implemented following the general lines of von Hippel's original logic[59]: (i) the lead-users projects have a clear defined and finite scope, takes place in a limited time; (ii) the starting point is the definition of the search field (the need for a new product/service on an existing or new market); (iii) the next step is to establish the unsatisfied needs within the field (the trends) and identify the lead-users; (iv) finally, a workshop is organized with the lead-users as well as an established team of chosen employees, with the goal of creating a number of powerful, concrete, and radical new product/service concepts.

Another strategy for user innovation is the Mass Customization (for details please see 3.3). This is usually implemented in the form of a toolkit that allows users to design, prototype and design-test products and/or services[60]. The toolkits provide the user with different characteristics along product/service dimension, which can be chosen and combined as to configure the final product best suiting their needs and expectations. An additional benefit of user innovation toolkits is their potential use as marketing tools: the interaction user-toolkit and the statistical relevance of the final product gives precious insight into general user preferences and can be applied in standard (non-customizable) product design[61]. The main goal of the toolkit-based strategy is mass customization, and not new ideas as is the case with the lead-user approach.

Regardless of the OI method employed, be it one of the above or any other one (*e.g.*, user community, innovation tournaments, crowdsourcing), its practical implementation remains challenging, with companies often failing to harvest the promising benefits. Considering the above, it becomes apparent that the organization *per se* needs to be designed and prepared for OI and user innovation. For example, the "not invented here syndrome" is damaging, as it limits the absorptive capacity and prevents the effective leverage of

[58] on http://www.openinnovation.eu/.

[59] Eric von Hippel, "Lead Users: A Source of Novel Product Concepts," *Management Science* 32, no. 7 (1986).

[60] Eric Von Hippel and Ralph Katz, "Shifting Innovation to Users via Toolkits," *Management Science* 48, no. 7 (2002): 821–33.

[61] Nikolaus Franke and Frank Piller, "Value Creation by Toolkits for User Innovation and Design: The Case of the Watch Market," *J. Prod. Innov. Manag.* 21 (2004): 401–15.

external input[62], so one needs to find and promote people able to work not only with their own ideas, but with the ideas of others as well.

In a recent interview[63], Henry Chesbrough addressed the issue and suggested three tips for applying OI:

(i) The first and foremost step is a thorough analysis and understanding of the particular business needs and goals relative to innovation.

(ii) Secondly, the organization needs to open up internally prior to doing so externally.

(iii) The management has to be aware that, although not all the smart people work for them, they still need smart people in the organization who are able to work and collaborate effectively.

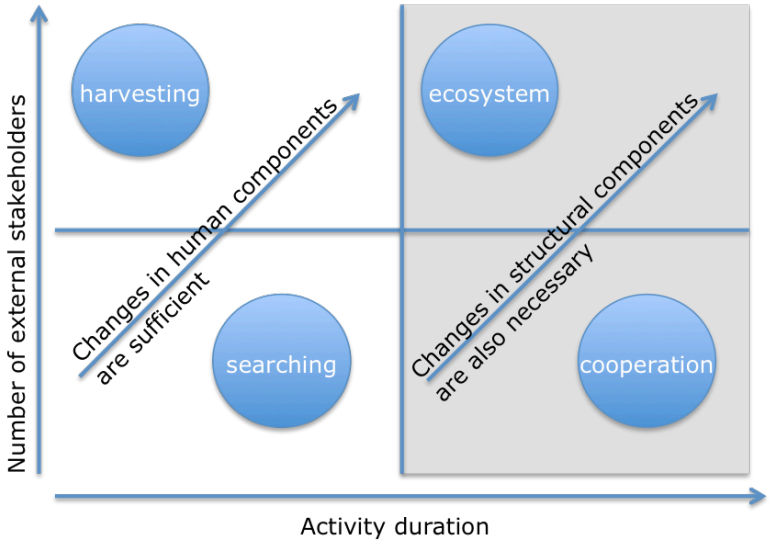

Figure 2-5: User innovation strategies (adapted from[64]).

Keinz *et al*[65] have comprehensively treated the implications of the OI paradigm in organizational design, drawing on a large body of existing literature. The authors identified the following four strategies for user innovation and their challenges for the organization and develop organization design principles (Figure 2-5).

Searching strategy

It builds on activities of limited duration and involves a small number of external individuals (*e.g.*, lead-user projects). The organization challenges are mainly limited to the

[62] Christoph Hienerth and Christopher Lettl, "Exploring How Peer Communities Enable Lead User Innovations to Become Standard Equipment in the Industry: Community Pull Effects," *Journal of Product Innovation Management* 28, no. s1 (2011): 175–95.

[63] www.wobi.com/wbftv/henry-chesbrough-three-tips-applying-open-innovation

[64] Ibid.

[65] Peter Keinz, Christoph Hienerth, and Christopher Lettl, "Designing the Organization for User Innovation," *J. of Org. Design* 1, no. 3 (December 14, 2012): 20.

human component (find the right mix of employees) and do not extend to the company's strategies and structure. The design principles for the searching strategy are:

1. Convince employees by demonstrating the potential of user-generated content and by creating appropriate incentive systems.
2. Develop competencies as to identify lead-users and moderate workshops.
3. Develop cooperation incentives. Although lead-users do not start with the intention of commercializing their ideas (Section 2.2.2), if the company wants to cooperate with a lead-user after the workshop on a certain idea, incentives will be necessary.

Harvesting strategy

It involves also occasional activities of limited duration, but employs a much larger number of external individuals (*e.g.*, crowdsourcing, innovation contests). Harvesting challenges primarily the human components of the organization, and the design principles here are:

1. clear description of the problem and solution parameters as well as implementation of incentive and control systems. As this strategy addresses a large number of users that are not familiar with the corporate strategy, the company needs to align the problem-solving activities with the goals of the innovation contest.
2. Consideration of user's fairness perception in the design of the contest: the incentives (pecuniary or otherwise), as well as the integration of the users in rating the solutions need to be designed in order to attract a large number of participants, which in turn positively affects the quality and quantity of the solutions.
3. Involvement of the company's middle management and employees by implementing appropriate incentive systems. This is crucial for avoiding internal resistance to the process and solutions.

Cooperation strategy

It involves a relatively low number of contributors, but on a continuous basis. In addition to the challenges implied by the searching strategy, cooperation leads to a corporate strategy shift towards innovation leadership; In this case, the design principles are similar to those of the searching strategy, but since structural changes call for additional ones:

1. Adaptation of the corporate strategy to deal with radical/disruptive innovation. The top management has to anchor innovation leadership in the corporate strategy, in order to overcome organizational inertia.
2. Appointment of persons responsible for the relationship management with lead-users and external experts, as to establish durable relationships with lead-users.

Ecosystem strategy

It focuses on collaborating with a large(r) number of external individuals, (*e.g.*, mass customization). It entails a fundamental organizational (re)design, not only on human but also along its structural dimensions. As mass customization directly affects core

structures, and the value proposition to the customers change, the organization needs to be designed and prepared to face and successfully cope with "markets of one"[66]. All the design principles described above should be applied, and additionally, the authors of the study recommend the following:

1. Design the organization as part of the innovation ecosystem and adapt its structure. The company is just one of the actors in the ecosystem, so powerful synergies have to be created and used – the boundaries between the company and the external world become blurred. The middle management needs to be empowered and even encouraged to search and collaborate with users and other collaborators in the ecosystem. In general, flat hierarchies have a positive effect on the success of OI strategies. Furthermore, the production processes need to be organized as to coop with, *e.g.*, modular product architecture necessary for mass customization.
2. Appointment of persons responsible for proactively participating in and managing the community. Since the users are not contractually bound to the company, the only effective way of managing them is by building strong relationships.

A more detailed classification of the four OI/UI strategies and their challenges entailed (as developed in[67]) are provided in Appendix 7.2.

2.2.4 Critical remarks on Open Innovation

It is already widely recognized that innovation in general is rapidly shifting its locus towards the Open Innovation paradigm. With innovation being a key factor towards economic success, many companies (have to) follow suit and employ OI to a smaller or larger degree in order to survive and thrive.

The academic literature and the business world at large offer a large number of possibilities and toolkits for OI. Although it seems easy to pick one such well-developed recipe and apply it, reality shows that the success rate strongly depends on the fundamental fit between the company in its integrity and the particular method chosen. There are challenges that need to be mastered, starting with a deep and honest understanding of the organization, followed by transformations not only in attitude but even the core structures and strategies. Failure to fundamentally adapt to the OI philosophy can result in deep troubles for the company, as exemplified in[6869] for a number of established industry leaders involved in mass customization.

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[66] Ahmet Bardakci and Jeryl Whitelock, "Mass-Customisation in Marketing: The Consumer Perspective," *J. of Consumer Marketing* 20, no. 5 (2003): 463–79.

[67] Keinz, Hienerth, and Lettl, "Designing the Organization for User Innovation."

[68] Franke and Piller, "Value Creation by Toolkits for User Innovation and Design: The Case of the Watch Market."

2.3 Is innovation *per se* a product?

Traditionally, the innovation process ends as soon as the innovation starts to be manufactured and commercialized in volume without changes – it becomes a "standard product" in the portfolio. The lifecycle continues until, for whatever reason, the product is not sold anymore in its present version (incremental innovations included). What if the lifecycle ends with the commercialization of only one or very few "standard products", in other words by selling just the innovation?

The Business Dictionary offers a comprehensive definition of product:

"a good, idea, method, information, object or service created as a result of a process and serves a need or satisfies a want. It has a combination of tangible and intangible attributes (benefits, features, functions, uses) that a seller offers a buyer for purchase"[70].

According to this definition in conjunction with any definition of innovation (Section 2.1), the answer to the question posed in the title cannot be anything else but yes[71]. Hence, a business can offer or "sell" innovations as either products or services, if it so chooses to.

Nevertheless, practice shows that this is a tricky business: selling innovation requires by definition selling a novelty, if not complete at least partial. This entails careful and continuous management involvement, high R&D and production costs, possibly low market share. It actually goes against the common sense business success recipe: innovation means costs, which can only be recuperated once the standard product is sold. The consequences can be dire if the organization is not prepared for such a non-traditional business model. On the other hand, the advantages are obvious: brand name, remaining ahead of the pack, low concerns regarding obsolete product lines and production facilities, premium priced offerings.

In a rather poetic manner, Bernstein et al. refer to Organizations that favor exploration over exploitation as having a "jazz mindset"[72]. The authors argue in a convincing manner that organizations led this way can maximize learning, remain responsive to short-term emergent opportunities and strengthen long term dynamic capabilities: "*Jazz bands are organized similarly to Mintzberg's adhocracy, Burns and Stalker's organic structure,*

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[69] B. Joseph II Pine, Victor Bart, and Andrew C. Boyton, "Making Mass Customization Work," *Harvard Busines Rev.* 71, no. 5 (1993): 108 – 119.

[70] *Business Dictionary*, Online, www.businessdictionary.com/definition/product.html.

[71] For the sake of completeness, it needs to be added that the above argument can be readily extended to services as well. Depending on the innovation type, it can also be equated with a service.

[72] Ethan S. Bernstein and Frank J. Barrett, "Strategic Change and the Jazz Mindset: Exploring Practices That Enhance Dynamic Capabilities for Organizational Improvisation," in *Research in Organizational Change and Development*, vol. 19 (Emerald Group Publishing, 2011), 55–90.

Brown and Eisenhardt's high-velocity firms, and Tushman and O'Reilly's ambidextrous organizations. Jazz bands, in short, embody many of the characteristics of postindustrial, post bureaucratic organizing. […] Jazz bands have minimal hierarchy, decision-making is dispersed, and they are designed to maximize flexibility, responsiveness, innovation, and fast processing of information". In short, such an organization would favor exploration and guard against excessive exploitation, which is nothing else than favoring the innovation over the standard product.

The question to be addresses is how to achieve this in an economically viable manner.

2.4 Diffusion of innovation

In order to tackle on the commercial viability of selling innovators, one has first to understand how innovations are adopted on the market. Everett Rogers defines diffusion of innovation in his seminal work[73] as:

> *"the process by which an innovation is communicated through certain channels over time among the members of a social system".*

The first important characteristic of the innovation diffusion is the rate of adoption. Rogers ([74], page 23) defines the latter as "*the relative speed with which an innovation is adopted*". This would appear as an S-shaped curve when plotted as percentage of market penetration (or cumulative number of adopters) versus time (Figure 2-6, red curve). Such an S-curve could be drawn for each particular innovation, evidently with different rising slopes as to indicate individual rates of adoption. The graphical display of the adoption rate clearly shows three regions: (i) the slow beginning, when resistance to change is to be felt and only a small number of individuals are adopting; (ii) the rapid rise in adoption rate follows as soon as the innovation reaches the main market;(iii) finally, the market will show saturation effects, with less and less number of adopters appear. This is usually when the innovation is (or should be) to be replaced by a newer one.

Another dimension along which the diffusion of innovation can be described is the type of adopter. Rogers (chapter 7 in [75]) separates innovation adopters in the following idealized categories (Figure 2-6, blue curve):

Innovators: the first to adopt. Their salient value is venturesome, to the point of being obsessed with trying new ideas. The innovator has sufficient technical knowledge and can cope with a high degree of uncertainty about the innovation and its function. The innovator plays the role of launching the new idea and proving that it indeed works.

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[73] Everett M Rogers, *Diffusion of Innovations* (New York; London: Free Press ; Collier Macmillan, 1983).

[74] Ibid.

[75] Ibid.

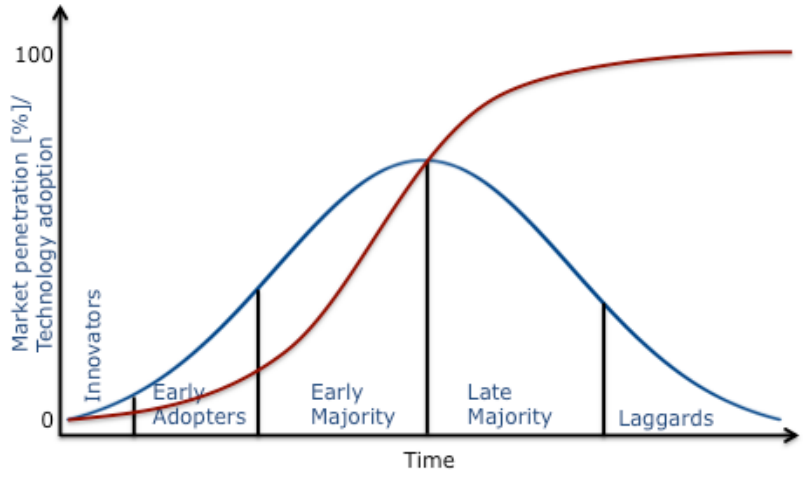

Figure 2-6: Rate of innovation and technology adoption, acc. to [76].

Early adopters (Visionaries): respectable, more integrated in the social system, and have the highest degree of opinion leadership. Their vision connects the innovation with future opportunities. The early adopter decreases the uncertainty and evaluates the innovation, as well as spread the word to peers and potential adopters.

Early majority (Pragmatics): adopt the innovation just before the average member of the social system. They are deliberate, so their adoption decision takes longer, require references, and are driven by practicality. Although they interact with their peers, they usually do not hold leadership positions. The early majority has the important role of interconnecting the system's network. Additionally, the shear number of members in this segment makes winning them over a *sine qua non* for profit and growth.

Late majority (Conservatives): skeptical and adopt only after the average member of the system, and require pressure (social or otherwise) to do so. Rather than buying innovations, they purchase established standards. The late majority enjoys a similarly large number of members as the early majority.

Laggards (Skeptics): the last to adopt an innovation. They are traditional, with the point of reference in the past. The laggard is usually suspicious and has limited resources.

In the era of the *prosumer*, when satisfying individual users is absolutely necessary, this understanding of the user/customer type gains even more weight for innovation management and innovation marketing.

[76] Ibid.

3 Mass Innovation – theoretical concept

The diffusion of innovation model put forth by Rogers[77] has been successfully used by many a High-Tech company. However, in this industry more so than anywhere else, the adoption of innovations (especially disruptive and radical ones) has proven to happen in a much more erratic way than the model predicts. While many ideas have succeeded and gained market share or even created new markets, other very promising innovations have never reached the adoption threshold to make it on the mainstream markets (*e.g.*, the SEGWAY). Furthermore, one needs to reconcile the traditional concept of the monolithic mainstream market with that of the *prosumer* who requires individual solutions for their particular problems.

