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How to prevent product piracy using a new TRIZ-based methodology

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Abstract

In recent years, product and brand piracy has significantly gained importance and risen to a worldwide mass phenomenon. Companies are gradually facing up to the challenge and taking action. Besides legal measures, an increasing number of firms is also willing to implement strategic and technical measures into their organisations respectively products. But the potential of these approaches is so far only being exploited to a limited extent, mainly due to lacking knowledge regarding the functionality and benefits of technical know-how protection mechanisms.

Focusing on this issue, the paper introduces the so called Product Piracy Conflict Matrix (PPC Matrix). The PPC Matrix methodically resembles the well-established TRIZ Contradiction Matrix and is also based on Neemann's work (2007), who recently introduced a new approach for product-based imitation protection including a set of technical, strategic, organisational and legal instruments. The PPC Matrix combines both approaches to a new framework to help companies to find expedient measures against product piracy.

The article introduces the new methodology by giving detailed insights into its theoretical backbone, providing practitioner's guidance and outlining examples from industry practice.

Keywords: Product piracy; Product imitation; Technology know-how protection; Contradiction matrix; Ideality approach;

1. Product piracy as a new challenge for companies

Product and brand piracy has significantly gained importance in recent years and risen to a worldwide mass phenomenon [1]. Companies are gradually facing up to this new challenge and taking action. Besides legal counteractions, an increasing number of firms are also trying to implement organisational or technical measures against product piracy [2]. Nevertheless, the potential of these approaches is so far being only exploited to a limited extent which can mainly be traced back to lacking knowledge regarding the functionality, benefits and application conditions of these new know-how protection mechanisms [3].

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When it comes to identifying concrete protection mechanisms and implementing these into a running business, companies often face problems and conflicts, which seem insurmountable: on the one hand, a burdened company quests for powerful protection strategies for its product and brands. Yet on the other hand, companies are not willing to accept excessive modifications to their products and value chains. From a corporate point of view, a common requirement for instance is that the general product functionalities must not be noticeably affected by the implementation of a protection feature. In other cases, financial limitations, after sales service requirements or constraints by regulations have to be considered. Due to these restrictions, companies often face a "deadlock situation" when trying to install suitable measures against product piracy.

In order to overcome such conflicts, companies require systematic methodological support in finding appropriate measures that do not influence their value chains in a negative or harmful way. In line with this claim, the article introduces the so-called Product Piracy Conflict Matrix (PPC Matrix). This new problem-solving approach has been developed by the Fraunhofer Institute for Production Technology IPT based on insights from numerous consulting and research activities in the field of product piracy protection.

2. The PPC matrix and its theoretical backbone

The PPC Matrix has been designed as a methodical guideline for companies to select appropriate protection measures against product piracy. Contrary to other approaches ([2] [4] [5]) the PPC Matrix pays special attention to boundary condition within the value chain of a company, which may not be influenced in an undesired or harmful way by the implementation of protection measures.

The methodology primarily addresses professionals in R&D management who are searching for means to protect their products but yet have little experience in that issue. Also it can be helpful for experts who have already considered certain protection schemes but would like to double-check their selection in order to reduce the risk that a more appropriate measure might have been forgotten.

2.1. The contradiction table of TRIZ as a methodological frame

The basic idea of the PPC Matrix is derived from the contradiction analysis as a well-established method within TRIZ. The TRIZ approach relies on expressing a challenging problem as either a technical contradiction, for which solutions can be identified in a systematic way based on innovative principles. A technical contradiction exists, if improving a parameter "A" of a system causes a different parameter "B" to deteriorate, whereas a physical contradiction exists if some aspect of a product or service must simultaneously adopt two opposing states. Expressing the problem in question as a technical or physical contradiction is therefore a prerequisite to applying the contradiction table [6]. The analysis then relies on fitting the problem to a table of conflicts between 39 technical parameters and identifying solutions based on 40 innovative principles, which have proved successful in solving these conflicts. In this sense, the contradiction table represents a comprehensive data compilation of expert knowledge on the applicability of innovative principles in solving technical or design problems (for a more detailed description of the contradiction analysis see for instance [7]).

