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**SOME METHODOLOGICAL ISSUES OF
TECHNOLOGY ROADMAPPING
EXPERIENCED DURING CONSULTANCY**

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Abstract: The authors share some of their methodological recommendations based on their TRM-consultancy experience. They recommend: (1) using an 'environment' dimension of analysis (i.e. layer of the roadmap) instead of just 'market', (2) avoiding the usage of the popular oversimplified version of SWOT analysis instead of the full version, (3) using weighting scales based on the 'magical number seven plus-minus two' rule by Miller (1956) for quantifying the relations between the units of the TRM-analysis

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Introduction

We described some organizational issues from our technology roadmapping (TRM) experience in our previous paper in PIEB (Pataki, Szalkai, Bíró-Szigeti, 2010). In our present paper we discuss some methodological issues of TRM what we found useful during our Hungarian TRM-consultancies. Our findings are related with two areas: the recommended dimensions of the TRM-analysis (i.e. the layers of the roadmap), and the avoidance of some observable oversimplifications.

Broadening the dimensions of roadmapping analysis

The top layer of the technology roadmap is usually called the „market”. During our practical work we also started our analysis from this aspect. However, we learned from our experience that considering solely the market is not enough, as sooner or later we always ended up analyzing the broader environment. Taking everything into consideration, this comprehensive analysis of the situation shows the current position of the company, broadly describes its operating environment, and reveals the potential success and failure factors. This is useful because it provides information to the analysis of the company which is operated by a certain strategy and forces the firm to take its growth potentials into consideration. The marketing situation shows the current situation and the environment of the company.

The assessment of the company's environment is essential to reveal the marketing situation. The marketing approach divides the environment of the company into macro and micro level (Kotler, 2003). The elements of the macro environment include demographical, economic, social-cultural, environmental, technological and political-legal factors. These broadly considered macro environmental factors

affect each company and their effects can only be partially or not controlled at all. The micro environment covers those elements that have stronger relationship with the company: the company itself, suppliers, intermediaries, customers, competitors and the public. This is actually the market, whose participants operate in the above mentioned macro environment. The newest division of mainstream marketing (Kotler and Keller, 2006) deals with the company's marketing and task environment (including actors directly participating in the manufacturing, distribution and promotion of the product or service) and the broad environment of the business (including the macro environment factors) rather than the company itself. In this article we suggest using Porter's five forces model (Porter, 1979, 1980, 1985), which is well-known from strategic management, to analyze the micro environment. Although the five forces model refers to the industrial environment it covers most elements of the micro environment. We use the widely known STEP (or PEST) model to analyze the macro environment. The above mentioned methods can be used to reveal the current situation of the company. Let's see some examples why we think it is advisable to use these models instead of examining only the market. We don't describe the models themselves because they are well known in management and business studies.

Porter's five forces model

Competitors. At one of our client companies the possibility of a technical investment occurred when one of its competitors went bankrupt and they had the opportunity to buy the modern equipment of the other company at a very low price. We did not get to the point of contemplating the possibility of the technical investment by following the “market demand - satisfying product - necessary technology” logical order. Instead, we approached the

question from a quite different angle, through a more detailed analysis that included the competitors as well. The five forces model drew our attention to this direction.

Substitute products. In certain industries converging services based on converging technologies are blurring the boundaries between the traditional categories of “competitor” and “substitute product”. We learned from our experience that in these industries competition has to be examined more flexible than the traditional division of the above mentioned two categories. It means that the sub-layers of the competitors and the substitute products should not necessarily be separated in the environmental layer of the customized technology map. Instead, they should be analyzed together in a common sub-layer.

Suppliers. Companies usually consider all those market participants as their suppliers who provide information and can contribute to the development of products, services and processes. We gained from our experience that it can be useful to involve suppliers into technology roadmapping because they can reveal new perspectives and insights which can't be seen from the company using their supplies, because they work in different industries.

Customers. It is the equivalent of the market dimension of TRM, not a new dimension compared to the well-known ‘market - product - technology’ layers.

Potential new entrants. The competitive power of potential new entrants is a threat that they can enter the market as new competitors. It is not adequate to consider only those potential competitors who might become new entrants based on their current business field. A much broader overview and environmental analysis are needed. This can draw the attention to the competitors emerging unexpectedly from completely different line of business. For example Tesco is planning to enter the Hungarian mobile communication market while still maintaining its current retail business (Tóth, 2011). In some countries its private label mobile services have already gained success. If we focus only on the market dimension in technology roadmapping we can't identify this participant as it is not yet a competitor of the current mobile service providers since it is active on a totally different market, even though it can jeopardize the market share of the current market participants.