3.1 Visionaries vs. Pragmatics: the chasm in TALC

Geoffrey A. Moore[78] proposed a revised model of adoption for High-Tech innovation, where the border regions between the five groups of adopters in TALC show a non-monotonous and even discontinuous behavior. This is associated with different degrees of adoption difficulties one groups has relative to the preceding one. Although such chasms exist between any two adjacent groups, the widest one with the highest consequences for the process of successful innovation adoption on the mainstream market is the one between the Early Adopters and the Early Majority (Figure 3-1).

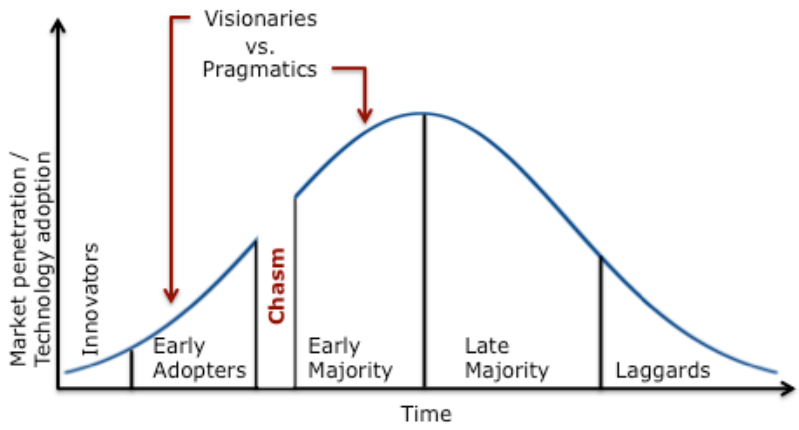

Figure 3-1: High-Tech Adoption life cycle[79].

[77] Ibid.

[78] Geoffrey A Moore and McKenna, *Crossing the Chasm Marketing and Selling High-Tech Products to Mainstream Customers* (Pymble, NSW; New York, NY: PerfectBound, 2001).

[79] Ibid.

As already mentioned, the increasing complexity of High-Tech innovations leads to a sizable gap between the producer's knowledge and that of the user/customer. The vast majority of mainstream users simply do not understand all the technical differences between products which seem to satisfy the same basic need, which drives them to rely almost entirely on references to justify their purchasing decisions[80].

The chasm in the adoption curve above arises mainly due to a low credibility of the Early Adopters for the Early Majority, with the later being reluctant to use the former as references. This is based on the almost complete lack of affinities between the two groups, more so than between any other neighboring groups on the curve. Moore identifies four distinguishing disjunctions between the two groups (page 69 and beyond in[81]), summarized here in Table 3-1.

Visionaries (Early Adopters)	Pragmatics (Early Majority)
Lack respect for the value of colleagues experience	Deeply value the experience of their colleagues and peers
Take grater interest in technology than in their industry	Do not put value on futuristic things
Do not acknowledge the importance of existing infrastructure	Connect with the mainstream practices
Little self-awareness about the impact of the discontinuity	Committed long term to their work.

Table 3-1: Visionaries vs. Pragmatics.

Considering the differences, it becomes apparent that, while the Visionaries look for "state-of-the-art", the Pragmatics expect "industry standard", and hence referencing the former to the latter is not easy. Furthermore, the chasm typically goes unrecognized, since the number of customers is relatively the same, so there are no direct signs of it happening. Moore proposes a "D-Day" type strategy to cross the chasm (chapter 3 in [82]):

1. focus on a market niche;
2. force the competitors out of that niche;
3. use the conquered niche for expansion to the mainstream market.

He then offers a set of tools to be used for each of the strategic steps, which do not make the subject of the present work. These tools are comprehensive marketing techniques, useful as soon as one accepts the D-Day strategy as being the appropriate one.

[80] in the case of Late Adopters and especially Laggards, it is mainly the peer pressure which convinces them to make the purchase of "new gadgets".

[81] Moore, *Crossing the Chasm Marketing and Selling High-Tech Products to Mainstream Customers*.

[82] Ibid.

3.1.1 Critical remarks to TALC

It needs to be stressed that the Visionaries–Pragmatics chasm should only be tackled once the Early Market has been conquered. This is consequential, since entrepreneurs or SMEs (the subject of this thesis) often introduce disruptive and radical: they do not enjoy the resources to simultaneously gain the early adopters and work on crossing the chasm.

The clear goal of crossing the chasm is to enter the mainstream market. Traditionally, this is the point where the company can really enjoy the fruits of innovation and product development, when little to no change is necessary, (mass) production can start, and stakeholders start receiving their dividends. This is still the case on the high volume consumer-type High-Tech products/services, where the number of sold items is measured in millions if not more, with all of them being essentially the same. This also explains the Bell-shaped curve of the technology adoption, with its characteristics following the normal (Gaussian) distribution[83].

The D-Day strategy shows how to transform a particular innovation into a success story on the mainstream market, with the result that everybody will purchase essentially the same product. This tacitly implies that, from the Pragmatics to the Laggards, all want the same solution to their problem:

$$customer\ purchases\ solution = customer\ wants\ \mathbf{that}\ solution \qquad \text{Equation 3-1}$$

This ansatz is not necessarily and full applicable on all markets, as demand is heavily filtered by the producers themselves: actually, not everybody wants the exact same product, but they are purchasing it due too a lack of alternatives (scarcity as defined in[84]). Hence,

$$available\ solution\ space \leq demand\ space \qquad \text{Equation 3-2}$$

This work is about crossing the chasm in a somewhat different kind of High-Tech business type: low volume, high value products for business-users (B2B) who are themselves developing innovations. Such a market is the Scientific Instruments one (exemplified in the Photon case below), aimed at research institutions. It is though necessary to understand that the innovation adopters still bear the main characteristics of the Rogers classification relative to the technological innovation under scrutiny.

[83] Rogers, *Diffusion of Innovations*.

[84] Lionel Robbins, *An Essay on the Nature of Significance of Economic Science*, 2nd Edition (Macmillan, 1945).

Here, the mainstream market is not a monolithic construct anymore, but a large number of niche markets. Even the Pragmatics require unique solutions to perform jobs never done before. Although these solutions fall under the same broad product category and hence we can define the mainstream market, each of them needs to have different features. The differences range from incremental to radical, with the latter deserving the appellative of innovations themselves.

3.2 The Long Tail

The Long Tail abstraction was developed by Chris Anderson[85] for the demand curve: "*Our culture and economy are increasingly shifting away from a focus on a relatively small number of hits (mainstream products and markets) at the head of the demand curve, and moving toward a huge number of niches in the tail. […] a Long Tail is just culture unfiltered by economic scarcity*". It draws on the economies of abundance (everything is available to everyone, page 11 in[86]), which transforms Equation 3-2 into:

$$available\ solution\ space \gg demand\ space \qquad \text{Equation 3-3}$$

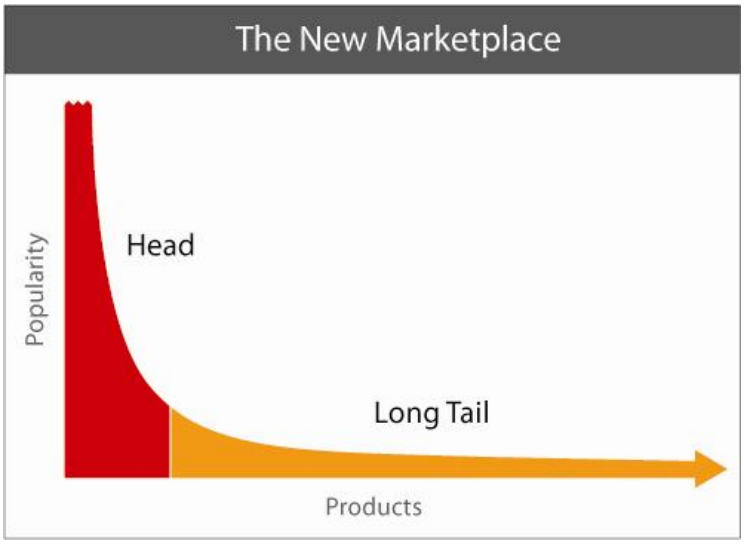

Figure 3-2: The Long Tail of the demand curve.

This can be displayed graphically using the demand curve in Figure 3-2: at the head of the curve (red), we have the popular products sold in large volume and for which the mainstream market defined above is indeed a monolithic one. These are the "hits", the successful innovations that, form the traditional point of view, made it. Nevertheless, when customers are given a large number of solution choices, they tend to gravitate towards niches (the orange Long Tail) since they satisfy the particular demands better.

[85] Chris Anderson, *The Long Tail; Why the Future of Business Is Selling Less of More* (Hyperion e-books, 2008).

[86] Ibid.

Consequently, it is desirable for a company to reach the niches and address individual needs. This desire is not new, but for most companies it remains unreachable: the costs are too high.

Anderson develops the details of this new economic concept for the consumer market, which is fundamentally changing based on the computer and Internet infrastructures. The latter allows for cheap production of digitalized goods (democratize the tools of production), cheap distribution thereof, as well as cheap means of connecting supply and demand[87].

The Long Tail attracted its fare share of critics, such as B. Schwartz in "The Paradox of Choice"[88]. In this psychology-based study, the author argues that more choice doesn't bring more happiness, as the consumer has to "invest time, energy, and no small amount of self-doubt, and dread" (p. 4 in[89]) which leads to the "tyranny" of choice (p. 155 in [90]).

One way to mitigate the two antithetical concepts is to offer the consumer "just enough" amount of choice and, without leading to confusion, as well as appropriate filters and support to navigate the choice. It is not about more choice, it is more about better choice.

Brick-and-mortar High Tech SMEs involved in B2B type business need to simultaneously satisfy several niche-markets, at high costs and low profits. Furthermore, with the object of the purchase being innovations, the demand curve does not have a pronounced Head, but is rather a flat Tail.

The strategic aim for such a company is to effectively leverage the potential of large offerings variety by:

1. recognize that heterogeneity of needs (the Tail) is not a threat, but a unique profit opportunity;
2. fatten the Tail;
3. lengthen the Tail just enough to satisfy individual demands in the market niches, but avoid confusion of choice (decision fatigue).

In a more mathematical form, this can be expressed as:

$$available\ solution\ space \cong demand\ space \qquad \text{Equation 3-4}$$

Traditionally, this means pure customization of innovations: each customer gets their unique product, researched and developed just for them. Clearly, this entails extremely

[87] Ibid.

[88] Barry Schwartz, *The Paradox of Choice: Why More Is Less* (HarperCollins e-books, 2004).

[89] Ibid.

[90] Ibid.

high costs and volatility for the producer, as well as long lead times, high-price, not always the expected quality, and even confusion for the customer.

The above predicament can be solved by employing yet another emerging concept to provide a strategic advantage and economic value in today's highly dynamic business environment: Mass customization. Basically, we need ***Mass Innovation: mass customization of innovations***.

3.3 Mass Customization

Grammatically speaking, the concept is an oxymoron: a construct from two otherwise antithetical concepts: mass and craft (single piece) production.

3.3.1 Definition and concepts

MC can be seen as the next step in the evolution of Production, after hand-made (manufacturing in its original sense) and the Industrial Mass Production. It is also part of the new Informational Society put forth by Alvin Toffler in his "Third Wave" book, where one should "*roll back the Industrial-Era creed of <<standardization>>, as exemplified in the one-size-fits-all approach typical of institutions of this era, such as the education system, factories, governments, mass media, high volume mass production and distribution.*"[91].

The first scholar to discuss and define MC was Stan Davis in 1997[92] (page 169), the term was popularized in 1993 by J.B. Pine II, [93], and the widely adopted definition is the one offered by Tseng and Jiao in[94]:

> *"producing goods and services to meet individual customer's needs with near mass production efficiency".*

Similar to OI, MC is a paradigm shift when it comes to manufacturing. The change to the industrial-era production is the active participation of the customer in the creation and/or production processes[95]. The co-production process[96] should though not be confused with the "do-it-yourself" approach, which implies the autonomous creation by customers.

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[91] Alvin Toffler, *The Third Wave*.

[92] Stan Davis, *Future Perfect* (Addison-Wesley Publishing, 1987).

[93] B. Joseph II Pine, *Mass Customization: The New Frontier in Business Competition*, Reprint (Harvard Business Review Press, 1999).

[94] Mitchell M. Tseng and Jianxin Jiao, "Mass Customization," in *Handbook of Industrial Engineering: Technology and Operations Management*, 3rd Edition (John Wiley and Sons, 2001).

[95] Frank T. Piller, "Mass Customization: Reflections on the State of the Concept," *Intern. J. of Flexible Manufacturing Systems* 16, no. 4 (2004): 313–34.

MC is a strategic opportunity to align the company with the customer needs by offering the latter what they want when they want it. MC offers better customer retention by building a long lasting learning relationship, which offers the advantage of more customer information, an always up-to-date customer preferences database - the "institutional memory" (p. 181 in [97]).

Salvador *et al* have identified three organization capabilities that determine the fundamental ability of a company to mass customize[98]:

Solution space development: the identification of idiosyncratic needs of its customers, specifically the product attributes along which customer needs diverge the most. Once this is realized, the company can define the solution space and therewith delimitate what it will and will not offer. This is one main competitive challenge for mass customizers, since it relates directly to the degree of individualization for that product/service. By also incorporating the preferences of the "interested only" potentials who end up purchasing somewhere else, the company can even better define the solution space, as well as adapt and refine it whenever necessary.

The solution space is usually defined along more dimensions, which are identified via market research, analysis of the user-generated data as well as past experience. The relevant dimensions, as well as their number are to be determined for each company (or even product) individually.

Robust process design: the capability to reuse and recombine existing organizational and value-chain resources, as to provide customized solutions with near mass-production efficiency and reliability. The goals here are to ensure the efficiency of the resources as well as the reliability of the delivery at a level comparable with the mass production.

There are various methods of reducing the impairment of the company's operations by the MC, with two examples being flexible automation and process modularity[99]. Actually, the literature addresses this in terms of Mass Customization Manufacturing Systems, with their performance depending on four critical areas: product design, product configuration, product processes, and supply chain operations[100].

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[96] Ramirez, "Value Co-Production."

[97] Richard Whiteley and Diane Hessan, *Customer-Centered Growth: Five Proven Strategies For Building Competitive Advantage* (Basic Books, 1996).

[98] Fabrizio Salvador, Pablo Martin De Holan, and Frank Piller, "Cracking the Code of Mass Customization," *MIT Sloan Manag. Rev.* 50, no. 3 (2009): 71–78.

[99] Pine, Victor Bart, and Andrew C. Boyton, "Making Mass Customization Work."

[100] Thorsten Blecker and Gerhard Friedrich, *Mass Customization Challenges and Solutions* (New York: Springer, 2006).

Adaptive human capital is another integral part of a robust process design - employees and managers have to be capable of dealing with novel and ambiguous tasks to offset any potential rigidness that is embedded in process structures and technologies [101]. Organizational types that can cope with such tasks are ambidextrous [102] in design.

The concept of Duality between stability and change[103] (Section 3.4) is an encompassing strategy for creating, developing and maintaining the robust processes necessary for MC.

Choice navigation: the capability to support customers in identifying their problems and the solutions while minimizing the complexity and burden of choice[104]. Inability to provide the right choice navigation can lead to confusion[105][106] (when the cost of choice evaluation is higher than the benefit of having the choice in the first place), which results in purchase postponement and even classification of the producer as undesirable and complex. The goals here have to be the minimization of the choice complexity, as well as the maximization of the enjoyment of the search process. Currently, there is a large number of configurators readily available as inspiration as well as ready-to-use tools. On his website[107], Frank Piller offers an encompassing list of available configurators.

MC can is the strategic process of placing and moving the company within a continuum space, with mass production at one end and customization at the other. This is a dynamic process, which needs continuous readjustments and changes, amounting to a perpetual customization of the customization[108]. The MC implementation is highly dependent on the particular competition, technology and customers needs, and should not "blindly use successful mass customizers as templates to copy"[109].