In certain cases, the contradiction table itself is already applicable and helpful in the context of product piracy protection. Yet in general, its direct applicability is limited, mainly due to two reasons:

- Users often fail in structuring and expressing piracy problems in terms of technical or physical contradictions due to lacking knowledge and experience. That is why more problem-specific guidance is required.
- Solutions against product piracy are clearly not limited solely to technical principles. That is why the scope of innovative solutions generated by the contradiction table is limited and thus inappropriate for piracy problems.

However, the issue of creating solutions against product piracy can as a whole be viewed as a physical contradiction, due to the already mentioned conflict: on the one hand, protection mechanisms are called for, yet on the other, persons responsible are not willing to take negative or harmful alterations to their product into account. In many workshops that Fraunhofer IPT has conducted with companies in different lines of industry, this conflicting

situation represented a major restriction or even a knock-out criterion against the implementation of powerful protection measures. The idea of a problem-specific contradiction analysis arose from this insight.

2.2. The analogy between the TRIZ contradiction table and the PPC matrix

Following the basic idea of the TRIZ contradiction table, the PPC Matrix is designed to identify standard solution principles against product piracy threats, for which suitable solutions must be identified. Therefore, the structure of the PPC Matrix is quite similar to the contradiction table. The rows contain actuating parameters or levers to implement protection mechanisms. The columns on the other hand represent a list of reactive parameters that could be harmfully affected by the actuating parameters. In short, the analogies between the traditional contradiction table and PPC Matrix can be described as follows:

- Conflicts between active and reactive parameters are recorded at the intersections of the rows and columns of the PPC Matrix.
- Standard solution principles within the PPC Matrix are based on a catalogue of protection measures as a research result of the Fraunhofer IPT [2] [8].
- The application of the PPC Matrix is embedded in a comprehensive problem-solving procedure that comprises an initial problem analysis and the identification of main conflicts and is followed by the development and validation of solutions based on standard principles proposed in the cells of the Matrix.

2.3. Design of the PPC matrix

In contrast to the contradiction table, the PPC Matrix is designed in a non-symmetric way. Although several parameters can be found simultaneously in the columns and the rows of the Matrix, the structuring frameworks for the rows and the columns are different (Figure 1): Derived from a game-theoretical analysis, the parameters within the rows are classified according to the generic behavioural pattern of the imitator and original product manufacturer. On the other hand, the parameters in the columns are arranged according to the standard value chain of a company. These two basic structuring concepts will be described in detail in the following.

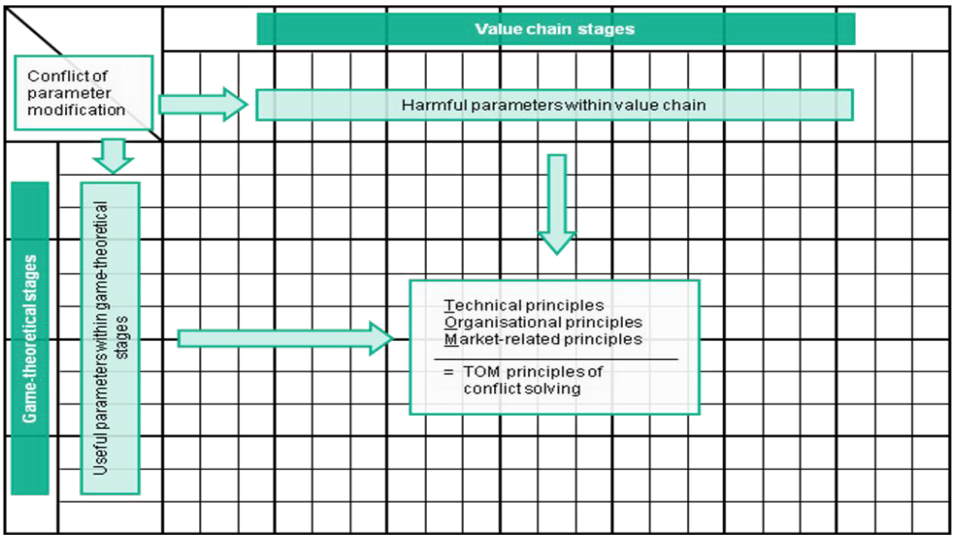

Figure 1: Concept of the PPC Matrix

2.4. Structuring the rows based on game-theoretical analysis

From a game-theoretical point of view, there are four more or less sequential stages which are suitable to generically describe the behavioural pattern of an imitator and thus, the stages of opportunities for an original product manufacturer to take counteractions [2]:

