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Technical debt and customer value added as the parameters of technology innovation based strategies

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Abstract: Market introduction of technologically innovative products or services is based around a desire to create offerings with superior customer value. This perceived customer value creation process has to be divided into segments to provide a diagnostic tool which can usefully assist managers create new superior value technology based products or services by including customer participation in the development process. The use of such a tool, based on customer value and technical debt as parameters, will allow company decision makers to analyze and measure the nature of customer perceptions and the innovativeness of a proposed offering enabling them to define concrete marketing strategies as a result and minimizing the risk of market failure of an innovation based product. The importance of technical debt and customer value added as the parameters of technology innovation based strategies is discussed in this article.

Keywords: technology management, value creation, innovation, technical debt
JEL: O33, O32, M31

1. Introduction

In analyzing the context of the customer role in the company strategy formation process, it is important to underline the relationship between company innovativeness and its value perception by customers. This also includes interactions between the innovativeness of the customer and the innovativeness of the organization. This last can be defined as a firm's tendency to support new ideas and to foster creative processes that are aimed at the development of new

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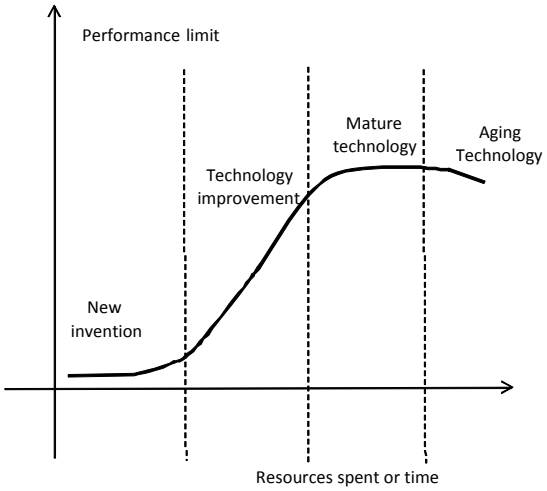
products and/or the implementation of new processes completing the perspective of possible bilaterally of the innovation process by extending the definition of organizational innovativeness (Garcia, Calantone 2002). Understanding this complementarity and its positive impact on the commercialization of new technology should provide justification for developing new mindsets that concretise technology innovation management strategy development. In these, the customer leads the innovation process by predetermining the company value creation process model as customers with a high level of innovativeness have more experience in managing change in product-oriented processes. Based on their experiences, managers may be able to more precisely determine the value of the technology innovation inputs. Confirming the importance of the customer role in value conceptualization imposes the borderlines for value creation as the compromise between customer and firm vision resulting in defining value creation as a trade-off between quality and price (Ulaga 2001). The importance of technical debt and customer value added as the parameters of technology innovation based strategies is discussed in this article.

2. Technology S-Curve as a Determinant of Innovation Strategy - Proposal for an Evaluation Tool

Current marketing strategy models use a life cycle model as the basic determinant of company action. In fact management at any technology-based company must adopt a strategy which should integrate business and technology goals. To anticipate technological progress, a tool often used by company strategists is the technology s-curve, presented about a quarter century ago by Foster (1986). This curve tracks the progress of a base technology as a function of the R&D effort. In the beginning, progress for any new technology is slow. Then, as a critical mass of engineering expertise is built up, progress can be rapid, even exponential. After a while, however, the technology matures and progress slows. The curve's shape makes it easy to see that productivity derived from R&D effort will begin to decrease after the inflection point, that is, the point on the curve where the arc changes from concave to convex. At that point, as Foster proposed, strategists should be looking for a new technology because further effort in the old technology will result in diminishing returns. The s-curve has been used in plotting technologies

and the basic concept of the s-curve has been extended to the areas of product and technology substitution (Fig.1).

Fig.1. Technology S-curve.



Source: Bowden 2004: 2.