The success of the process is subject to the development and deployment of the three capabilities, as well as their interplay (Figure 3-3). A company need not necessarily

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[101] Salvador, De Holan, and Piller, "Cracking the Code of Mass Customization."

[102] Sebastian Raisch et al., "Organizational Ambidexterity: Balancing Exploitation and Exploration for Sustained Performance," *Organization Science* 20, no. 4 (August 2009): 685–95; Michael Tushman, Karim R. Lakhani, and Hila Lifshitz-Assaf, "Open Innovation and Organizational Design," *Journal of Organization Design* 1, no. 1 (May 31, 2012): 24–27.

[103] Moshe Farjoun, "Beyond Dualism: Stability and Change As a Duality.," *Acad. Manag. Rev.* 35, no. 2 (April 2010): 202–25, doi:10.5465/AMR.2010.48463331.

[104] Franke and Piller, "Value Creation by Toolkits for User Innovation and Design: The Case of the Watch Market."

[105] Rémi Desmeules, "The Impact of Variety on Consumer Happiness: Marketing and the Tyranny of Freedom," *Academy of Marketing Science Review* 12 (2002).

[106] Barry Schwartz, *The Paradox of Choice: Why More Is Less*.

[107] http://www.configurator-database.com/database

[108] Joseph Lampel and Henry Mintzberg, "1996_lampel_customizing Customization.pdf," *Sloan Manage. Rev.* 38, no. 1 (1996).

[109] Salvador, De Holan, and Piller, "Cracking the Code of Mass Customization."

improve on all of them simultaneously, but on that or those considered critical at a particular moment. However, all three capabilities are needed to reap the MC benefits.

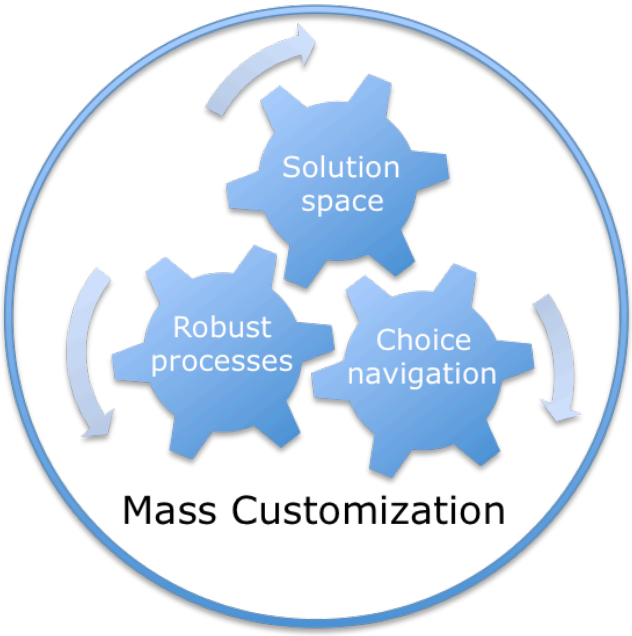

Figure 3-3: Fundamental MC capabilities and their interplay.

The three capabilities contribute directly to the MC value creation, provided they are correctly implemented: the solution space leads to increased gross utility to the customer, while appropriate choice navigation and robust processes will reduce the total costs.

3.3.2 Approaches to Mass Customization

MC is a value chain based strategy, as it incorporates the supply chain, development, manufacturing, marketing, logistics and all other segments along the value chain that need to adapt to this new paradigm. By definition, it also requires the involvement of the customer at a certain point along the value chain. Although each segment maintains its operational authority, the MC process is more often than not centrally coordinated[110].

Gilmore *et al*[111] have identified four basic approaches to MC:

Collaborative customization: here the customizer is engaged in a direct dialogue with the customer, aiming at articulating the latter's needs and identifying the offering that satisfies the need(s). This approach is Mass Customization par excellence, for it involves the customer from the design stage on (co-creation); it is appropriate when the customers cannot easily articulate what they want and grow frustrated by too many options.

Adaptive customization: here the customer can modify the product according to their particular needs after the purchase. The producer offers a standard but customizable product. It is the product that customers directly interact with, and not the producer. The

[110] Pine, Victor Bart, and Andrew C. Boyton, "Making Mass Customization Work."

[111] James H Gilmore and B. Joseph II Pine, "The Four Faces of Mass Customization," *Harv. Bus. Rev.*, January 1997, 91–101.

adaptive approach is appropriate for those markets where the customer demands different uses at different occasions, and the technology allows them to customize themselves.

Cosmetic customization: the product is standard, but its representation is customized (Figure 3-4). This approach is used when customers use the product the same way, but they are interested in individual ways of product presentation. This customization takes place late in the value chain (packaging), but it adds value to the customer.

Transparent customization: the customer is provided with customized products without explicitly knowing that they are unique. Transparent customization is appropriate when the customers' needs are predictable and when they (customers) do not want to state their needs repeatedly. Here there is no direct interaction between the customizer and the customer, with the former observing the latter's behavior inconspicuously.

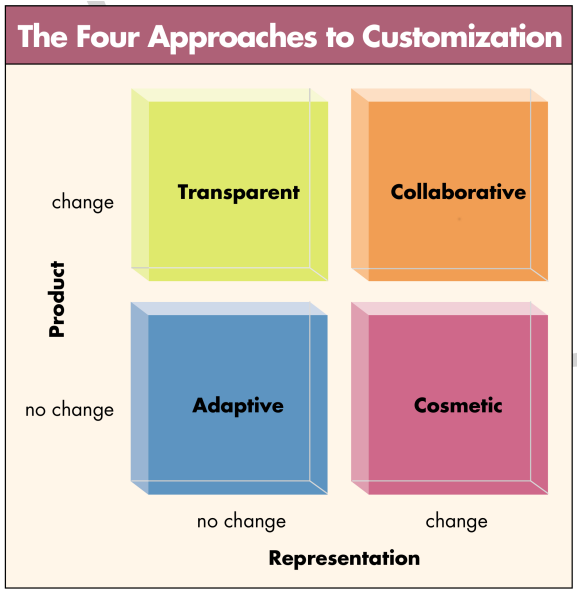

Figure 3-4: the four MC approaches along product and representation dimensions. Extracted from [112], p. 95.

Each and every one of the four approaches can shift the paradigm towards MC. However, a company can choose to implement a combination of them. As Gilmore *et al* put it[113] "*the key is to draw on <<whatever>> means of customization prove necessary to create customer unique value*".

3.3.3 MC and Postponement: Leagility

Fetzinger *et al*[114] identify an major point in the implementation of MC: "The key to mass-customizing effectively is postponing the task of differentiating a product for a specific customer until the latest possible point in the supply network (a company's supply, manufacturing, and distribution chain)". This is strongly related with the concept of

[112] Ibid.

[113] Ibid.

[114] Edward Feitzinger and Hau L. Lee, "Mass Customization at Hewlett-Packard: The Power of Postponement," *Harv. Bus. Rev.* 75, no. 1 (1997).

postponement, defined by Van Hoek [115]. The definition and a classification of postponement are offered in Appendix 7.4 below.

The connection between MC and postponement can also be seen in the context of **leagility**. Mason-Jones *et al*[116] define Leagility as the "*combination of the lean and agile paradigm within a total supply chain strategy by positioning the decoupling point so as to best suit the need for responding to a volatile demand downstream yet providing level scheduling upstream from the decoupling poi*nt". MC is indeed predestined for Leagility, as it implies both lean manufacturing (efficiency/mass), as well as agile manufacturing (responsiveness/customization). The different approaches to MC shift the Decoupling Point along the manufacturing continuum.

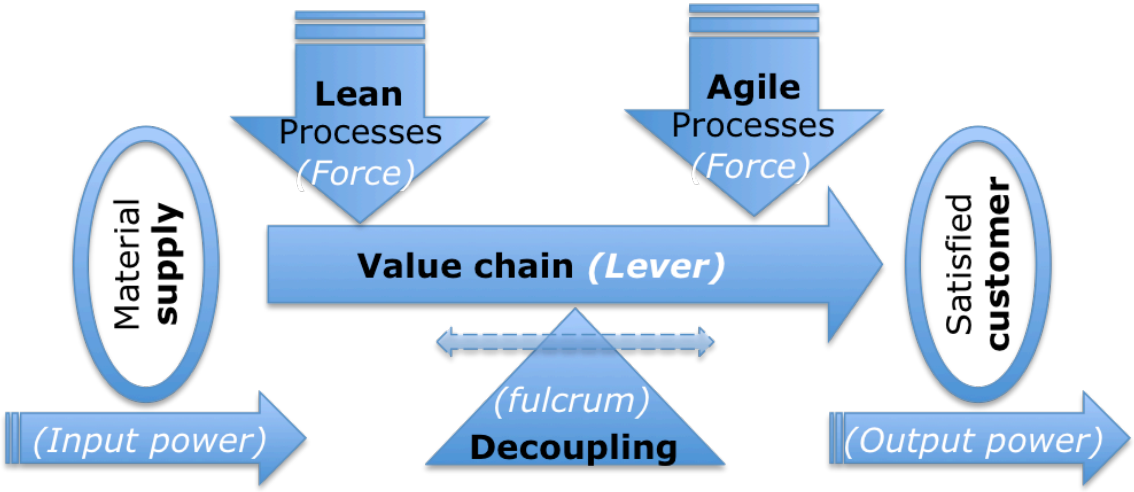

Figure 3-5: Leagility in the value chain. Based on Figure 1(c) in [117].

Figure 3-5 conceptualizes Leagility and the decoupling of the lean and agile parts of the value chain process. The figure is based on Figure 1(c) in the Mason-Jones paper[118] but it is somewhat adapted. The authors[119] see the Decoupling Point as a rupture between the lean and agile processes. I view the Decoupling Point more as a fulcrum onto which the manufacturing process as a whole can pivot similarly with a lever. The parallel with the physical concept of the lever appeals here, since it offers a more dynamic and encompassing view. The influence of the material supply (input power for the lever) can be transformed into maximum satisfaction of the customer (output power) by not only displacing the decoupling point (fulcrum) along the value chain (lever), but also (ii) by

[115] Remko I. Van Hoek, "The Rediscovery of Postponement a Literature Review and Directions for Research," *Journal of Operations Management* 19, no. 2 (2001): 161–84.

[116] Rachel Mason-Jones, Ben Naylor, and Denis R. Towill, "Engineering the Leagile Supply Chain," *International Journal of Agile Management Systems* 2, no. 1 (2000): 54–61.

[117] Ibid.

[118] Ibid.

[119] Ibid.

changing the importance (weights) of the lean and agile processes according to the particular needs.

3.3.4 Modular product architecture

One of the main enablers of the MC strategy is the offering itself. When it comes to products, one usually thinks about the modularity of the product architecture. This allows for near mass production efficiency and limits the options to the established solution space[120]. Modularity allows for a seamless transition from economies of scale towards economies of scope, where a limited number of components allows numerous end product possibilities[121].

Product architecture modularity was defined by Ulrich *et al*[122]as the use of "chunks" or modules with defined interactions and one or multiple functions. Although the concept of **module** enjoys numerous definitions, for the present purpose I choose the Gershenson *et al* (page 297 in [123]) one: *"Module is […] a component or group of components that can be removed from the product non-destructively as a unit, which provides a unique basic function necessary for the product to operate as desired".*

Modules share a series of fundamental characteristics[124]:

(i) cooperative subsystems that form a product.

(ii) main functional interactions within rather than between modules

(iii) one or more well-defined functions that can be tested in isolation from the system; are a composite of the components of the module

(iv) independent and self contained, may be combined and configured with similar units to achieve different overall outcome.

Modularity is not an absolute concept, with different producers applying it to different levels and using different types of modules. A module classification was offered by Duray *et al*[125] and is summarized in Appendix 7.5.

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[120] Piller, "Mass Customization."

[121] Pine, Victor Bart, and Andrew C. Boyton, "Making Mass Customization Work."

[122] Karl Ulrich, "The Role of Product Architecture in the Manufacturing Firm," *Res. Policy* 24, no. 3 (May 1995): 419–40, doi:10.1016/0048-7333(94)00775-3.

[123] J. K. Gershenson, G. J. Prasad, and Y. Zhang, "Product Modularity: Definitions and Benefits," *Journal of Engineering Design* 14, no. 3 (September 2003): 295–313.

[124] Russell Marshall, P. G. Leaney, and P. Botterell, "Enhanced Product Realisation through Modular Design: An Example of Product/process Integration" (presented at the Third Biennial World Conference on Integrated Design and Process Technology, Society for Design and Process Sciences, Berlin, 1998).

[125] Rebecca Duray et al., "Approaches to Mass Customization: Configurations and Empirical Validation," *J. Oper. Manag.* 18, no. 6 (November 2000): 605–25, doi:10.1016/S0272-6963(00)00043-7.

Modular architecture is mostly associated with benefits: use of modules across product families, ease of update, product variety (MC), decreased lead-time, etc. Nevertheless, there are also costs resulting from a modular architecture as opposed to an integral one.[126][127]: static architecture, lack of performance optimization due to lack of interaction, decreased component optimization which rise the variable costs, lack of synergistic effects, etc. For successful MC, modular product needs to be constantly renewed.

Most of the available literature on modular architecture refers to optimization of traditional product development, and less to innovation. Henderson *et al*[128] make the connection between the two fields under the umbrella of **architectural innovation**, defined as: *"Innovations that change the architecture of a system without changing its components".*
This concept can have deep implications in competitiveness level of incumbent company, which by inertia tend to innovate more on a component level and lack creativity on the system (product) level, thus missing on architectural opportunities to innovate.

3.3.5 Mass Customization generated value

The main question here is: how much value does MC generate relative to other strategies, if at al? As I have heard more often than not, the correct answer to such a question is "it depends". Indeed, it depends on the exact industry, company, time, etc. Nevertheless, one can (conceptually and qualitatively) answer the question. In my attempt, I draw on those heard in a recent class from Frank Piller. In the class, he mentioned the question, and made the comparison between MC and MP strategies. For the purpose of this work, this is not enough though: High-Tech SMEs rarely (are able to) employ MP, they usually come from the craftsmanship end of the spectrum, as innovators and even pure customizers. Figure 3-6 summarizes in a simple and intuitive manner my understanding of the value generated by the three main strategies.
In *Mass Production*, the product represents a certain gross utility (GU) to the customer. In order to obtain this GU, the costs to the customer are those related to acquisition (AC) and search and evaluation (SEC). Since this is a standard product, we assume that all costs are already minimized (standard offering in an economy of scale), and we can take the GU as standard measure. Then, the generated value (GV) is:

$$\mathrm{GV}_{mass\ production} = \mathrm{GU} - (\mathrm{AC} + \mathrm{SEC}) \qquad \text{Equation 3-5}$$

[126] Gershenson, Prasad, and Zhang, "Product Modularity."

[127] CC Huang, "Overview of Modular Product Development," *\ldots Sci. Counc. Repub. CHINA PART A \ldots* 24, no. 3 (2000): 149–65.

[128] Henderson and Clark, "Architectural Innovation : The Reconfiguration of Existing Product Technologies and the Failure of Established Firms."

For a *pure customization* strategy, the GV can be written as:

$$\mathrm{GV}_{pure\ customization} = (\mathrm{GU} + \delta\ \mathrm{GU}) - (\mathrm{AC} + \Delta\ \mathrm{AC}) - (\mathrm{SEC}\ \Delta\ \mathrm{SEC}) \qquad \text{Equation 3-6}$$

The GU perceived by the customer is larger than the one derived for MP (GU + δ GU). The difference (δ GU) is attributed to the availability of customization, as the customer does not need to compromise to the best standard product alternative (closing the sacrifice gap).

On the other hand though, the costs associated increase as well: being a pure customized product, the acquisition cost will be much larger (AC + Δ AC); furthermore, the SEC is also increasing significantly (SEC + Δ SEC), since the customer has to actively participate throughout the process of defining the desired outcome. Hence, although the GU is large, the generated value (GV) here is expected to be (and practice shows that it is indeed the case) much lower than for MP. This conclusion is nothing else than the paradigm of the industrial era.

The *Mass Customization* strategy is a combination of the above two. At a quick glance, the GU should be the same with the case of pure customization, since the customer does get exactly what they need.