- Selection of a product to be copied
- Analysis of the product
- Reproduction of the product
- Marketing and sales of the imitation

The first decision an imitator has to make is the selection of the product he intends to copy. Needless to say, the imitator's decision mainly depends on the expected commercial benefits which are linked to the imitation. Hence, the initial selection and decision-making process of the imitator represents the first stage for the original product manufacturer to take action. By shifting certain parameters within the product design or business model (e.g. in terms of production techniques or after sales services), the original product manufacturer can deliberately lower the imitation attractiveness of his products.

After an imitator has decided to copy an original product, the second lever is to make the product analysis or reverse engineering as time-consuming and tedious as possible for the imitator. Various counteractions can be considered, yet most of them are directly affiliated to the product structure or design (e.g. increase of product complexity or limitation of product access).

If the imitator has succeeded in analysing a product, the third and subsequent stage is the reproduction (in terms of manufacturing) of the original product by the imitator. For the original product manufacturer, the according lever is to impede the imitator from actually realising a reproduction. At this stage, mainly measures related to supply chain management (e.g. limiting the access to essential suppliers or components) can be considered.

Finally, assuming the imitator has actually achieved in manufacturing a false replica, the remaining lever for the affected company is to hinder the imitator in bringing his imitation to the market and gaining market shares. Counteractions primarily apply either directly to the design of sales channels or to implementing appropriate authentication means.

These four stages represent a suitable classification framework for a generic list of actuating parameters companies can modify in order to implement protection measures. The according parameters represent the rows of the PPC Matrix.

2.5. Structuring the columns based on the ideality principle

According to "ideality thinking" as a central TRIZ principle, a technical sub-system should fulfil its desired functions without calling forth an undesired effect of the corresponding entire system. The TRIZ dictum says: effective technical solutions evoke maximal positive effects within a system and simultaneously limit possible negative effects to a minimum. The effectiveness E is a universal TRIZ ratio to evaluate the degree of ideality of technical system.

$$E = \frac{\text{Sum of the positive effects}}{\text{Sum of the negative effects}}$$

Metaphorically speaking, the ideal system provides a desired function without even existing [9]. Following this line of thinking in the context of product piracy, protective measures can be considered subsystems of an (already existing) system, i.e. of the value chain of the burdened product which has to be protected. Hence, an ideal measure against product piracy fulfils its desired function without bringing harmful effects into the value chain system it is supposed to protect. A full corporate value chain generally comprises seven stages [10]:

- Research & Development
- Procurement
- Production
- Distribution
- Marketing
- Sales
- Service

As illustrated in the introduction already, certain characteristics within the value chain may be influenced in a harmful or destructive way by the implementation of protection measures. This circumstance accounts for the conflict companies are faced with in the context of product piracy. Consequently, according to the notion of ideality, the PPC Matrix offers standard solution principles which enhance the positive (protective) effects and minimise the negative (value chain-modifying) effects.

2.6. The 26 TOM principles

Based on the research results of Neemann, Fraunhofer IPT has compiled a list of 26 principles that can be applied to dissolve the described conflict. Neemann provides an even more comprehensive list of 42 principles. Fraunhofer IPT has used a number of workshops with companies from different industry sectors to test these principles. As an outcome of these workshops, 26 principles have proven to be highly promising solutions against product piracy. Three basic categories have been distinguished to classify these principles:

- Technical principles: they are directly integrated within the product as additional features or as modifications of existing product components
- Organisational principles: they can be implemented within the internal organisational structure, without considering external links to markets
- Market-related principles: they are implemented according to customer requirements and relationships, i.e. taking the market of the burdened product into account.

According to the initials of the three categories, the 26 principles against product piracy are labelled the TOM principles (Figure 2). In analogy to the 40 inventive principles of TRIZ, the TOM principles represent standardised mechanisms in an abstract form. This implies that a principle considered justified must be adjusted to individual problem characteristics, i.e. to product and corporate boundary conditions.