However, to enable the s-curve method to be used for decision-making in a commercial product environment several business issues must be considered. For instance, analyzing the possible management application of technology, Asthana (1995) remarked that the primary barrier to adopting a new technology is uncertainty about its acceptability to the market. Any unfamiliar technology takes time to gain acceptance, and early market penetration is slow because the size of the buyer market is small. Being first makes places the company in the unique situation of acting without competitor pressure and so the capture of a large part of the market is possible together with the role of market innovator. This situation makes it possible to realize exceptional profits, but at same time this unique market position is also very tempting for other companies. In spite of these advantages, being first to market is somewhat overrated as a winning strategy, among other reasons because the concept fails to take into account the impact of how long it might take for the market to accept new high-technology products. For a product that has no time lag between the technology s-curve and the marketing s-curve, first-to-market certainly could be a winning strategy. However, this is a very optimistic vision as the inverse can also happen. The company, that is second or third to enter the market may have an advantage: it can target an already educated, receptive market and can thus spend its marketing resources on

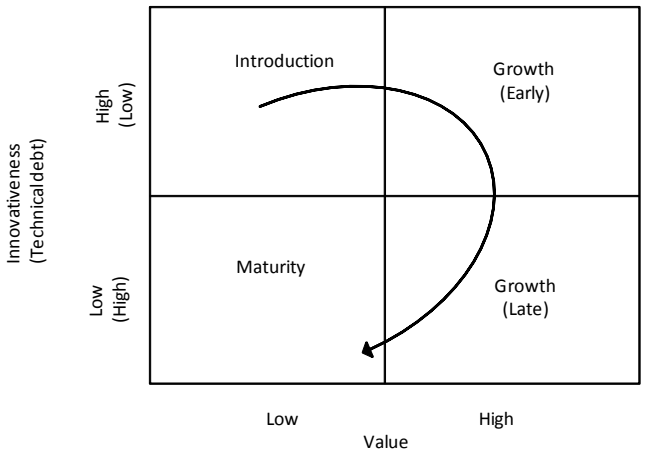
promoting its brand image. Sood and Tellis (2005) signalizing the multitude of technological s-curve interpretations, presented a holistic description based on a three stage approach.

The first stage is introduction, during which a new technological platform makes slow progress in performance during the early phase of its product life cycle, because the technology is not well known and may not attract the attention of researchers. A second reason for this slow progress is the need for translation of new technology into practical and meaningful improvements in product performance.

The second stage is the growth stage which consists of a rapid propagation of the new technology, this stage usually begins with the emergence of a dominant standard which determinates the characteristics of most products and consumer preferences. This consensus stimulates research on the new platform, which in turn leads to improvements in its performance. Furthermore, publicity of the new standardization draws a large number of researchers to study the new technological platform. Their cumulative and interactive efforts also lead to rapid increases in performance. This rapid progress leads to increases in sales of products based on the new technology, which in turn, increases revenues and profits and offers further support for research and for performance improvement.

The third stage is maturity. This is the period of slow technology propagation and market saturation. This maturation stage is due to a reduction of innovation activities because of the large competitive offer and the loss of attractiveness for customers.

Fig.2. Proposed Concept Tool based on an s-curve holistic interpretation.



Source: based on Filipowicz 2014: 13.

Pearce and Robinson (1994) remarked that in a rapidly growing market, even a small or relatively weak business is often able to find a profitable niche. The business strategy of differentiation requires that a business has sustainable advantages that allow it to provide buyers with something uniquely valuable. A successful differentiation strategy allows the business to provide a product or service of perceived higher value to buyers at a differentiation cost below the value premium. This differentiation usually arises from one or more activities in the value chain that create a unique value important to buyers. The innovative company can show the importance of the innovation through its goals which are different from one firm to another. In some firms, innovation is the essence of its products and services; therefore, the business philosophy must demonstrate the firm´s commitment to technological innovation. The simplest way to visualize this commitment may be by the application of the tool presented in Fig.2. To use this tool, each of the firm products and services is plotted according to innovativeness rate and value.