A closer consideration reveals that, if employed, the process of co-creation itself adds to the GU, with customer showing hedonistic and instrumental benefits when customizing their selection (similar to the shopping experience); hence the total GU will be the highest (GU + Δ GU). Provided the offering does fulfill the individual customer needs, there is no doubt that the GU is larger in this case than for MP. On the other had though the costs also increase when compared to MP but not as high as pure customization: the acquisition cost is usually larger for an individually tailored product (AC + δ AC), but if produced according to the MC principles not as large as for pure customization (δ AC < Δ AC); the search and evaluation here involves the customer much more, raising the costs as well (SEC + δ SEC), but again not as high as for pure customization (δ SEC < Δ SEC).

$$\mathrm{GV}_{mass\ customization} = [(\mathrm{GU} + \Delta\ \mathrm{GU}) - (\mathrm{AC} + \delta\ \mathrm{AC}) - (\mathrm{SEC} + \delta\ \mathrm{SEC}) \qquad \text{Equation 3-7}$$

Interestingly, it appears that the GV in the MC case is lower than for MP, but larger than for pure customization.

In order for MC to perform in a successful manner, one needs not only to maximize the GU (or the solution space), but also to actively strive to decrease the acquisition costs (associated with the robust processes) and the search and evaluation costs (choice navigation) ideally to the level of their MP correspondents (graphically represented by the

downwards arrows in Figure 3-6). It can be said that MC creates value by addressing individual needs and closing the customer sacrifice gap.

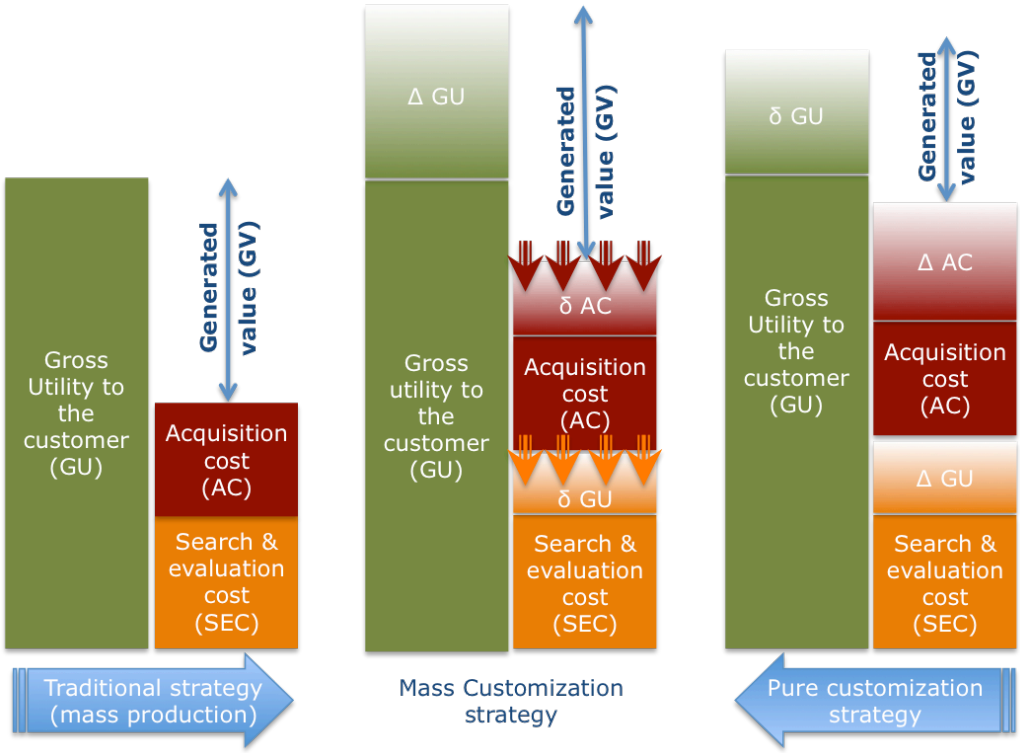

Figure 3-6: Generated value by MP, MC and pure customization strategies.

A second important learning is that, all other being equal, the value generated by MC is higher than for pure customization. The main take home message is that a customizer should always aim towards MC as strategic means to grow and prosper.

The question of a price increase necessity (relative to MP) or decrease (relative to pure customization) remains open here, since I believe it to be complicated enough to grant a case-by-case strategic consideration. Furthermore, here we deal with High-Tech innovative SMEs, hence mainly customizers. In such cases, the prices of the custom products are already at the uppermost segment allowed on the market. Consequently, the MC implementation (with the reduction in costs outlined above) can only lead to a price reduction, hence a positive effect on both customer and producer.

Form the producer perspective, an additional benefit of MC is the increased product lifetime: if what the customer buys is customized, the probability for the product to get out of fashion decreases. The producer simply increases the lifetime by offering more variations as well as changing the variations whenever necessary (knowledge from the

institutional memory), and thus also allowing for too-late adopters to find their own product.

3.3.6 Prerequisites for mass customization

The success of MC as competitive strategy depends on a number of internal (within the organization borders) and external (market and ecosystem) factors. The literature abounds with recipes for success and a sufficiently detailed overview can be found in in [129], Section 2.5. Here I only extract and list the relevant factors.

Although satisfying these factors is necessary, it is not sufficient: the whole process (consisting of numerous sub-processes) needs to be coordinated and managed in a strategic manner. Pine *et al*[130] argue that managers who intend on applying MC need to turn their processes into modules and consequently link such that it allows them to integrate rapidly the best way or sequence required to tailor the products or services.

	Internal factors	External factors
Mass Customization	**customizable nature of the product** (modular architecture)	**appropriate market conditions** (competitive & turbulent environment)
	culture and organizational design (*e.g.*, knowledge sharing, empowered management),	**customer customization sensitivity** (uniqueness of customer's needs & level of customer sacrifice)
	supply chain readiness (e.g., flexibility, need for "just in time delivery")	**Short product life cycles**
	integrated value chain (reduce complexity)	**Conscious customers**

Table 3-2: Internal and external success factors for MC.

The quote below contains the essence of the leadership requirements for successful MC:

> *"Managers in these ever-changing settings are coordinators whose success depends on bow well they perfect the links that make up the dynamic network. They must create a culture that places a big value on the diversity of employees' capabilities. […] And leaders must replace a vision of "being the best" in an industry with an ideology of satisfying whatever customers want, when they want it. […] In addition to different attitudes about customer interactions, leaders of continuous improvement companies and mass customizers foster very different approaches to the future. The former think they know what the organization needs to do to succeed in the future, whereas the*

[129] Aiste Altonen, "Success Factors of Mass customization–Cases: Chocri and Shoes of Prey" (Master's Thesis, Aalto University, School of Economics, 2011).

[130] Pine, Victor Bart, and Andrew C. Boyton, "Making Mass Customization Work."

latter believe that it's impossible to know and heresy to try because the future should be shaped by each successive customer order"[131].

3.4 Duality as strategic organizational management

Traditionally, most companies are organized either for exploitation (static stability and efficiency, mass production, repetition, consistency), or exploration (strategically organized around leveraging the novelty and not the resulting product/service, change, flexibility, variability, innovation, adaptiveness). The original description of the terms was offered in the context of organizational learning by March [132] in 1991 with direct consequences in an organization's survival:

The essence of exploitation is the refinement and extension of existing competencies, technologies, and paradigms. […] The essence of exploration is experimentation with new alternatives.

Numerous subsequent literature debates not only the definition of the two terms, but also their usage and their implications for organizations (for a more comprehensive and in depth review on the subject, the reader is directed to [133] and the references therein)

With the advent of the distributed knowledge society, Open Innovation, and Mass Customization, it became apparent that the times when the customer can buy the car painted in any color as long as they it is black[134] and Nicola Tesla being the archetypal (mad) inventor are at an end. The real challenge for organizations, therefore, was in recognizing and accepting that the tension between stability and change is natural and legitimate, and that each side of the paradox has merit[135], and ambiguity is an asset. As this is a different and at times confusing state of mind required from the modern leadership, this section aims at displaying possibilities for dealing with it as well as a number of implications.

There are successful companies employing both aspects, but in a pendulum-like motion, following the „either/or" logic. For example, temporal ambidexterity (or punctuated equilibrium) encourages periods of flexibility followed by ones of reliability and back again; structural ambidexterity separates the business units along the two dimensions and

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[131] Ibid.

[132] J. G. March, "Exploration and Exploitation in Organizational Learning," *Organization Science* 2 (1991): 71–87.

[133] Gupta, Smith, and Shalley, "The Interplay between Exploration and Exploitation."

[134] Henry Ford (1922), My Life and Work, Chapter IV, p. 71: "Any customer can have a car painted any color that he wants so long as it is black."

[135] Graetz and Smith, "Duality Theory and Organizing Forms in Change Management."

manages them separately under a shared vision[136]. Conceptually, this could be described as a well-managed **dualism**. Under a dualism perspective, the exploitation/stability and exploration/change sides are treated as mutually exclusive and their juxtaposition paradoxical. They are complementary, but contrasting, antithetical and with clear boundaries and no overlap[137]. This might be a result of the general academic pursue to explain systems and situations by splitting them into stand-alone impermeable characteristics. Often this black/white perspective is literally applied by managers kin to use the knowledge gained either at the "Innovation management" or "Operations management" seminars, disregarding the whole palette of gray in between. Large organizations might have the luxury to separate the two in different structural units, *e.g.*, R&D and production, respectively, but for SMEs such a dualism might prove challenging.

M. Farjoun[138] constructs (based on the Jackson work[139]) an alternative conceptualization to dualism, the **duality**:

> *"the twofold character of an object of study without separation. Duality resembles dualism in that it retains the idea of two essential elements, but it views them as interdependent, rather than separate and opposed. Consistent with duality, I maintain that stability and change are fundamentally interdependent—both contradictory and complementary. I explore in particular how these elements, while conceptually distinct, are mutually enabling and a constituent of one another".*

Here, stability and change (or alternatively exploitation and exploration) are not only compatible, but also interdependent and mutually enabling. In other words, they cannot be clearly separated, as they are constituents of each other. They are simultaneously outcomes, objectives and underlying mechanisms (*e.g.*, processes). As such, reliability- and stability- oriented outcomes might require and promote variation-inducing mechanisms such as innovation and vice versa[140].

The choice of Farjoun's dimensions over others available (*e.g.*, the characteristics by Graetz et al.[141142]) is based on the fact that the former are not purely descriptive and

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[136] Raisch et al., "Organizational Ambidexterity."

[137] Gupta, Smith, and Shalley, "The Interplay between Exploration and Exploitation."

[138] Farjoun, "Beyond Dualism: Stability and Change As a Duality."

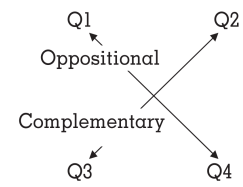
[139] W. A. Jackson, "Dualism, Duality and the Complexity of Economic Institutions," *International Journal of Social Economics* 26, no. 4 (1999): 545–58.

[140] Farjoun, "Beyond Dualism: Stability and Change As a Duality."

[141] Fiona Graetz and A. C.T. Smith, "The Role of Dualities in Arbitrating Continuity and Change in Forms of Organizing," *International Journal of Management Reviews* 10, no. 3 (September 2008): 265–80.

[142] Graetz and Smith, "Duality Theory and Organizing Forms in Change Management."

explanatory, but suggest direct connections between duality components. The discussion below is based on and draws extensively on the Farjoun study[143].



Outcomes (performances, objectives)	Mechanisms (processes, practices, forms): Stability — Habits, routines, institutions, discipline, tight coupling, limits, commitments, control, and low variance	Mechanisms (processes, practices, forms): Change — Search, mindfulness, redundancy, openness, preoccupation with failure, imagination, and variety
Stability — Continuity, low variance, predictability, regularity, and reliability	**Q1. Exploitation** Selected manifestations: • Control reduces variation • Standardized routines and formalization lead to efficiency and undermine innovation • Commitment and specialization enhance reliability and reduce adaptability	**Q2. Change enables stability** Selected manifestations: • Redundancy and loose coupling increase reliability • Moderate experimentation mitigates drastic failures • Doubt and mindfulness foster security and continuity
Change — Adaptability, high variance, innovation, and flexibility	**Q3. Stability enables change** Selected manifestations: • Control enables design and invention • Routines and formalization help manage the nonroutine • Commitment and specialization enhance adaptability	**Q4. Exploration** Selected manifestations: • Redundancy and loose coupling promote flexibility and innovation • Experimentation promotes adaptability and undermines reliability • Doubt stimulates discovery and change

Figure 3-7:Duality: classification of change and stability relationships[144]

3.4.1 Duality relationships

This is a dynamic equilibrium where one outcome requires elements of the other. Farjoun summarizes the relationships between stability and change in a graphical manner, reproduced here (from page 206 in[145]) in Figure 3-7. Quadrants 1 and 4 show the dualistic opposing view of exploitation and exploration and their implications, while Quadrants 2 and 3 display the duality interdependence and the implications of stability and change.

3.4.1.1 Change and variation enable stability

In a dynamic environment, stability cannot only refer to rigidity and passivity, but also adaptability, and it needs to e based on reliability[146]. In the dualistic framework, reliability is opposing efficiency (as defined in the dualistic morel), as it requires diversity, duplication, overlap and a varied response repertoire. Enabling and enhancing reliability allows for stability (long and short term), safety and robustness against perturbations:

Redundancy and loose coupling increase reliability - built in technological and economical systems, they enable learning and detection and correction of multiple small failures. Based on variety, excess, and duplication, they allow both stability and adaptability.

[143] Farjoun, "Beyond Dualism: Stability and Change As a Duality."

[144] Ibid.

[145] Ibid.

[146] I find the Farjoun's referral to the acrobat on a wire as nice intuitive visualization of the relationship stability – adaptability – reliability.

Moderate experimentation: failing less by failing more – although counterintuitive, trial-and-error risk-taking is preferable for securing stability, since without trial there are no errors and hence no learning. Failure draws attention to potential problems and stimulates the search for solutions[147]. Therefore, in the long run systems can fail less, meaning in less drastic and painful ways, not by avoiding failure but by actively and intelligently engaging in small or quasi-failures.

Mindfulness: Fostering Security and Continuity by Encouraging Doubt - in some settings (*e.g.*, high-risk), trial-and-error is not appropriate. Instead, the organization tries to avoid or circumvent failure via cognitive and operational processes (*e.g.*, preoccupation with failure, deference to expertise, reluctance to simplify interpretations) to augment feedback controls with anticipatory feed-forward learning processes. Novelty activates doubt and alertness via inevitable encounters with surprises and anomalies, and this fosters anticipation and adaptive reactions.

3.4.1.2 Stability enables Change and adaptability

Innovative firms do use control systems and rely on highly disciplined specifications in their innovative process[148].

Institutions and limits as enabling - while traditionally they constrain choice, reduce flexibility and restrain freedom, if correctly employed they can serve as higher-level premises, fostering legitimacy and trust, and constituting enabling frameworks for emergent action. They can also reduce uncertainty, facilitate adaptation, and regularize innovation, provide group autonomy and supply security and consistency.

Design and Invention as Disciplined Imagination – engineering knowledge is based on selecting scientific principles and rules of thumb. Scientists and researchers heavily rely on "educated guesses" which draw on their education and experience. Such discipline and selectivity allow for adaptability and free up resources to deal with nonroutine tasks.

Routinizing the Nonroutine –routines and stable processes enable the organization to tackle unexpected situations. To innovate, organizations need to reduce uncertainty, forster coordination for guiding, promoting and reproducing the innovation processes towards sustained progress. Although parts of creativity / innovation are hard to systematize and institutionalize, an effective use of well chosen bureaucracy, control systems and formalization can enable and facilitate nonroutine work, and even provide a frame to put into practice ideas leading to radical innovation.

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[147] Sim B. Sitkin, "Learning Through Failure: The Strategy of Small Losses," *Research in Organizational Behavior* 14 (1992): 231 – 266.

[148] R. Simons, *Levers of Control: How Managers Use Innovative Control Systems to Drive Strategic Renewal* (Harvard Business School Press, 1995).