One example for a technical principle is the principle of De-standardisation. Today there are numerous industry standards existing in order to ensure the exchangeability of components and to increase economies of scale. Engineering departments often try to achieve a maximum quota of standard components in their products, which can be easily purchased from catalogues. On the one hand, this proceeding reduces costs in purchasing and enables the integration of different products. On the other hand however, standardisation makes it easy for imitators to reproduce original products, because they can source standard product components on worldwide markets.

Technical principles:

T1	Fixed cost-intensive manufacturing
T2	Branded functionality
T3	Product (de-)activation
T4	Decomposition barriers
T5	Functional black boxes
T6	Fake black boxes
T7	De-standardisation
T8	Local increase of performance density
T9	Product authentication
T10	Product bundling

Organisational principles:

O1	Product certification
O2	Staff retention
O3	Codification of documents
O4	Proprietary development of production facilities
O5	Collaboration with imitator
O6	Chinese walls in the supply chain
O7	Contracted supplier relationships

Market-related principles:

M1	Lead time
M2	Release management
M3	Simultaneous market launch
M4	Price differentiation
M5	Product differentiation
M6	Shadow placement
M7	Mass customisation
M8	Extended life cycle services
M9	Establishment of industry standards

Figure 2: The 26 TOM principles for product piracy protection

The principle of De-standardisation is based on the idea to focus not on existing standard material when constructing key components of a product but instead to design these components individually. The individualised components only deviate slightly from the standard component. The imitator does not notice the deviation of this

particular component and uses standard material instead. As a result, the imitator's product does not run correctly or shows much lesser durability than the original product.

2.7. Industry example: Rolling bearing

For the bedding of a spindle, a machine manufacturer uses rolling bearings which have an external diameter slightly above the diameter of the industry's mainstream bearings. When trying to copy the machine, imitators with little technical capability will probably copy the diameter of the bore in which the outer ring of the bearing is located but will resort to the standard bearing, which they easily get on the world market.

Thus, the bearing fit will be loose and abrasion will accelerate. The imitator's machine will have much lower durability and accuracy whereas the imitator will probably never find out, where that comes from.

A sound example for an organisational principle is the proprietary development of production facilities. That is also an option to make the reproduction of the original product difficult for the imitator. In the first place, it reduces the risk of know-how outflow, which can take place when production facilities for a specific product are developed outside the own company. The developer of the facilities is willing to use the specific technologies or machinery also for other commercial purposes. Thus, he tends to sell his development to other companies. The special product-related know-how is not exclusively owned by the original product manufacturer anymore. This risk can be reduced by the proprietary development and maybe also manufacturing of production facilities. An expedient practice in terms of this principle is also the product-specific modification of standard machinery instead of the completely new development of the production facilities.

2.8. Industry example: Special production facilities at OSRAM

OSRAM is a market leading producer of lighting systems. OSRAM's special machinery which is necessary for the production of their product lines has always been developed and manufactured company-internal.

According to OSRAM, this procedure not only lowers the time-to-market of their products but also works as a powerful protection mechanism against product piracy. No other supplier has the technological capability to develop machines as capable as the OSRAM production facilities [11].

Finally, Mass Customisation is an expedient practice in terms of market-related principles. From the outset this mechanism lowers the imitation attractiveness by offering products that are specifically tailored to each customer but however derive from mass production.

Mass customisation is already well-established in the automotive sector, where customers have a wide scope to individually configure their own cars. However, mass customisation requires highly-flexible production facilities, which is the first reason why it can hardly be offered by most imitators. On the other hand, imitators would need infrastructure for direct customer contact to take individual orders from them. Most imitators flinch from building up this kind of infrastructural capacity to avoid fixed expenses.

2.9. Industry example: Tailored consumer goods for mass markets

The clothing and accessory producers Polo, Timberland und Longchamp allow customers on their companies' homepage to configure their ordered products after their own fancy. Customers have various degrees of freedom (e.g. for embroideries) and thus can individually create their own clothes [4].