The described approach is also helpful for estimation of potential participation of customers in developing new technology based products. Innovative companies, in aiming to anticipate the optimal value of new technology product incorporation, have to be strongly engaged in co-production activities, hence the necessity of management operationalization of the presented model. Firms need to consider if this can attract new market segments, or they may need to encourage their customer segments to adopt a more participative relationship, which becomes one of more important factors in an innovation oriented management process. It is also important to underline the communication function of this tool by providing simple visualization of changes appearing in value allocation towards different innovation based products providing management with a holistic perspective on the company's value creation process and allowing comparison of the development of different projects or technologies.

However, company product innovation strategy must be conceptualized not only by focusing on R&D activities, but also by linking the innovativeness of the prepared concept to the company potential. In fact analyzing the actual state of an organization, innovation strategy design should be associated to technical excellence which has to be measured both by capacity to deliver customer value today and to create an adaptable product for tomorrow, hence the concept of lowering technical debt - improving the ability to adapt - as an integral part of the development process (Highsmith 2009). Thus the application presented of technical debt as the new

technology based product innovativeness. In some cases, technology based competitive advantage is not the key company success factor because, due to rapid propagation, international competitors can easily react and offer imitation products. In this situation, some producers try to enlarge the customer value proposition which originated in the new technology and develop a complete sales solution. This then appears as one of main reasons for assigning the innovative dimension not only to a product but also to complementary services in a way to make the offering more adopted to satisfy market needs. This kind of commercial combination can also be very interesting for companies as it can build a strong relationship with the customer over time giving the company the possibility to develop an innovation based value proposition based on user function development which is concurrently linked to technical debt dynamics.

3. Model Operationalization Determinants

The customer centered value creation process has to be realized with the understanding that in some situations, the company must evaluate the compromise between cost management and value to the customer. In fact, maximization of the customer value proposition can imply the diminution of value delivered to the firm (Chen, Quester 2009). For this reason it will be crucial to understand any increase in the gap between the two, so that the firm can deliver superior value profitably. From this perspective, the customer is an integral part of the firm's value proposition and marketing. This service-centered view presupposes that the customer is always an active participant in value creation and is thus a co-producer of the service. The confrontation of those two perspectives – the company innovativeness offer proposition and its customer value – will be useful for the company when analyzing innovation initiatives, particularly in the case of formulating a technology strategy as an innovation based differentiation strategy. Hence validation of the proposed tool will also require objective parameterization of the model, particularly concerning its axes being innovativeness and value.

3.1. Innovation Based Value Estimation

A company shareholder perspective is focused on value maximization as the principle purpose of business. In a marketing oriented company this is strongly associated with creating and providing products which offer value for the customer. Additionally, a value based management process underlines the importance of competitive customer value added as the most important source of shareholder value (Porter 1985). From this perspective, customer value add (CVA) can be defined as the relationship between the degree of customer satisfaction with the products and services received and the satisfaction with the price paid. A company creates customer value added when its products and services for customers are of greater value than they could expect from those of competitive companies in similar markets. CVA can be measured through market surveys of customer satisfaction and is calculated as a ratio of a company's performance relative to its competitors (Laitamaki, Kurdupleski 1997).

This definition of customer value is however based on a comparison of competitive offerings on the premise that they are available, which is something which occurs rarely for innovation based products or services. Another limitation of this definition is the much longer time lag between the purchase of a product or service based on new technology and the moment the customer perceives its value. In effect, CVA is an external measure of customer value based on analysis of competitive products or services. From an internal perspective, the capability of an organization to capture the strategic value of a new technology implementation is a critical competence for successful innovation and thus, for competitiveness. Due to the complex nature of rapidly emerging technological changes, this organizational capability is imperative yet difficult to create and sustain. As a result, the strategic process of technology evaluation for successful innovations varies from company to company.

Companies which are successful with innovative technology take into consideration customer needs before the introduction of technological changes by applying technology evaluation strategies. As part of these strategies, technology evaluation with the participation of potential customers is critical, and should therefore form an integral part of innovation routines. However, there are still very few studies on the strategic implications of company technology evaluation and innovation strategies. This is in spite of the fact that market dimensions for

technology evaluation are often critical for diffusion of innovation and the future technological radicalness of new products or services.