Adaptability through Specialization and Commitment – commitment enables innovation and flexibility since (i) it implies behavioral channeling and hence frees resources for flexibility, and (ii) it focuses attention and provides the background to stimulate the discovery of solutions[149].

3.4.2 Remarks on Duality

In the real world, innovative organizations make use of several of the above relationships simultaneously to reach the two overarching goals of long-term reliability (stability) and sustained[150] innovation (change). The duality theory need not be the holly grail. It appeals to me especially since is closer to reality than other theories based on "either/or", or concepts sold according to "use [insert concept/method name] to have the perfect organization in 5 easy steps". It allows for nuances, as well as includes the important dynamic dimension. Even more, it relates to a certain extent to another theory preaching adaptability: the Black Swan theory developed by Nassim N. Taleb[151]. Here, Black Swans are unexpected events that happen seldom (disruption) and have large consequences (positive as well as negative). Since such events are unpredictable, one has prepare for the future without knowing what the future brings – a similar view with the one needed for Mass Customization leadership.

For duality to work its magic, the whole value chain has to be prepared and aligned accordingly: from the supply chain, going though production and company-internal processes, sales and marketing strategies, to the customers/user. All components of organizational design need to be considered: structural components (goals, strategy, structure, etc.) as well as human components (processes, people, incentives, culture, etc.). In other words, it is a strategic decision of the leadership backed by the organizational culture, and its correct implementation makes the difference between chaos (unwanted), and duality as dynamic and creative tension between "opposing poles"[152][153] (wanted).

One of the two goals of MC is reaching "near mass production efficiency" (Section 3.3.1 above). As soon as we broaden the meaning of the word "efficiency" and replace it with

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[149] Thomas S. Kuhn, *Structure of Scientific Revolutions*.

[150] In this context, sustained innovation refers to strategy of innovating over a long period of time, and should not be confused with one sustainable innovation.

[151] Nassim Nicholas Taleb, *The Balck Swan - the Impact of the Highly Improbable*, 2nd ed. (Random House, 2010).

[152] RT Pascale, "Surfing the Edge of Chaos," *Sloan Manage. Rev.* 40 (1999), http://sloanreview.mit.edu/article/surfing-the-edge-of-chaos/.

[153] Paul A. L. Evans, "HRM on the Edge: A Duality Perspective," *Organization* 6, no. 2 (May 1, 1999): 325–38.

”reliability”, we are faced with yet another dichotomy very similar to the change-stability duality. Hence, this student argues that MC can enable duality and vice versa.

3.5 Mass innovation

The discussion below is restricted to High-Tech brick-and-mortar companies involved in a B2B business type, as opposed to online and/or B2C. Although many of the findings might be applicable to other type of businesses, this is not the object of this work.

High-Tech B2B companies: customizers

MC is strongly associated with short product life times. Nowhere is this more present than in the High-Tech industries, where innovation and customization are continuously necessary for the very survival and growth of the companies involved. In other words, these organizations (customizers) are attacking the MC paradigm from a different perspective than the one of the standard producers (producers of standard goods). The customizers (also named craft producers or one-of-a-kind manufacturers) are enticed by MC as a strategic journey towards volume expansion based on existing similarities between end products[154].

The available literature on MC seems to be more concerned with standard (and large) producers, with only a handful of studies actually granting the customizers enough importance to be treated separately. One such work is the one by Duray *et al*[155], who develop an empirical study on the origins of MC and touch upon the differences between standard producers and customizers. They find that the two producer kinds differ along two identifiers of MC, the customer involvement point and the “mass” aspect. The differences can be summarized as:

(i) standard and custom producers adopt distinctly different MC approaches. The latter involve the customer earlier in the MC process.

(ii) those practicing MC also produce non-MC products in the same plant. Customizers are involved in both MC and pure customization.

(iii) companies adopting approaches to MC that most closely resemble the non-MC products will exhibit higher financial performance.

These differences are especially meaningful: customizers should tailor their MC strategy to closely fit their customization capabilities, and not to mimic those of a standard producer. The first step towards this goal is to thoroughly understand one’s existing capabilities and environment.

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[154] Blecker and Friedrich, *Mass Customization Challenges and Solutions*.

[155] Rebecca Duray, “Mass Customization Origins: Mass or Custom Manufacturing?,” *International Journal of Operations & Production Management* 22, no. 3 (2002): 314–28.

High-Tech B2B SMEs: customizers & innovators

SMEs deal with limited resources, highly demanding customers and large product variety necessary. Many (still) strive to cross the chasm to the mainstream markets[156] (Section 3.1). If many a large corporation can afford to allocate resources to different business units / department in charge of either the innovation (exploration) or the production (exploitation) sides respectively, in a smaller company this is practically impossible. One reason for it is the scarcity of resources, many of which cannot be strictly allocated and are used "in common" (fungible).

Furthermore, a small company in High-Tech B2B needs to be not only a customizer, but a strong innovator and usually has a low(er) number of (high value) customers. This entails that (i) the customer is involved in the value chain form the very beginning – the decoupling point shifts towards the innovative idea, and (ii) the organization, its processes and leadership must be much more flexible – the agility part of the Leagility is more powerful in order to counterbalance the shift in the decoupling point.

Is Mass Customization of Innovations even possible? In other words, can one successfully innovate by employing the framework and tools of Mass Customization?

A number of deviations from the standard MC theory can be identified here:

(i) the customer participates in defining and refining the solution space, which cannot be pre-defined, but allows for swift changes at all times (permeable boundaries).

(ii) highly increased individual customer pressure (high value customers) shift and/or enlarge the existing solution space towards pure customization

(iii) the interaction producer – customer takes place face to face and at all levels, from R&D to Sales and Marketing. This improves the choice navigation (active human dialogue) and reduces the need for elaborate online configurators, but also increases the importance of the agility in company's organizational design.

The first deviation above is very similar to the Open Innovation paradigm. Hence, a company fit for OI would have a higher chance to succeed here. MC requires a "fixed solution space", which is defined by the producer and is not subject to change by the customer: the latter does not participate in the choice definition, but only in the configuration of the solution during the phases of design, fabrication, assembly, or use[157].

[156] This is indeed just a common sense assumption, since I do not have hard data to support it. Nevertheless, at least the company chosen for the case study detailed later on follows the assumption. Hence, the reader is advised not to take this as full generalization.

[157] Paul Zipkin, "The Limits of Mass Customization," *MIT Sloan Manag. Rev.*, no. Spring (2001): 81–87.

In OI, since the customer is involved in the development from the idea stage (genesis), the boundaries of the solution space are somewhat permeable: although the producer has the last word, the customer can propose solutions to his problems which deviate from the existing solution space. Clearly, such deviations have to be small; otherwise the "mass" part of the MI would not apply anymore. They will also happen seldom, and can be associated with propositions of radical or even disruptive innovations. In such cases, one deals with a hybrid solution, part MC and part "pure customization"[158] – see Appendix 7.6 for an argument on radical innovation in the Mass Innovation framework.
The second deviation should not raise problems to a pure customizer, since this pressure to customize is already "daily business".
Finally, the third deviation from the standard MC model can be accommodated by an organization designed along the Duality Theory lines.

In conclusion, **Mass Innovation** is possible by strategically implementing the right mix of MC, OI and Duality capabilities. The stress here is on "strategic" and "right mix": the company has to analyze and understand its capabilities along the three dimensions, establish its goals strategically and improve on those dimensions that lag behind.
Figure 3-8 displays in a conceptual manner the strategic mix necessary for successful Mass Innovation. It also suggests the dynamic nature of Mass Innovation and hence the capability mixes: this is not a static model, which once implemented will remain unchanged. On the contrary, it necessitates adjustments continuously, as to follow the momentary and future needs of the company and customer.

Furthermore, the choice of a propeller as visual vehicle should direct towards another significant symbolic implication: Mass Innovation is the strategy enables success by moving the company ahead but it does require an engine to power it (organization and production), fuel (customer), and a rudder to establish the right course (leadership).

[158] Blecker and Friedrich, *Mass Customization Challenges and Solutions*.

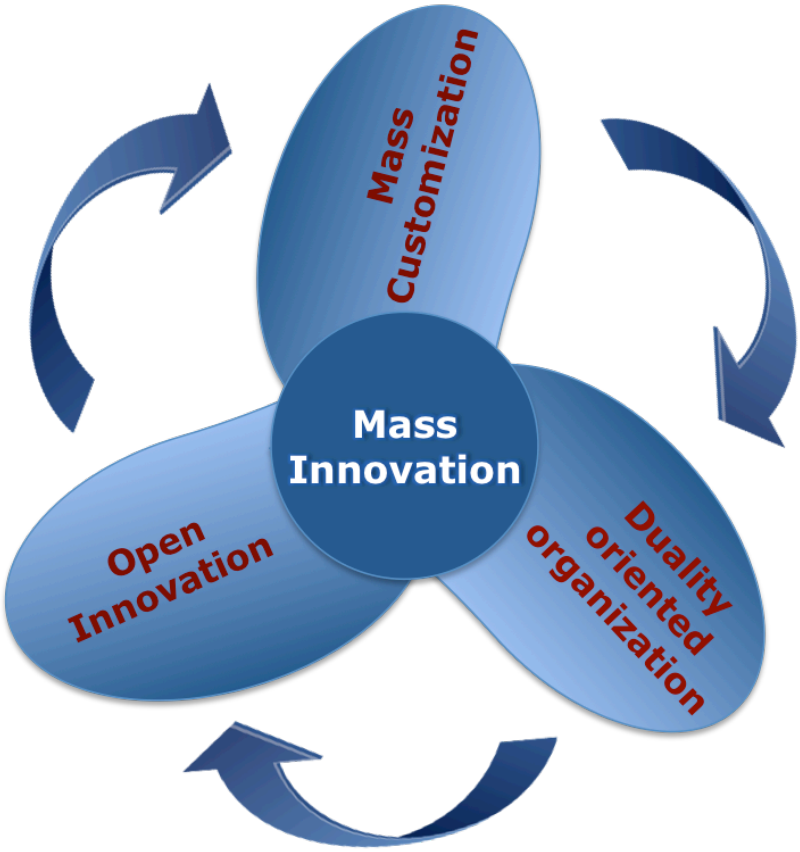

Figure 3-8: Mass Innovation- strategic mix of Open innovation, Mass Customization and Duality capabilities.

Mass Innovation is ideally suited as strategic enabler for High-Tech innovative SMEs doing B2B business in their endeavor to cross the early market to mainstream market chasm. Making the connection between the incremental-to-radical (or alternatively breakthrough-to-continuous) innovation space and the technology adoption life-cycle, the company employing Mass Innovation has to focus with the breakthrough innovations on the early market (mainstream market dislikes discontinuities) and continue with the more continuous ones onto the mainstream one. This way, the firm can actually cross the chasm with products displaying different degrees of innovativeness addressed to different adopter type. If correctly deployed, Mass Innovation allows for innovating and customizing the same product family.

4 Photon case: High-Tech B2B SME facing chasm

This chapter treats the case of Photon, one High-Tech B2B SME faced with the chasm between the early market and the mainstream one. The treatment is done form an overarching strategic perspective. It aims at establishing the applicability of MI for crossing the chasm and the readiness of the company for it, as well as at suggesting strategic improvements and changes whenever necessary.
The choice of the company is motivated on three grounds: (i) it is highly innovative, to the point of selling innovation and not standard products; (ii) its customers are inventers and innovators themselves; (iii) it is an SME.

4.1 Photon: company profile

Photon is a producer of special High-Tech state-of–the-art photonics equipment. Its primary customer circle (~95%) is composed by research institutions around the world, ranging from Universities to National Laboratories. This qualifies the classification of the company as being active largely on the B2B Scientific Instruments market.

It was founded in 1999 as spin-off of a renowned university in Munich, Germany, with the two founders still owning it. It is and always has been self-financed via bootstrapping, and investments are done out of the cash flow. The company is active globally, and performs direct sales on some geographical markets, while having Distributors on others.

It currently employs 47 people, and hence it qualifies as SME. The founders themselves are well-known researchers, and as such they have extensive technology and market experience. More than 50% of its employees hold a high education degree (MSc, PhD, PD, or Professor) in natural sciences or relevant engineering and are recognized specialists in photonics. The organization is based on a flat hierarchy, and information flows freely. Every employee is not only encouraged, but expected to take responsibility for their product/project, but for the whole company as well.

Photon’s offerings are complex and demanding High-Tech innovations, customized to a large degree. They are perceived as top-notch and address mostly the niche of the most demanding research applications. Pricewise, the products are placed on the high end of the range.

4.2 The market

Photon is mainly active on the Scientific Research market at a global level. The market branch where its products are found concerns the Photonics Equipment, with an overall size estimated to about 100 million EUR and a healthy (but not explosive) growth rate. The growth rate is higher in the Developing Countries, especially where education and scientific research are recognized as strategic capabilities and investments increase. The market can be further segmented along the applications where the equipment is used, but each segment would show similar characteristics, in a fractal fashion (fractal is a natural phenomenon or a mathematical set that exhibits a repeating pattern at every scale[159]).

The products range from components (priced between hundred and thousand(s) EUR), to integrated systems reaching prices in the one million EUR range. This means that orders count in the single or at few units. The money is vastly public in origin, being allocated from state budgets for science and research following public tender procedures (the procedures are different for each country and granting agency or authority). The efforts and resources necessary "to bring in a sale" correlate with (i) the value of the sale (ii) the amount of customization necessary and (iii) with the momentary state budget situation. The sales process for a system can take two years or longer, and the production and delivery to the end user between 6 months and one year. Standard components are mostly available on stock, custom ones and all the integrated systems are made to order.

As expected, radical and even disruptive innovations and innovators are a common presence on such a market and the lifetime of most products is rather short.

4.2.1 The end customer

Officially, the Photon's customer is the research institution. Nevertheless, apart from singing the contract, the sales process takes place directly with the researcher interested in the equipment, which applies for the budget and also decides for or against the purchase. With the institution involved only in the administrative part of the transaction, it is the researcher who can be considered the real customer. The discussion hereafter is solely concerned with the researcher, who is named either customer or end user.

All end users are by default innovators, making use of the equipment in the quest for new discoveries, either on the fundamental technology level or on a more applied level (new applications). This is a different setting when compared with the "normal" industrial or consumer market, since success is measured almost entirely along the "newness" dimension: researchers are by definition interested in discoveries, and their success along this line is what gives them recognition among the peers. Consequently, they either

[159] Benoît Mandelbrot, *Les Objects Fractals: Forme, Hasard et Dimension* (Flammarion, 1975).

employ or combine almost standard equipment to perform new operations, or require completely new equipment capable to perform new and very specific operations. The difference between these two end user categories is of paramount importance in understanding the diffusion of innovation on this market and also allows for a differentiation of the offerings.

Since customers here are innovators, the need arises to amend the denomination of innovation adopters developed by Rogers[160] and detailed in Section 2.4 above. This is done along the expertise of the user with respect to the technology[161] and their use thereof, and less along their socioeconomic characteristics.

Table 4-1 summarize the main characteristics of the end users (innovation adopters) on the scientific research market. The most notable difference from the Rogers model is the split of the Early Adopters into Experts and Lead users. This is qualified here, since the Experts demand breakthrough innovations for "proof of the principle" type applications, while the Lead Users require deeply customized equipment (unique) for completely new applications. Furthermore, the place of the Laggards is taken by the appearance of a secondary market (the industrial applications). This is not to say that the 2nd market is traditional, it simply appears later than the research one.

Innovation adoption	Point of adoption	Rogers[162] typology	Scientific Research Market
Early market	Immediate	Innovators	**Developers:** • Extensive tech. knowledge • Active tech. participation in breakthrough/radical innovations; • High potential to develop disruptive innovations
	Early adopters	Visionaries	**Experts:** • Deep tech. knowledge; • Demand breakthrough or radical innovation • Moderate tech. participation in the development • Evaluate innovation **Lead Users:** • Sufficient tech. knowledge • Demand deep customization; • Develop new applications. • Application not possible without

[160] Rogers, *Diffusion of Innovations*.

[161] For the limited purpose of this work, the notions of "technology" and "innovation" are used interchangeably.