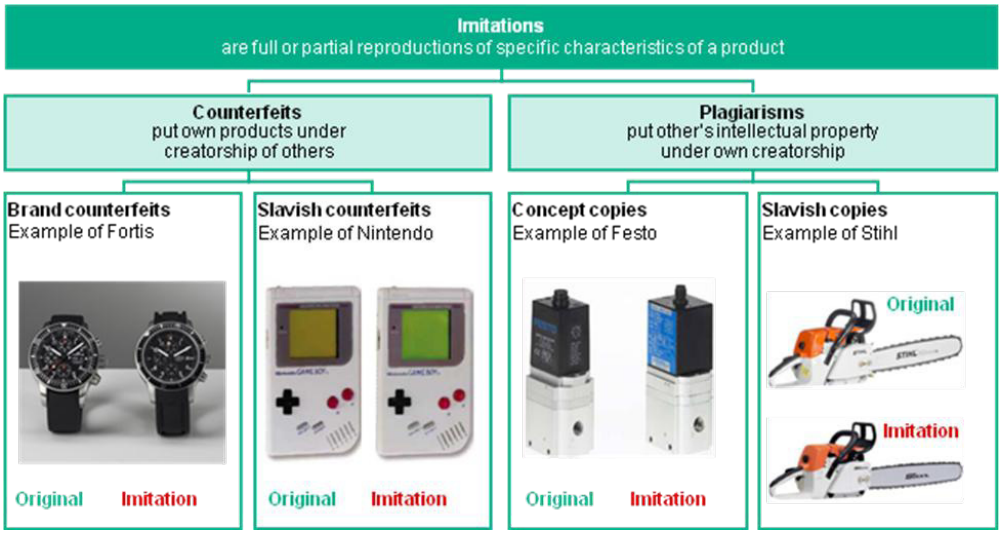

Figure 3: Generic types of product imitation (image source: www.plagiarius.com)

3. Practitioner's Guidance for Application

The Fraunhofer IPT has also elaborated a user's guideline, how to apply the PPC Matrix and what critical factors to consider. A six-step procedure is suggested and will be introduced in the following.

3.1. Step 1: Piracy problem analysis

A detailed problem analysis is the first step to applying the PPC Matrix. During this initial phase, the company's specific situation must be investigated i.e. the actual or most likely imitation scenarios determined. The following categorisation of imitation types (Figure 3) gives companies guidance to clarify this issue:

Companies must get a clear idea about what kind of imitation they actually fear. Furthermore, there has to be considered, what kind and extent of commercial issues are implicated by these forms of imitations. For instance, concept copies will probably not result in unjustified product liability complaints. Only slavish counterfeits will do so and demand for appropriate counteractions. In other cases, when very simple and obvious brand counterfeits are reproduced by the imitator, this probably may not immediately end up in significant sales losses because the potential customers of the imitation are not the same as those of the original product; a decrease in brand reputation is much more likely to fear for this type of imitation scenario.

3.2. Step 2: Identification of relevant stages for counteractions

As next step, the relevant (game-theoretical) stage for taking counteractions must be identified. Questions to ask in this context are: is the considered product highly attractive to be imitated? Has the product already been analysed by potential imitators resp. has technical know-how already left the boundaries of the company (e.g. due to personnel fluctuation, trade fairy appearances etc.)? Have concrete product imitations already emerged or are they however foreseeable?