From an organizational perspective, a system approach incorporating customer value in the technology evaluation process should be considered as one of the strategic activities of a company (Ho 2011). On the other hand, conventional strategic analysis looks at a market perspective with a company's market share as the most important determinant of competitive advantage. Innovation based value creation processes should arise from individual perceptions of future customers and thus analyzing their opinion before market testing of a new product or service becomes even more important. These processes need to be aligned to a personalization of the product or service offering and to customer expectation of immediate feedback. Hence, in searching for new ways of creating value and innovation, companies need to organize their front line focusing on those parts of the process closest to the customers.

Increased personalization, combined with an increased expectation of immediate feedback, necessitates a transfer of decision making authority and increased responsibility to the front line, in addition to an increased focus on providing customers with an offer that meets their expectations (Johannessen, Olsen 2010). This individualized customer approach can be regarded as a critical factor in a situation where a company tries to commercialize new technology. The role of the customer is decisive and their opinion should be benefited from even in the user function determination process, thus much earlier than market testing of new products or services. This strong emphasis on the customer role in the innovation development process makes possible a parallel development of the commercialization concept which minimizes operations time and the risk of market failure (Ritter, Walter 2012). In effect, linking technology development to the customer value conceptualization process runs against the linearity of conventional innovation development. To be able to succeed in such an endeavor requires companies to change their organizational logic from hierarchy and bureaucracy to a front-line organization.

The description of technical debt cost composition presented above is associated with the development of product functionality normally seen by the customer as a new user function. Analysis of the proposed value level should therefore enable a definition of the set of user functions F_0 which are to be available in a specific version of product in period RD_0. A definition of which is essential for efficient planning of commercialisation. In the value creation model

proposed by Ho et al. (2014), value, described as val(n) of user function f(n), is defined as the weighted average of the ascribed user function priorities from among all the (weighted) criteria from all the (weighted) interest parties. One can conclude from this that to total value offered TRV(F_0) is defined as the sum of all the values of the individual user functions: $\mathrm{TRV}(F_0) = \sum_{f(n)} val(n)$. Obviously, the degree of value offered to a customer will also be associated with the quality of the product at a specific moment of time where the simplest approach is to associate this with the number of defects identified which are eliminated in subsequent versions. Another approach is to assess the number and types of pre-release tests performed on the product. For each user function it is possible to define test procedures depending, to a large extent, on that function's initial complexity. In this way it is possible to define the estimated quality of user function F(n) as $Q(n, a_n, b, t_n)$ where for a given user function f(n): t_n are test activities, a_n is the anticipated number of defects, b is a coefficient showing the defect distribution as a function of the number of tests. Based on this method for estimating the quality of user functionality it is possible to define the quality of a specific product version as the aggregate of the discrete (quality) values of the specific user functions. The enlargement of total value offered based on the user functions can be adopted in the discussed model (fig.) Hence the new formulation of CVA as the ratio of customer value perceptions of the offered functions relative to the TRV(F_0).

3.2. The Concept of Innovativeness Assessment Based on Technical Debt

It is possible to identify a strong congruence between customer perceived value and the perceived innovativeness of company technologies, its products or services. This congruence leads to a definition of the objective level of a proposed technology, which has to be valuable from a quantitative perspective and thus can be linked to the company financing sources (Radford, Sridhar 2005). In fact, the initial development phases of most innovation based companies as well as in most innovation projects use internal financing which in extreme cases is then converted to internal assets. These assets then become significant elements in the assessment of the value of a given activity. Thus, limited access to financial sources combined with their relatively high cost results in strong pressure on operating cost and on meeting innovation commercialisation timetables. The search for increased competitiveness and customer

attractiveness obliges companies to constantly undertake innovative activities not just in an anticipatory direction but also as an adaptation to consumer needs. However, adaptation based innovation normally takes place in ways which run counter to classic link management processes characterised by definition and acceptance of strategies and budgets. An approach based on evolution and adaptation as proposed by Highsmith cannot be equated to planning and optimisation processes as innovations develop in much the same way as living organisms. This framework can also be applied to develop new products and its non-application could result in a significant gap between the requirement to develop new and innovatory products and the actual capability of a company to provide these to its customers. This in effect, describes the degree of innovativeness in the sense that most innovative solutions have no value for the market without their customisation.