[162] Rogers, *Diffusion of Innovations*.

			customization
Mainstream market	Early majority	Pragmatics	**Early Users:** • Low tech. knowledge • Demand medium customization • Establish the applications of lead users • Customization important for application
	Late majority	Conservatives	**Late Users:** • No technical knowledge • Demand low custom. • Establish the applications of lead users • Customization less important for application
	Laggards	Skeptics	**2nd market** • Demand low-level customization along existing dimensions • Demand deep customization along new dimensions (*e.g.,* size)

Table 4-1: End user typology on the Scientific Research market.

It noteworthy that **most end users require customized solutions**. It is this finding that grants the attempt to use MI for better economical leverage of the technology.

Within the scientific research community, the culture of information exchange is very well developed. It is in the nature of the every customer to plainly state their desires (low level of latent content) as well as collaborate and freely provide their know-how towards fulfillment of their needs. Hence, the readily available dialogue bypasses the need for extensive and costly market research with the users and prospects.

Open innovation: the customers are offering an enormous pool of innovative ideas, which can be brought in and implemented into the next product(s). This leads to the desired situation where ideas and innovations originate both within the company, as well as outside its organizational boundaries. An example of Open radical Innovation at Photon is offered in Appendix 7.7.

The academic literature differentiates and still debates the user involvement in OI (defined as (potential) beneficiaries of the innovation itself) and established Research Institutions outside the company boundaries (*e.g.*, Universities, National Laboratories), as well as the different consequences for the company commercializing the Innovation. It is worth mentioning here that the company under scrutiny here enjoys the privileged position

where this differentiation is not necessary: the customers/users are Research Centers; hence the best of both worlds is available.

In summary, the customer on the Scientific Research market shows the following defining behavioral traits:

- Purchases individual products, no bulk transaction
- Requires a direct knowledge-intensive interaction with the sales team
- Rarely purchases the same product twice
- Is willing to pay a premium price
- Requires products able to perform unique jobs.
- Users within the same niche strive to differentiate from each other.
- Even pragmatics are dreamers: want “industry standard” products (market leader), but tailored to their particular dream application.
- Shows very high loyalty for their brand of choice
- Is willing and sometimes eager to participate in the innovation process.

4.2.2 Competition

There are six companies in direct competition on this market branch.

Photon, together with another firm of somewhat smaller size target mostly the high end of the market.

There are two firms of much larger dimensions with Business Units present on the mainstream market (mainly late users) with more standard products and lower prices. Combined, they capture about 75% of the market. During the past years, they have acquired several other small companies active on the market as well as subsystems suppliers. They are recognized as followers, and their offerings differentiate among themselves mostly along the price dimension. They hold a much better position regarding the value chain, as they insource most of the components necessary for equipment production. Furthermore, they also supply major subsystems to Photon. They represent a strong competition for Photon, but also very rigid. Their products are either standard, or follow an adaptive customization strategy: the user can customize the system along one or maximum two dimensions, within fixed limits, after purchase.

The last two companies provide only one type of equipment, representing only one product in Photon’s portfolio. They are little known outside their home markets, and their combined sales represent about few percent of the total market.

There are another two companies in occasional competition with Photon: they offer much larger systems and only seldom appear as direct competition. Also occasionally, they integrate Photon equipment, so they are also OEM customers.

Based on the nature of the market and also due to the almost maturity of the technology, disruptive innovations[163] are becoming a real threat. The existing customer competence traps corroborated with not enough strategic foresight and technical arrogance can lead to a "we are and will always be the best" attitude.

4.2.3 Market trends

A close look at the existing market (research field fashion, technology maturity, etc.) reveals that currently the number of Experts decreases, while the number of Lead Users increases (more research applications using the technology). This is of course followed by a corresponding increase of User numbers, and hence an overall increase in the market. This has two main effects on the equipment producers. In the first place, it shifts and increases the customer base from developers and experts (few) to lead users (more) and towards users (many). Secondly, it shifts the focus of the marketing message and sales discussion from „technological parameters" towards „equipment fit to application". This requires Sales & Marketing personnel with extended knowledge of different applications.

An emerging market is Industrial Applications (system integrators or applications for the common consumer, healthcare, etc.). Currently, this type of equipment is strongly underrepresented on this market. Its introduction here would be nothing less than disruptive to the current generation of utilized systems. The problem is that the photonics equipment is still as far as one can get from a standard product: every specification comes with a cost. Lower prices would drive more sales, but even if the systems were free, most of them would not be used in most industrial applications. Nonetheless, this market sector is constantly increasing.

A second important chasm is present between the Late Majority and this emerging/secondary market. I consider this to be a chasm, since the end users on the new market (industrial applications) mostly require deep customization along different dimensions. For example, size becomes an issue, the equipment needs to operate in different environment types on a 24/7 schedule, delivery times need to decrease and reproducibility to increase. Price plays here a much more decisive role than on the primary market. Hence, the cross from the primary market to the secondary one requires different strategies and resources. Success here is about serving niche players who are first to bring new applications to market and the expectation is that if the equipment price comes down enough and reliability increases, the market will expand. Although this is not the object of this work the concept of Mass Innovation might be applicable here as well.

[163] C.M. Christensen, *The innovator's dilemma* and *The innovator solution*, Harper Business; *The innovator's manifesto*, M.E. Raynor, Crown Business New York.

4.2.4 Photon's market position

Photon captures about 10 - 15% of the total market volume. Within certain market niches, it enjoys an almost monopolistic position, mainly based on extensive IP obtained mainly via OI. These market niches amount to around 70% of Photon's annual revenue.
In general, its offerings are recognized as high quality, premium price innovations, and the brand is highly regarded and respected.

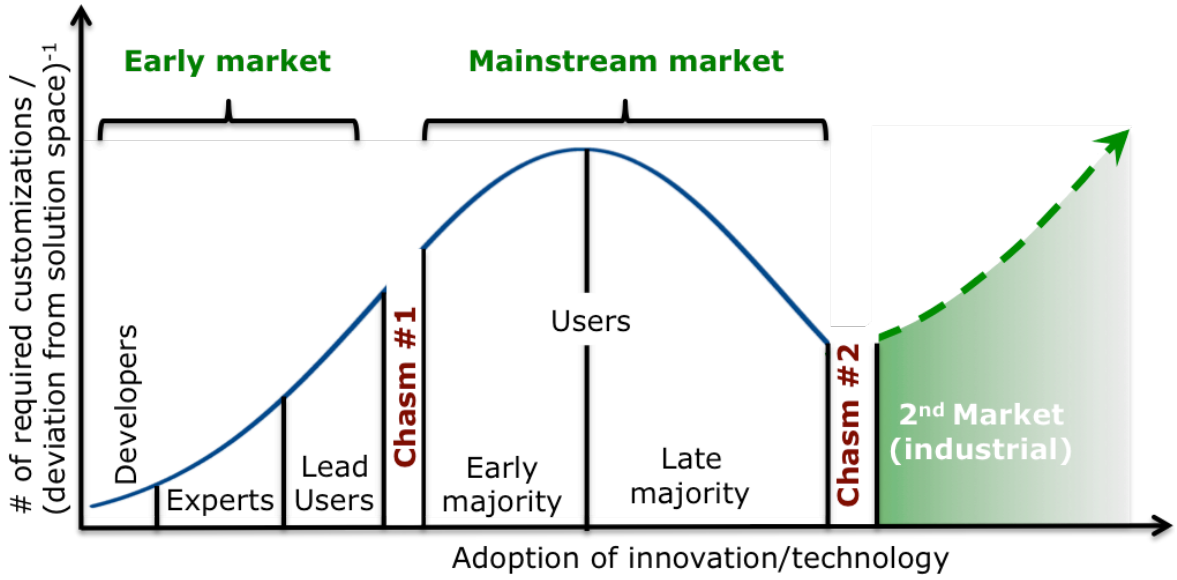

Figure 4-1: Innovation/Technology adoption cycle on the Scientific Research market

Traditionally, the company is a pioneer and first mover, heavily inclined towards the Early Market where it is an incontestable leader. Its presence on the mainstream market is limited, with only few of the early majority users being its customers. Currently, the main challenge Photon is facing is crossing the chasm to the mainstream market (Chasm #1 in Figure 4-1). It needs to keep innovating as to address early market with unique products, while simultaneously customize in an efficient way in order to tap into the promised land of the mainstream market. In other words, Photon needs to better exploit its explorations, rather than give up the former for the latter.

Considering Photon's environment, it appears that the external prerequisites for Mass Innovation are fulfilled.

4.3 Photon's business model

4.3.1 Selling innovation

By the very nature of its offerings and customers, Photon is a highly innovative company: most of its products are customized, they are sold in low numbers, product life cycle is very short, output parameters are improved constantly, from one product sold to the next. In short, Photon is selling innovations, ranging from incremental (system parameter customization) to radical ones (new equipment enabling new applications). Photon does not employ any formal model or toolkit for innovating. Innovations originate both internally (R&D department mainly) and outside the company borders. In many cases Photon employs a co-creation process, where its R&D department partners up with the customer.
Photon's main USP is the highest product quality and extensive flexibility. As such, Photon is addressing customer sacrifice gaps.

Photon's strong innovativeness can be tracked to a number of **strengths and opportunities** both within the company itself as well as in its immediate environment:

- Impressive know-how / technological competence: allows for innovative solutions.
- Founders' extensive technology and market experience: allows for identifying innovations and market opportunities.
- Open culture: empower employees
- Open Innovation: Innovations originate both internally and outside the company borders. In many cases Photon employs a co-creation process, where its R&D department partners up with the customer.
- Customized solutions/innovations: basically all customers get customized solutions / innovations tailored on their needs.
- Technology leverage[164]: Photon recognized the future opportunity of leveraging its technology competence also on the potentially larger 2nd market. The competence was successfully de-linked from the existing product lines, and potential customers needs were identified. Production resources were allocated (mostly of fungible nature, human and financial), and two new product families are under development.

Simultaneously though, many of the above strengths can be seen as **weaknesses or threats** as well, together with other important factors:

- Over-focused on early market: with most customers being experts or lead users, the company is constantly facing the chasm between the early and mainstream market.
- Constant innovation: products remain for an extensive time at the prototype level.

[164] Erwin Danneels, "The Process of Technological Competence Leveraging," *Strateg. Manag. J.* 28 (2007): 511–33.

- Deep involvement of the customer*:* requires very costly and demanding customer management, high R&D and production costs, as well as highly qualified Service, Sales & Marketing; premium product prices still offer a low net profit.
- Limited resources*:* too many competing ideas lead to bottlenecks in the development and marketing process; financial situation is precarious.
- Lack of robust processes: even from the pool of ideas that make it to becoming innovations, only few bring a real economic impact.
- Technical arrogance*:* creates a gap between what the customers/users need, and what the company thinks they need.
- Insufficient strategic foresight: many innovations take place mainly because "it's a cool idea", with less economic foresight.
- Insufficient technology competence leverage*:* re-linking[165] is a hurdle; the customer competence trap is reality, denoting the lack of second order marketing competence.

4.3.2 The product mix

Photon's main available product families are shown in Table 4-2. The company is offering a large number of "standard" products built along a modular architecture: the larger the system, the larger the number of used modules and the larger the level of integration of other product families (nested modularity).

Product Family (variations #)	# of different platforms	Modularity type (level of interdependence)	Feasibility for Mass Innovation
A (200)	n.a.	n.a.	Low, if sold as combination
B (17)	8	sharing, bus, swapping. (some require A)	High
C (93)	4	sharing, bus, swapping. (require A & B)	Very high
D (17)	2	sharing, bus, swapping. (require A, B, C, and even variations of D)	Very high

Table 4-2: Photon's main product families.

Nevertheless, the compatibility between product families is not optimal. Along certain dimensions, (*e.g.* size), certain modules are incompatible with others and cannot be fully integrated. Consequently, either the next customer suffers, or major modifications up to product re-development are necessary at a later and more costly stage.

[165] Ibid.

Products of the B, C, and D type are either made to order or engineered to order (Figure 7-1, postponement strategy). Only basic components (of A type) and basic modules are on stock, with larger and most costly subsystems being either produced or purchased from suppliers after the receipt of the customer order. Although this should entail low risk, the supply chain management is currently following a "just in case" strategy. This leads to bottlenecks in the production (*e.g.*, major subsystems arrive later than expected) with the negative effect of significant delays in product delivery to the customer.

Even with so many available products, Photon is heavily relying on customization. This is exemplified in Table 4-3, where the statistics of the sold products (the A family and C+D families, respectively) are shown over a period of time significant for the business cycle.

Product family A is composed mainly of stand-alone components. Photon sold at least one items of almost all portfolio products (98%), with (in average) less than 10 items of one kind. This implies that (i) the pre-defined solution space is very well aligned with the customers needs, and (ii) the product family A is a Long Tail. Customization here is mostly pure customization, with very low feasibility for MI. Even so, the number of unique customized items sold represents 19% of the one for portfolio items.

Product Family		Portfolio items	Custom items
A	Items sold	1851	78
	Unique items sold	196	37
	Revenue (% of revenue for portfolio items)	100%	21%
(C+D)	Items sold	34	18
	Revenue (% of revenue for portfolio items)	100%	**160%**

Table 4-3: Portfolio vs. custom items sold.

For systems, (families C+D together), the number of sold customized systems[166] relative to the standard ones is significant: 53%. There have been identified 14 systems with one customized subsystem, 3 with 2 customized subsystems, and 1 with 3 customized subsystems[167]. Actually, more often than not, the customization is not necessarily a physical component, but an output parameter. This already implies a more complicated interplay between existing and completely new building blocks (components, modules, and subsystems) as well as specific R&D efforts, hinting towards innovations (with different degrees of radicalness) and not only customization. Looking at the revenue, the

[166] those systems with customization only at component level (product family A) are not considered here.

[167] Insufficient data points prevent a rigorous statistical treatment, but considering the random occurrence of the customization as well as their discrete nature, the Poisson distribution is expected to describe the data.

significance of the custom(ized) systems is even higher: they generate more than 160% the revenue generated by standard ones. This strongly indicates a business model and strategy where customized offerings play an important role is appropriate, and MI might be useful in order to increase the profit[168].

Many of the Photon's large system are based on architectural innovation: changes in the overall architecture do not require new components.

4.4 Mass Innovation at Photon

Following the Photon's organizational design (Jazz like), business model, and environment, it is clear the company is heavily oriented towards the Early Market. Furthermore, Mass Innovation is the right strategic enabler for the company to cross the chasm to the Mainstream market.
Below I conclude by summarizing the findings from the MI strategic mix perspective (Figure 3-8 above), and identifying the main capabilities that need improvement.

4.4.1 Open Innovation

Photon is selling innovation, rather than products. Its innovations range from incremental to radical, and more seldom disruptive. This is in line with its main market expectations as well as new market development. Innovation in general, and OI in particular is aided by considering that most employees are recognized specialists and have direct contact with the customers. This allows for a permanent inflow and outflow of relevant information, leading to continuous innovative solutions.

The company employs Ecosystem and Collaboration strategies for OI and the organization is fit for it. The organic and continuous dialogue with the customers (mainly Developers, Experts and Lead Users) alleviates the need for formally organized Lead User Workshops proposed by the OI academic community. Beyond the stated advantages of OI (Section 2.2.2), this allows for high visibility and brand recognition, alleviates the need for crowdsourcing, and provides the fortunate situation where the customer finances the innovation to a large extent.

Although OI per se is well integrated into the business model, the strategic innovation management is lagging behind, leading to limited technological competence leverage.

[168] Lack of quality data prevents the deeper analysis of the profit generated by customized systems relative to standard ones.

4.4.2 Mass Customization

Both the market and the technology are ripe for MC. This provides an opportunity for developing market niches, increase the generated value, and could also raise entry barriers. Currently, Photon deploys a customization technique similar with the Collaborative Customization.

Solution space: with customers being integral part of the creation of innovation, they participate at the definition of the solution space, which consequently shifts continuously. The challenge faced by Photon here is that sometime strong deviations from the available solution space are associated with high costs (pure customization) and insufficient generated value. To some extent, such deviations can be balanced by price increases, but they also result in bottlenecks. Improvements are necessary along the Leagiliy dimension, as to shift the decoupling point in the lean direction, by strategically offering the customer those choices that are easier and cheaper to implement and better product design. Furthermore, by better understanding the (latent) expectations of the customer, Photon can offer customizations/innovations that better capture the "sacrifice gap".