Porter was asked in an interview what he would add as a sixth force if he had a chance to rewrite the five forces model after more than two decades (Argires and McGahan, 2002). He answered that he thought of two nominees but finally rejected them both. One of Porter's candidates was government, but it is “not a sixth force because there is no monotonic relationship between the strength and influence of

government and the profitability of industry. You can't say that ‘government is high, industry profitability is low’, or ‘government is low, industry profitability is high’. It all depends on exactly what governments do. Also, there are many different parts of government, each with its own distinct impacts. And how do you assess the consequence of what government does? Well, you look at how it affects the five forces.” Porter's other candidate involves organizations whose products are complementary to the observed organization's ones. “Again, there is no monotonic relationship between the extent of complements and profitability. Sometimes having many complements is consistent with high industry profitability, sometimes with low profitability. It has to do with how complements affect the five forces.”

STEP model

The macro-environment of a company is usually analyzed with the help of the STEP model. It has several modified versions; the original is from Aguilar (1967). We use here the original version.

Social. The business unit of one of our client company is influenced by a forthcoming cultural revolution - according to company experts - that will slowly brings the need for new services in the future. This kind of change-over will be most likely slow, its impact can be hardly perceived at the moment. The new additional services will probably slowly change the main profile of the company, the new consumer behaviour and needs will present only narrow market niches until then. At another client company of us in the construction industry partly the demographic change (namely the decrease of population in Hungary) has a long time impact on the product range. On the other hand the principle of “less is more” is getting more and more visible which comes from the consciousness of customers and their reduced consumption. Not the quantity, but the quality of consumption is important. For example, smaller flats and offices would be more attractive and the above mentioned principle can be found in higher quality and better space utilization. Or complex services in informatics will appear when the customer buys everything he or she needs from one supplier and therefore gets discount or extra services.

Technological. Our experiences show that the technological environment can be hardly separate from other macro environmental forces in many cases. For example due to such social and demographic changes like the aging society, the dramatic changes of the way of life induced by the new information and telecommunication technologies, or the increasing environmental consciousness, it is worth to concentrate on new product developments, combination or compatibility of existing technological solutions in the future (e.g. Internet based existing or new

applications). It is important to note that the spread of new products or services depend on the increasing price sensitivity of customers and value addition.

Economic. Recently a tendency has been noticed that the economic recession is the most important threat described by most of the companies. It has not been seen as opportunity for example for market growth in the future or for downcutting the number of competitors. We also remarked at our client companies, that since their customers are eager to have merged services and reduce prices because of the recession, it takes a continuous thinking to create new solutions. In this specific case the analysis of the economic dimension of the STEP model was closely correlated with the analysis of the buyer's bargaining power in the Porter model of the five competitive forces.

Political. The political environment was exclusively important for one of our client company where the governmental elections in every four year became sources of fundamental uncertainty so we were told to mark them on the technology roadmap. That is the industry they work in (construction industry) is naturally an industry where prospects and the trend of the demand curve highly depend on certain aspects of the economic policy. In turn, at another client company the experts considered the impact of the political environment on their industry negligible therefore the analysis of the political dimension in the technological roadmap became unnecessary. Meanwhile they reported to us that it was a bad idea to neglect this force then, because the change of the economic policy has had a serious impact since then. It would have been useful to draw up possible scenarios even if it was not easy. Lesson: the importance of the analysis of any of the elements of the STEP (or similar) model should not be inconsiderately underrated just because it had not been considerable impact onto the company for relatively long time before the technology roadmap project.

Avoiding oversimplified usage of some tools

During our consultancy we experienced that management consultants or professors sometimes do not introduce those popular and useful management technics which are essential for the proper analysis and strategic decision making in details. Because of these sketchy introductions, managers do not find the technics particularly useful, that is why it happened that we had to start the application of certain methodology with a disadvantage.

Oversimplified SWOT analysis

At one of our client companies the SWOT analysis was considered to be useless, because a former consultant presented only the four fields of the analysis but not the whole analysis

afterwards. They wrote only four lists but did nothing more. Contrary to this we introduced and applied the method in its whole depth. We analyzed each field not only as a pure list of factors, but with the help of matrices which quantify the degree of opportunities, threats, strengths and weaknesses and the probability of their occurrence (Aaker, 1995; Kotler, 2003). With the help of weighting we could concentrate only on the most important factors at the specific company. It is important to note that for a TRM analysis SWOT analysis should be made on the business unit level at a company and/or on market segments. Therefore it becomes avoidable that a complex, overall and hereby finally a useless matrix to be created.