A model illustrating this problem is the concept of technical debt used in the I.T. industry as a tool for describing the degree of effectiveness of information technology projects. This concept was introduced in I.T. in the 1990's by Cunningham (2009) and it arose in situations where activities were not managed effectively resulting in a lot of pressure to ensure on-time completion. Technical debt can appear right at the very start of a project and it is defined as the gap between the cost of implementing project changes and the optimal value level. Control of the level of technical debt enables a balance to be found between current benefits offered to customers and meeting their future expectations (Fig.2). Time and cost pressure due to the immediate market introduction of innovative products or services leads to functional instability and increasing modification costs.

According to Highsmith (2009), increasing technical debt reduces the ability to react to customer needs resulting in a lack of understanding by these customers of the reasons why implementing even minor changes takes such a long time. Customers normally expect very rapid product development enriching products with new user functions. Attempts to satisfy their needs results in an ever larger increase in technical debt in ever shorter time-frames. For this reason, activities to reduce the level of debt become increasingly expensive for an organisation and merely serve to maintain the current level of value without translating into increasing customer benefit. A significant point is the occurrence of technical debt in the early phases of product development where it might not be appropriate to limit it. This is because during these phases, when time and cost allocations are at a level geared to meet anticipated results, technical debt can

be allowed to reach an optimal level. For this reason, taking steps as early as possible to monitor technical debt and, when necessary, implement corrective actions, is logical and creates an appropriate process control framework.

The constant reduction of technical debt to ensure low modification cost often results in the development of a technology strategy for the company which includes a structural description of the value creation process where the essence is an analysis of the short and long term impact on value of the activities being undertaken. Increasing emphasis on customer value maximisation leads to an increase in the number of user functions included in the product. This in turn leads to a need for larger infrastructure to organise support which often results in changes in the organisational structure of a company. Leaving this aspect out of the management process significantly increases the risk of market failure and can have a negative impact on financial results. Therefore, a key requirement in the technical debt management process is an assessment of quality and future function degradation caused by commercialisation time pressures where the functions or quality level are essential to maintain an appropriate value level for the customer. During the project development cycle, technical debt management thus becomes a process of making choices between cost reduction and activities creating value where setup of this type of process will require a definition of acceptable limits of technical debt based on quantitative estimates. An initial concept with this type of model was proposed by Nord et al. (2012). This initial concept is based on an assessment of the cost of rebuilding a particular system (for example - an I.T, project) based on the introduction of each new element E_i, which is, for instance, an additional user function, introduced into version n of a product. The total cost T of version n is thus a function of the implementation and rebuild cost - C_i and C_r : T = F(C_i, C_r). For the described situation, this is assumed to be a summation of the two values. Implementation costs are calculated as: $\sum_k C_i(E_k)$ for each new element E_k where the implementation cost $C_i(E_k)$ is a given for all elements of architecture k.

Rebuild cost C_r for version n is calculated in a similar manner: $\sum_k C_r(E_k)$ for each new element E_k, whereas for existing elements E_j, the rebuild cost $C_r(E_k) = \sum_j C_r(E_j)$. If, however E_j is an element which already exists in a previous version of the product then $C_r(E_j) = D(E_j,E_k) \times C_i(E_j) \times P_c(n-1)$. In this case $D(E_j,E_k)$ is the number of associations occurring between E_ki E_j, C_i implementation costs whilst $P_c(n-1)$ is the change in distribution level of version n-1. The change in distribution level enables a definition of the number of

elements of the system which require modification as a result of a change of one element of the system. This detailed technical debt formulation is helpful for the parameterization proposed as the ratio of the total technical debt associated with new technology commercialization and its historical value realised with other technology projects but providing that they use similar organizational resources.