Robust processes: Photon is traditionally a pure customizer, and its organization is designed for that: it covers extremely well the "customization" part of the MC paradox, but less than ideal the "mass" part. Even from the pool of ideas that make it to becoming innovations, only few bring a real economic impact. This can be tracked on one hand to the extremely fast pace of change in customer demands, which leads to the necessity of new products. On the other hand though, transforming good ideas into true innovations also requires well-defined and transparent processes within the company.

The processes are in dear need of improvement. For example, the supply chain needs to be managed in a "just in time" and not "just in case" fashion; the offerings need to be designed not only along modularity, but also with a higher degree of compatibility across families to allow for better integration. The use of the morphological matrix could be useful to find the solution principles, combine them and eliminate the infeasible ones. A strategic rethinking is necessary here, by starting with recognizing and accepting the benefits of MI.

Choice navigation: this happens by individual sales & tech discussions with customers; although this works, it is costly, since tech-savvy sales force is necessary, and the discussions cannot always take place when and how the (prospective) customer desires. Hence, *e.g.*, the implementation of an online product configurator would not only decrease costs and create an easier, faster and more enjoyable search experience for the customer, but would also come with the additional intrinsic advantages of (i) easy optimization of the solution space and (ii) making the data regarding the customers' desires readily available in an organized form. This can also be analyzed using appropriate tools and subsequently used as an indication of the trends in existing markets, as well as of unexploited or

nascent markets. The existence of a well-designed configurator will also directly provide the main input necessary for the production: the exact product configuration, according to both the customer's desires as well company's capabilities, and bypassing possible misunderstandings of the sales force.

It is worth noting that the configurator can only be implemented for Photon's available product families and variations. Since many of the customizations necessary actually involve innovating (Mass Innovation), this has to happen in a dialogue with the user requiring face-to-face interaction.

4.4.3 Stability-change Duality

Photon's organization is an example where duality already exists to a great extent. The company exists and thrives largely owing to its pioneering spirit and culture: innovation is its main offering. The company grew organically around a team of technocrats (actually, scientists) with *experimentation* in their blood. Drawing on the strengths and opportunities listed above, the company knows its way when it comes to innovation. It is the stability that needs to be enhanced.

Here, "stability" and "reliability" are often used interchangeably. For Photon (at least), both apply to (i) the internal organization, structure, processes, as well as to (ii) its offerings. If the first part is rather common to all other companies[169], the latter is somewhat special. In engineering, "*reliability is usually defined as the consistency over time of the performance of a product or service and the duration of its functioning within a tolerated band of performance*" (excerpt from [170], attributed to[171]). Within the borders of the market Photon is active in, reliability is largely synonymous with quality, where the latter is viewed simply as "the set of system parameters in the user's laboratory". Hence, users/customers take innovativeness for reliability. This is possible since they are experts who get a one-of-a-kind machine, and they can go ahead and modify it according to their needs. Lately though, in pace with the maturity of the technology and market opening towards non-expert users, reliability and quality regains its traditional meaning described above. Hence, this is another aspect that Photon seriously needs to consider – the reliability part of the innovation gains importance for the user.

Change and innovation enable stability

Photon is "well equipped" when it comes to *mindfulness*: its employees are constantly faced with the non-routine, need to improvise and defer to expertise. *Dubito, ergo*

[169] Reliability is seen here as a goal both short term and long term, but not synonymous with the efficiency in the exploitation context.

[170] Farjoun, "Beyond Dualism: Stability and Change As a Duality."

[171] Nigel Slack, Stuart Chambers, and Robert Johnston, *Operations Management*, 6th ed. (Pearson, 2010).

cogitum, ergo sum is daily reality. It is not the unpredictable that raises issues, but the predictable and mundane: better planning and supply chain management, become more profitable, leverage the technology better, or increase the reliability of the offerings.

Symbolically speaking, the company is in its state of minimum free energy (stable) even when the entropy is large. Photon is in a Brownian motion[172] (continuous OI) and this differentiates it from the herd. Its leadership needs to get to terms with the fact that ambiguity is a value asset, write down the equation (even the Brownian motion is described mathematically) and describe their reality using that equation. In other words, they need to strategically embrace the change, but also extract and define the necessary processes and keep to them even when sailing (more) calm waters.

The continuous stream of innovative products allows Photon to experiment with *failing less by failing more*. They can readily apply here the strategic concept of Minimum Viable Product[173] – this will allow for a trial-and-error strategy as strong enabler of continuous learning and immediately applying the knowledge. In the context of an SME (limited resources) and very fast product life cycle, this avoids the need for extensive and lengthy R&D prior to launching. Furthermore, high skill development and broad problem-solving capabilities are important by-products for the whole organization.

Photon modular product architecture is the choice *for redundancy and loose coupling*. However, better module compatibility across product families is absolutely necessary, if the fruits of redundancy are to be fully enjoyed.

Stability enables change and adaptability

The need for trust and legitimacy is universal, even within highly flexible organizations. Furthermore, creativity requires an enabling framework – every artist has a style, and it is inside its limits where the creator is able to let their imagination free. In other words, everybody needs *institutions and limits as enablers.*

Traditionally, Photon is rather aversive to everything coming close to hierarchies and bureaucracies. Nevertheless, it becomes clear a well thought strategy is necessary to provide the legitimacy and reduce uncertainty, and just-enough bureaucracy has its merits. The company is making progress on this path, although the trap of jumping the gun and regularizing everything is still looming, especially in periods of scarcity.

Another dimension where stability leads to adaptability is the *design and invention as disciplined imagination.* Here, Photon excels: with the vast majority of the employees coming with an engineering background, problem-solving capabilities are enormous. Adhering to norms, addressing issues from different perspectives, thinking and acting in

[172] For a phenomenological description, see http://en.wikipedia.org/wiki/Brownian_motion

[173] Eric Ries, March 23, 2009, Venture Hacks interview: "What is the minimum viable product?", Lessons Learned

an orderly manner allow Photon to tackle insurmountable problems, as well as keep innovating. With “crazy” ideas appearing all the time, it is the discipline based on both science and real-world experience keeping things on track.

Routinizing the non-routine is where Mass Innovation fits like a glove. If one considers innovation and customization as vehicle for success, then satisfying every (potential) customer is definitely the main goal. But without a well-defined system able to sustain this goal and lead to economic viability, stability cannot be reached.

4.4.4 Mass Innovation– Photon’s vehicle to cross the chasm

Applying the MC concepts on a company organized according to stability-change duality principles under the MI umbrella brings a pivotal bonus: **bridge the chasm between the early and mainstream market**, as to profitably leverage the technology and innovations. Presently, Photon is in a complete standstill when it comes to bridging the chasm towards the mainstream market and fully leveraging its technological competences.

Mass Innovation at Photon proves to be the right strategic enabler for Photon and its environment. The analysis above reveals that the company has many of the necessary capabilities, and is partially successful at MI. This is though not yet sufficient. There are at least the following dimensions along which Photon needs to improve:

1. Strategically embrace its capabilities to combine stability and change in a dual manner, as well as MC as a vehicle to bring it from a pure customizer towards growth and financial welfare.
2. Innovate via strategic foresight, and not technical arrogance, to fully leverage the intrinsic innovativeness and technological competences.
3. Understand the fundamental differences between the Early Market and Mainstream Market users, and tailor its offerings accordingly.
4. Better organize its OI as to decrease their costs and maximize learning.
5. Increase process robustness; supply chain management needs special attention, as well as the better design of product modularity as to allow for a better compatibility.
6. Consider tools for improving the customer’s choice navigation.
7. Strive towards an economy of scope, and not one of scale.

The present discussion is to be seen as an initial step towards using MI capabilities in a strategic manner. A more in-depth understanding of the company and market situation is necessary in order to establish and stabilize the path towards achieving both its short- and long-term goals.

5 Summary and conclusion

5.1 Summary

The present work devised a conceptual pathway for innovative High-Tech SMEs involved in B2B type economic activities to *cross the chasm between the early and mainstream markets*. The discussion was centered around SMEs that "innovate for innovators", or in other words who's customers are innovators themselves.

The theoretical concepts of Innovation and especially Open Innovation, Mass Customization and Duality oriented organizations were detailed and critically discussed. Furthermore, the adoption of innovation was addressed along the adopter typology, and the early-to-mainstream market chasm was presented.
Thereupon, the abstraction of **Mass Innovation** was introduced as holistic framework drawing on the afore mentioned concepts: *the strategic infrastructure necessary for harvesting the unique opportunity that is the heterogeneity of needs, based on the synergetic combination of Mass Customization, Open Innovation*.
The stress here is on "strategic" and "right combination": the company has to analyze and understand its capabilities along the three main dimensions and any sub-dimension required, establish its goals strategically and improve on those dimensions that lag behind. Mass Innovation is to be strategically and successfully deployed when customization within a well-defined solution space is not enough, as each customer does require innovations as products and participate in the co-creation process.
The success factors as well as the vulnerability to failure have been critically discussed, as well as the necessary competencies and proficiencies the company needs to develop and master. These constitute prerequisites for a successful implementation of Mass Innovation

The Mass Customization framework has been applied on the case of Photon, a producer of special High-Tech state-of–the-art photonics equipment active on the Scientific Research market. All end users are (by definition) innovators, making use of the equipment in the quest for new discoveries, either on the fundamental technology level or on a more applied level (new applications). The innovation adopter ideal typology has been revised to better reflect this market's peculiarities.
The company is a pioneer and first mover (almost pure customizer), heavily inclined towards the Early Market. The existing company capabilities and its weaknesses have been discussed, and its readiness for Mass Innovation has been critically evaluated. Mass

Innovation has been identified as potential strategy for crossing the chasm to the mainstream market and supporting the company in fully leveraging its technological competencies.

5.2 Limitations

The present study is limited to discussing the instance of brick and mortar High-Tech B2B SMEs functioning under rather specific circumstances, such as innovating for innovators. For other business types or market situations, the findings herein might need to be amended accordingly.

Additional limitations of the study are methodological in nature:

1. With the deployed research method being conceptual analysis, the findings remain mainly qualitative.
2. The argumentation constitutes only a framework of the required capabilities and competencies. A more in-depth look at the concepts and their applicability, as well as the right choice of tools is necessary in order to develop a full strategy.
3. The Mass Innovation framework has been only discussed on a single SME, in a "proof of the principle" manner; broader generalizations are necessarily unclear.

5.3 Conclusions

The objectives of this study have been reached:

(i) Understand the challenges a company of this type faces, its goals, specific context and environment.

(ii) Appreciate the organizational requirements for dealing with the exploration-exploitation duality.

(iii) Rationalize the importance of innovation and its adopters for the company's success.

(iv) Acknowledge the existence and importance of the early-to-mainstream market chasm.

(v) Critically review the existing concepts and approaches, seek and synergetically combine the relevant ones.

(vi) Derive a comprehensive framework as competitive strategy for crossing the chasm.

(vii) Apply the framework on one "proof of the principle" company case.

This study might provide a platform onto which deeper treatments can be built in a modular architecture manner as to strategically support for different companies in their quest for success and growth.

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7 Appendices

7.1 Small and Medium Enterprise

Throughout this work, the concept of Small and Medium Sized Enterprise (SME) is used in accordance with the definition of the European Union (Recommendation 2003/361[174]). Accordingly, the main factors that determine whether a corporation is an SME are:

Corporation Category	Number of Employees	Turnover (Million €)	Balance Sheet total (Million €)
Medium	< 250	≤ 50	≤ 43
Small	< 50	≤ 10	≤ 10
Micro	< 10	≤ 2	≤ 2

Table 7-1: Classification of SMEs following the EU recommendations

The size alone is already responsible for a (larger or smaller) strategic drift between the SMEs and large corporations. There are a number of important differences between the two company types, with both positive and negative consequences. The following table summarizes some of these consequences fro the SMEs, albeit in a generalized manner:

SME Advantages	SME Disadvantages
Flexible and agile	No economy of scale
Adaptable to changes in demand	Lesser staff resources
Responsive to change in trends	Fewer customers
Faster reaction times	Highly dependent on individual custome
Leaner organization	Lesser financial resources
Tightly knit corporate culture	Highly dependent on individual employees.
Close relationship with customers/users – The personal touch	Low(er) market share
Niche player	Niche player
Often invisible, might “fly under the radar”	Mostly confined to the early market

Table 7-2: Advantages and disadvantages of SMEs when compared to large corporations

The consequences above should be regarded only as guidelines for the reader, as a more precise description depends on the particular company, its environment, industry, etc.
Here, both advantages and disadvantages outlined above, along with others, are of paramount importance as they set the stage of the discussion, since Mass Innovation takes full advantage of the SME peculiarities.

[174] “COMMISSION RECOMMENDATION of 6 May 2003 Concerning the Definition of Micro, Small and Medium-Sized Enterprises; 2003/361/EC.,” *Official Journal of the European Union*, 2003.

7.2 Organization design for different user innovation strategies

Companies face a number of challenges at the organizational design level when it comes to employing Open Innovation in general. Keinz at al[175] offer a useful overview and classification of the challenges associated with different user innovation strategies:

User Innovation	Typical Methods	Challenges for organizational design	Components addressed`
Searching	• Lead-user	• Unwillingness of employees to participate in lead-user projects due to additional work and "not-invented-here" syndrome	• People • Incentive systems
		• need for new processes (e.g., the search for lead-users and the evaluation of their lead-user status)	• Work process
		• Development of cooperation templates (if lead-users are asked to help in the further development of their ideas) including incentive systems and an IP strategy	• Work process • Incentive and control / coordination systems
Harvesting	• Innovation contests	• alignment of innovative activities by internals with corporate strategy	• Incentive and control / coordination systems
		• avoiding the perception of being "unfair" or exploiting external problem solvers (e.g., distributive and procedural fairness)	• People • Work Process
		• outsourcing of ideation might be perceived as a threat by members of R&D and marketing department	• People
Cooperation	• Lead-user • expert circles (repeatedly conducted)	• Capability building on the individual level • need for learning processes from prior lead user projects • Development of cooperation templates and a learning base	• People • Work processes • Incentive and control / coordination systems
		• global corporate strategy needs to change toward innovation leadership	• goals • strategy

[175] Keinz, Hienerth, and Lettl, "Designing the Organization for User Innovation."

		• new responsibilities for establishing long- term relationships with lead-users	• structure • work process
Ecosystem	• toolkits for user innovation and design • Co-creation with user communities	• Lack of capability to understand complex ecosystems • recognizing and designing the interfaces • aligned incentives /coordination systems among R&D, production, and marketing	• People • work process • Incentive and control / coordination systems
		• global corp. strategy needs to change because of new value proposition to customers (e.g., toward innovation leadership, mass customization, etc.)	• goals • strategy
		• re-organization of manufacturing and distribution system associated with a re- design of the organizational structure	• Work process • structure
		• new responsibilities for managing the user community	• structure • Work process

Table 7-3: Design challenges of the different user innovation strategies; adapted from[176]

7.3 Mass customization fundamental capabilities

The table below details tools and approaches to develop the three fundamental capabilities of Mass Customization, according to[177]:

Capability	Approaches to develop capabilities
Solution space development Identify the product attributes along which customer needs differ	**Innovation tool kits**: software that enables large pools of customers to translate their preferences into unique product variants, allowing each one to highlight possibly unsatisfied needs **Virtual concept testing**: approach for efficiently submitting differentiated product concepts to prospects via virtual prototype creation and evaluation. **Customer experience intelligence**: A tool for continuously collecting data on customer transactions, behaviors or experiences and analyzing that information to determine customer preferences.

[176] Ibid.

[177] Salvador, De Holan, and Piller, "Cracking the Code of Mass Customization."

Robust Process Design Reuse or recombine existing organizational and value-chain resources to fulfill a stream of differentiated customers needs	**Flexible automation**: Automation that is not fixed or rigid and can handle the customization of tangible or intangible goods. **Process modularity**: Segmenting existing organizational and value-chain resources into modules that can be reused or recombined to fulfill differentiated customers' needs. **Adaptive human capital**: Develop managers and employees to deal with new and ambiguous tasks.
Choice Navigation Support customers in identifying their own solutions while minimizing complexity and the burden of choice	**Assortment matching**: Software that matches the characteristics of an existing solutions space (that is, a set of options) with a model of the customer's needs and then makes product recommendations. **Fast-cycle, trial-and-error learning**: An approach that empowers customers to build models of their needs and interactively test the match between those models and the available solutions. **Embedded configuration**: Products that "under- stand" how they should adapt to the customer and then reconfigure themselves accordingly.