In the SWOT analysis the final step is to set the objectives and to choose the accompanying strategies. We present only the most important factors resulted from previous analysis so we concentrate on the main point. When we introduced the SWOT analysis in its whole depth to our client company, the former unfavourable opinion about the usefulness of the method became favourable. "Wow, that's quite a very different story!"- they reacted.

Oversimplified scoring

Another kind of oversimplification is the usage of scoring scales with too few grades for subjectively assessing the relative importance of different entities and their relations. These assessments are used for weighting the different product and business drivers (i.e. the relative importance of different product characteristics or other factors which are important for the customer and/or for the company), and also for characterizing the relationships between the drivers and product features, and between product features and technologies (i.e. between the typical layers of a technology roadmap). We discussed these commonly used dimensions of roadmapping in our previous paper in PIEB (Pataki, Szalkai, and Bíró-Szigeti, 2010). A typical example of this kind of relationship matrix is shown on Table 1 when F_j -s are the relative importance weights of the product features, r_{ij} -s represent the impacts of the technologies on the product features (i.e. their contributions to the required product performance), and T_i -s are the relative importance weights of the technologies.

The relationship matrix between the drivers and product features is similar. The calculation formula of T_i -s from F_j -s and r_{ij} -s is shown in equation (1).

$$T_i = \sum_j r_{ij} F_j \quad (1)$$

This kind of relationship matrix is also used for some other purposes as well, e.g. for technology portfolio analysis, not only for

technology roadmapping. Lowe (1995) recommends a 1+3 grade scale for scoring r_{ij} -s: 0 = not used, 1 = lagging, 2 = average, 3 = leading.

Phaal, Farrukh and Probert (2001) also use 1+3 grades: 0 = no impact, 1 = low impact, 2 = medium impact, 3 = high impact. But their scale is different from Lowe's scale from two point of view. One is that they use half grades as well between the integer numbers. But they use half

grades very rarely in their examples as if they consider them exceptional cases only. The other difference is that they give both positive and negative scores. The negative ones mean that a particular technology has negative impact on a particular product feature. For example an IT-safety technology makes the handling of a computer or a web service slower and more complex, using fingerprint identification, mobile phone ID number sending etc.

TABLE 1. PRODUCT FEATURE - TECHNOLOGY RELATIONSHIP MATRIX

		Product feature 1	Product feature 2	...	Product feature n
		F_1	F_2	...	F_n
Technology 1	T_1	r_{11}	r_{12}	...	r_{1n}
Technology 2	T_2	r_{21}	r_{22}	...	r_{2n}
...
Technology m	T_m	r_{m1}	r_{m2}	...	r_{mn}

During our TRM-consultancy we successfully used more grades than 3 even with half grades. Miller (1956) pointed out that our short-term working memory span is approximately 7 items, plus-minus 2. This "magical number 7" (as Miller rhetorically called it) has several different practical consequences. One of them is that we can distinguish cca. 5-9 different grades when assessing only subjectively evaluable entities. A newly graduated freshman in the field with only a few practical experience can distinguish 5 grades while an experienced master of the same field can give scores on a nine-grade scale. In accordance with Hayes's research this master level can be reached during cca. a decade of intensive and permanent cultivation of the same field (Simon, 1983). Hayes found this one decade duration generally valid, irrespectively from the nature of the field of expertise. M  r   (2002) also found the necessary duration of becoming a master one decade but not absolutely independently from the field. He found slight differences depending on the mathematical or non-mathematical nature of the field. If a particular field uses more mathematics then it takes a slightly shorter period to become a master. In M  r  's opinion this is because mathematical models and algorithms can be used as more or less universal toolkits for handling several problems, while in a dominantly verbal field there are only a few - if any - universal toolkits, and it is often needed to build up several different models and methods for understanding and solving the several different problems. But the average duration is the same according to both researchers: cca. one decade.

We use 1+5 grade scale in our consultancy practice and it works well. Our scale is: 0 = not

used / no impact, and 1...5 with half grades if used or has impact. The whole Hungarian education system uses five-grade marking scales so our clients are absolutely familiar with it and can use it very easily. The only difference is that we use half grades as well, unlike the education system, but this non-essential difference never caused any problem. Freshmen can use the 5 integer grades while masters can give half grades as well. If we recommended using only 1+5 integer grades without half grades then the more experienced professionals were unsatisfied with the scale and wanted to use half grades as well because they perceived the finer differences.

Summary

In this article we presented some methodological issues of TRM based on our roadmapping consultancies. We summarized our experiences around three main areas: the necessity of extending the market dimension of TRM; the incomplete application of some analytical methods; and the usable resolution of the scoring scales. The presented methodological experiences might be utilizable not only in technology roadmapping but also in some other similar strategic management activities.

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