4. Further research

The parameterization of value added presented above, allows an adaptation of these parameters as quantitative dimensions of the tool presented above for company strategy estimation of a new technology based product. The first concept of this model is using terminology derived from a normative approach (Tab.1.).

Tab.1. Proposed model parameterization and resultant formulation of basic strategies.

<table>
<tr><td rowspan="2">Innovativeness</td><td>High</td><td rowspan="2">Technical debt</td><td>High</td><td colspan="2">Business Model Institutionalization and Sales Platform Initiation</td><td>Sales Expansion with a Basic User Function Set</td></tr>
<tr><td>Low</td><td>Low</td><td colspan="2">Divestment or Open Source Platform</td><td>Sales Development based on User Function Differentiation</td></tr>
<tr><td colspan="4" rowspan="2"></td><td>Low</td><td>High</td></tr>
<tr><td colspan="2">Value</td></tr>
</table>

Source: author’s own elaboration.

The first formulization of strategy typology in the model presented above is based on the possibility of strategic analysis of a company products treated as a set of the functions, which can provide a new perspective for modelling a company's value creation process. This type of approach would be associated with four main areas of customer value addition: growth in the number of user functions, development of the product definition and development organisation, reduction in defect count, reduction of existing technical debt. This makes possible, future

research about the possible links between company innovations and the technical debt as the variables determining the company technological debt. In fact the role and place of technical debt in a pro-innovation management process is becoming one of most interesting areas for contemporary research of practical and theoretical aspects of strategic management processes. The diagnostic tool concept presented, gives increased possibilities of analysing the impact of introducing new technologies as well as of an assessment of the consequences of the development and commercialisation of the developed innovations, which will be an interesting area of future research. Monitoring the dynamics of technical debt within a company whilst research and development activities are taking place is a complementary tool in the process of assessing their future financial impact. Thus, very interesting development possibilities arise for application of this concept to model technological differentiation strategies especially with the regard to a strategy of value creation for the customer.

5. Conclusion

Implementing the technology innovation process, companies should provide the best possible solutions for the individual customer and, to assess this, a standard evaluation tool is needed that highlights changes in value perception for various technology commercializations enabling a company to observe and analyze changes in customer attitude. The tool presented and its parameterization should also assist in future market segmentation and minimize risk of market failure. Development of new technology makes possible the definition of new user functions which have to be evaluated, even during the innovation process, as early as possible. The customer role in this process is in helping anticipate the definition of the new product or service offering where execution of this process ensures the stability and reduces the unpredictability associated with future market introduction. Conceptualization of strategy for technology evaluation should involve the application of qualitative and quantitative methods, which improve the quality of market oriented strategic decisions and can also be incorporated in company decision systems.

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Dług techniczny i wartości dodana dla klienta jako parametry strategii opartych na innowacji technologicznej

Streszczenie

Wprowadzenie na rynek technologicznie innowacyjnych produktów lub usług opiera się na ofercie stanowiącej wysoką wartość dla klienta. Segmentacja procesu tworzenia wartości zorientowanego na klienta może stanowić podstawę utworzenia nowego narzędzia diagnostycznego umożliwiającego wspierającego menadżerów w tworzeniu większej wartości produktów lub usług bazujących na technologii, włączając w ten proces również klientów. Zastosowanie tego typu narzędzia bazujące na pojęciach wartości dla klienta oraz długu technicznego jako jego parametrach pozwala decydentom na analizę i pomiar natury percepcji wartości i poziomu innowacyjności proponowanej oferty celem określenia właściwej strategii marketingowej również jako narzędzia minimalizacji ryzyka rynkowej porażki produktów opartych na innowacji.

Kluczowe słowa: zarządzanie technologią, tworzenie wartości, innowacja, dług techniczny
JEL: O33, O32, M31