Table 7-4:Tools and approaches to develop the MC capabilities.

7.4 Postponement framework

Van Hoek[178] defines postponement as *"delaying activities in the supply chain until customer orders are received with the intention of customizing products, as opposed to performing those activities in anticipation of future orders".*

Postponement can take place on different dimensions of the value chain, *e.g.*, time, place (storage), or form (product finalization).

Yang *et al*[179] perform an encompassing literature review on the concept and implications of postponement, as well as its fit within the MC paradigm. Furthermore, the authors construct a comprehensive framework on postponement.

[178] Van Hoek, "The Rediscovery of Postponement a Literature Review and Directions for Research."

[179] Biao Yang, Neil D. Burns, and Chris J. Backhouse, "Postponement: A Review and an Integrated Framework," *International Journal of Operations & Production Management* 24, no. 5 (2004): 468–87, doi:10.1108/01443570410532542.

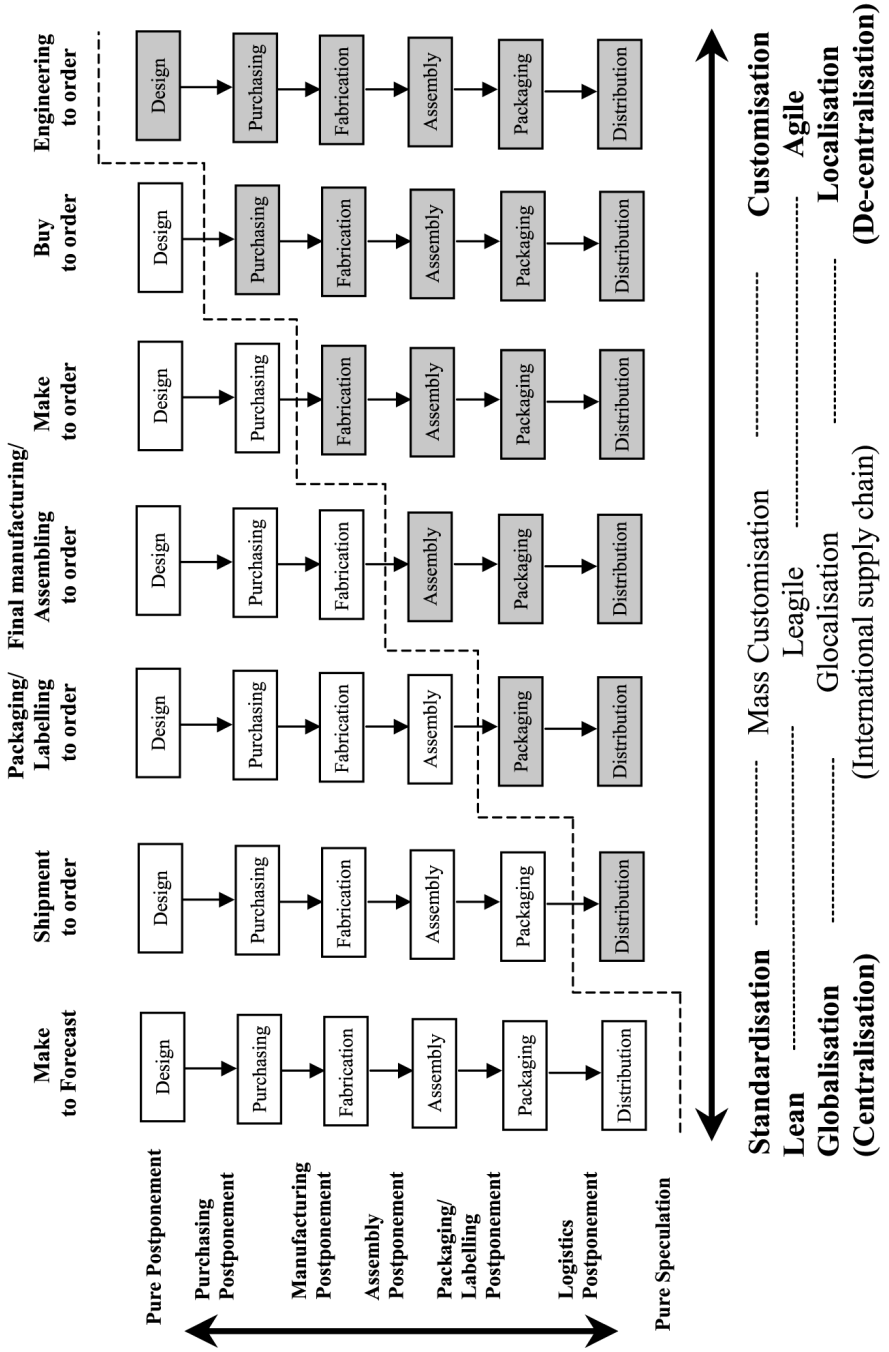

Figure 7-1: Postponement strategy. Extracted from Yang et al[180]

Figure 7-1 summarizes the different points of postponement within the value chain as developed in[181]. Moving downstream, the postponement types identified by the authors are: purchasing, manufacturing, assembly, packaging/labeling and logistics. The various postponement strategies displayed are also placed along the MC continuum, as well as the Leagile one.

[180] Ibid.

[181] Ibid.

Postponement can be seen as a tool for uncertainty management[182], aimed towards increased delivery reliability, improved speed of delivery and inventory cycle times, lowering logistics costs and obsolescence risk, as well as improving MC[183].

For a more in depth treatment of postponement the reader is redirected to the work of Yang et al, as well as the references therein.

7.5 Modular products

One classification of module types as offered by Duray *et al*[184], and graphically summarized in Figure 7-2 below.

Mikkola[185] has designed a mode quantitative way to assess the applicability of modular architecture to MC, by using the "modularization function" M(u):

$$M(u) = e^{-ux^2/2Ns\delta} \qquad \text{(Equation 7-1)}$$

The function measures the degree of modularity in a given product architecture (M(u)) with respect to the number of new-to-firm components (u), total number of components (N), the degree of coupling (δ) and the substitutability factor. For a deeper treatment of the Modularity function, the reader is referred to the original study[186].

Based on the modularity function, in a subsequent study, the same author identifies and proposes the following principle of modular products for MC:

(i) Utilization of unique components (both existing and new-to-firm) should be minimized

(ii) The level of product architecture decomposition should be maximized (high interaction of components within a module)

(iii) As many product families as possible should use the same unique components

(iv) Usage of standard component in other products should be maximized.

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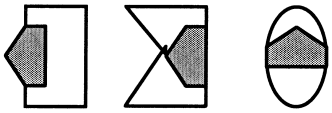
[182] B. Yang, N. D. Burns, and C. J. Backhouse, "Management of Uncertainty through Postponement," *International Journal of Production Research* 42, no. 6 (March 2004): 1049–64, doi:10.1080/00207540310001631601.

[183] Remko I. Van Hoek, "The Thesis of Leagility Revisited," *International Journal of Agile Management Systems* 2, no. 3 (2000): 196–201.

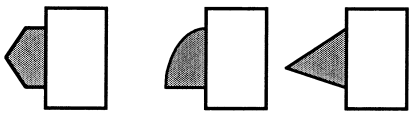
[184] Duray et al., "Approaches to Mass Customization: Configurations and Empirical Validation."

[185] Juliana H. Mikkola, "Managing Modularity of Product Architectures: Towards an Integrated Theory," *IEEE Trans. on Eng. Management* 50, no. 2 (2003).

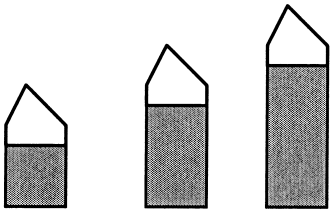
[186] Ibid.



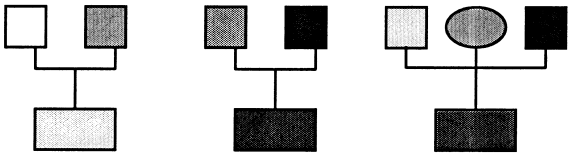
Component -sharing Modularity
Common components used in the design of a product. Products are uniquely designed around a base unit of common components Example: Elevators



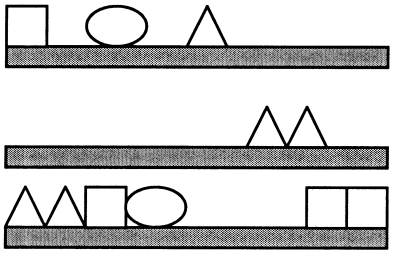
Component -swapping Modularity
Ability to switch options on a standard product. Modules are selected from a list of options to be added to a base product Example: Personal computers



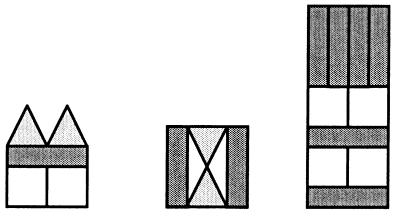
Cut-to-Fit Modularity
Alters the dimensions of a module before combining it with other modules. Used where products have unique dimensions such as length, width, or height. Example: eyeglasses



Mix Modularity
Also similar to component swapping, but is distinguished by the fact that when combined, the modules lose their unique identity. Example: House paint



Bus Modularity
Ability to add a module to an existing series, when one or more modules are added to an existing base. Example: Track lighting



Sectional Modularity
Similar to component swapping, but focuses on arranging standard modules in a unique pattern. Example: Legos

Figure 7-2: Modules typology. Extracted from page 609 in[187].

7.6 Mass Innovation for radical innovation

The dynamic framework of Mass Innovation proposed here enables companies selling innovations to cross the chasm towards the mainstream market in order to better leverage its technologies and capabilities.

One might insist that this is the case with incremental innovation, but by no means when it comes to radical innovation. I argue that the concepts aforementioned are not mutually

[187] Duray et al., "Approaches to Mass Customization: Configurations and Empirical Validation."

exclusive; there is no dichotomy involved. Nevertheless, it seems clear that in certain situations there might be only a partial overlap between the two.

Radical innovation doesn't necessarily mean inventing/developing something "from scratch". It usually implies the use of existing parts (or modules), as well as developing new ones for a new purpose, to satisfy a completely new need, or an existing need in a completely new manner.

Consider the LEGO bricks: in most cases, they are already cut to size, painted and packaged, ready to build a certain object depicted on the box. However, using the basic Lego pieces, enthusiasts around the world are able to create new toys, representations of their environment, or even working machinery prototypes. Recently, two guys who met on the Internet made the news around the world after building "a car made of Lego, that drives, has an engine made from Lego which runs on air (wheels and some load bearing elements are non-Lego)"[188].

Figure 7-3: The Lego-made car. (Photo: Super Awesome Microproject).

Of course, the reader is entitled to object: technically speaking, this is not innovation, since the exploitation part lacks. Indeed, there is no direct exploitation of the Lego-made car, but this can be seen as "proof of the principle" experiment: the example is used here solely to make the point that **mass-produced** parts like Lego bricks can be used in a **customized** manner to lead to a complete **novelty**[189]**,** which can in principle be commercially **exploited**.

[188] Raul Oaida and Steve Sammartino, "Super Awesome Micro Project," *Super Awesome Micro Project*, 2014, http://www.superawesomemicroproject.com/.

[189] The avoidance of the term innovation is deliberate.

7.7 Open radical Innovation at Photon – an example

This is one example of successful radical/breakthrough innovation at Photon, realized under the Open innovation framework. Unlike most innovations at Photon, this example has one clear inventor outside the organization.

***Technical** scope of innovation*: (i) use new to the world technology; (ii) improve stability/reliability of a photonics system by more than an order of magnitude; (iii) improve the output parameters by a factor of 3-to-5; (iv) improve user friendliness from the developer/expert level to the lead user level and hence appeal to other applications.

Economic Scope of innovation: (i) consolidate leader position on the market niche; (ii) enlarge market niche; (iii) raise barriers against competition and entrants; (iv) lower production and maintenance costs.

Radical innovation: completely new technology leading to new IP (patent).

Source of innovation: user of Developer/Expert type**.**

*The Innovation process***:**

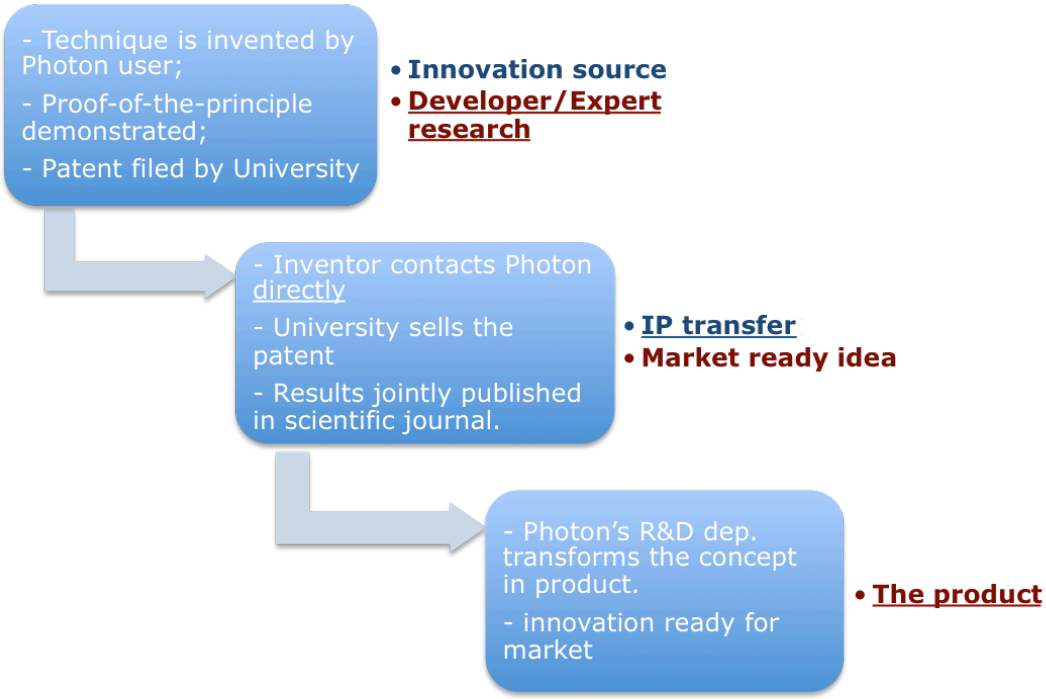


Figure 7-4: Open (radical) Innovation at Photon.

*RISK***:** low to medium. Innovation invented based on existing Photon product, moderate development necessary.

*REACH***:** very high. The market niche exists but it is small, Photon is leader; the inventor is well known, the end product is desired and expected.

*SPEED***:** medium. The purchased invention already constitutes a first prototype.

COST: low to medium. The IP costs are moderate, most components exist in house, testing is extensive but without high costs.

The Development Process - participants

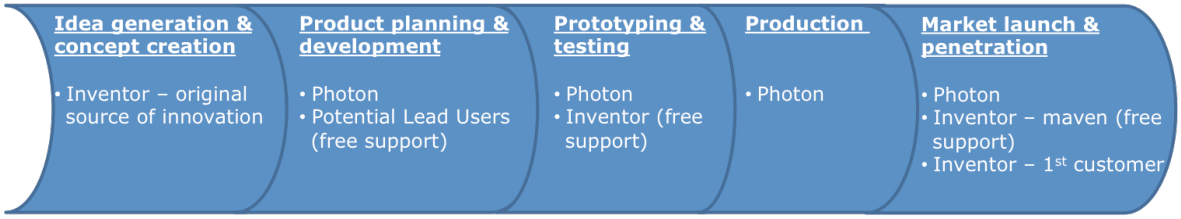


Figure 7-5: Product development process following OI at Photon.

Following the successful innovation, the new product entered the development phase. The inventor became the first customer. The product was later on implemented as module in larger systems architecture.