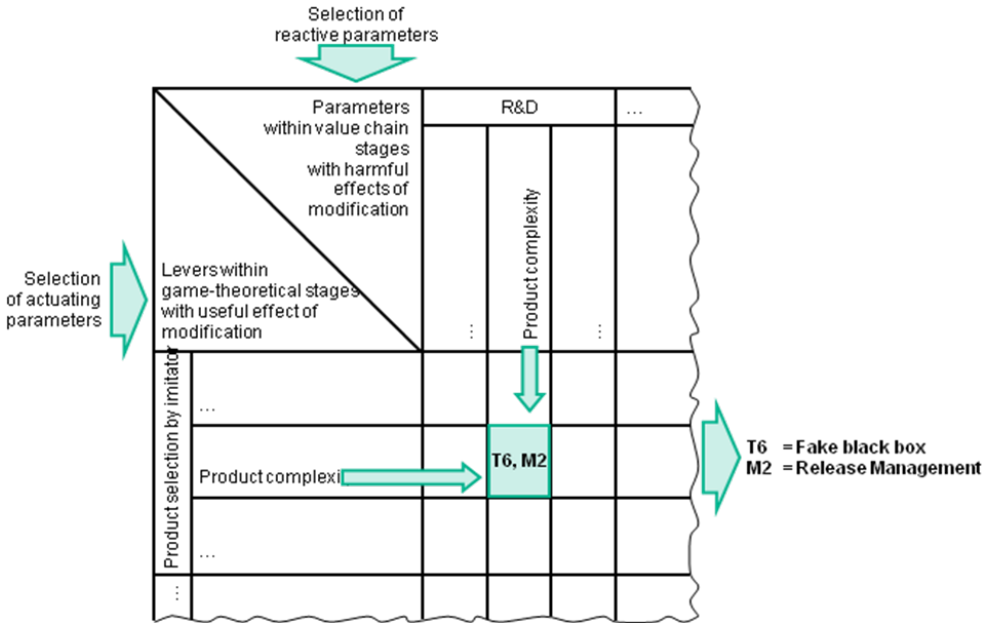

Figure 4: The 26 TOM principles for product piracy protection

Depending on how far the (expected) imitation process has already stepped ahead, companies have to define their appropriate stage for counteraction. When for example the product development has not been completed yet and no critical know-how has left the company so far, the product's attractiveness to be imitated can be reduced by certain technical and commercial characteristics so that imitators will not select the product for imitation purposes in the first place. However, when the product has been analysed by imitators already and reproductions of the original product are very likely to be proceeded, the appropriate stage to take counteractions would be the marketing and sales phase of the imitation.

3.3. Step 3: Selection of appropriate levers for protection mechanisms

The third step involves identifying those levers which are available for integrating protection mechanisms. In accordance to the stage for taking counteractions, the company must think about parameters in their own business to change, in order to prevent product piracy. This may include parameters like brand appearance, product complexity or even annual part volume.

Such useful parameters for modification are listed in the rows of the PPC Matrix. Needless to say, companies do not have to focus only on one parameter i.e. row of the PPC Matrix, but can also take three or four parameters into account. In this case the following steps would have to be conducted multiple.

3.4. Step 4: Identification of fixed parameters in the value chain

During the fourth step, the firm must consider the entire value chain and determine which phases are likely to be harmfully affected by modifying the selected parameters.

As taken as an example before, when decreasing the annual part volume in order to lower the imitation attractiveness of a product, the sales volume will decrease as well. It is easily foreseeable, that this kind of parameter modification will hardly be accepted because it might hurt the company's commercial performance even more than the appearance of product imitations itself.

The sales volume is included in the list of harmful parameter to be changed within the company's value chain, which constitute the columns of the PPC Matrix. The comparison of useful parameters against product piracy in the

rows and harmful parameters of the value chain in the columns state the conflict which is tried to be solved in the following step.

3.5. Step 5: Determination of appropriate TOM principles

Within the fifth step, the core of the PPC Matrix is finally applied. First, the line containing the useful actuating parameter to implement a protection mechanism is selected. Then the column that corresponds to the harmful reactive parameter is indentified, which represents the fixed aspect in the value chain that is negatively affected by an alteration of the actuating parameter. At the intersection of the line and the column, the solution principles capable of solving the conflicting situation are indicated with their respective short name as shown in Figure 4.

There always can be more than one principle within an intersection. For each TOM principle a short description as well as application advices are given, so that the user can get a clear picture about the principle and its effect against product piracy.

3.6. Step 6: Evaluation of TOM principles and company-specific adaptation

An identified TOM principle might be, but does not have to necessarily be, an appropriate measure for a specific case. Therefore in the next step it is inexpedient to evaluate a measure regarding its actual problem-solving potential for the particular product piracy scenarios.

For this last step all stakeholders that might be affected by the implementation of the measure have to be involved and asked about the principle's applicability from their point of view. After a principle has finally been approved from all experts as a suitable and applicable measure for the company to prevent product piracy, the technical, organisational or market-related adaptation of this principle can be initialised.

4. Example from industry practice

In the following, an example from Fraunhofer IPT's industry consulting practice will be introduced in order to point out the general proceeding of the PPC Matrix application. The company in this case, which will not be mentioned by name, was burdened by product piracy and asked for Fraunhofer IPT's support in that matter.

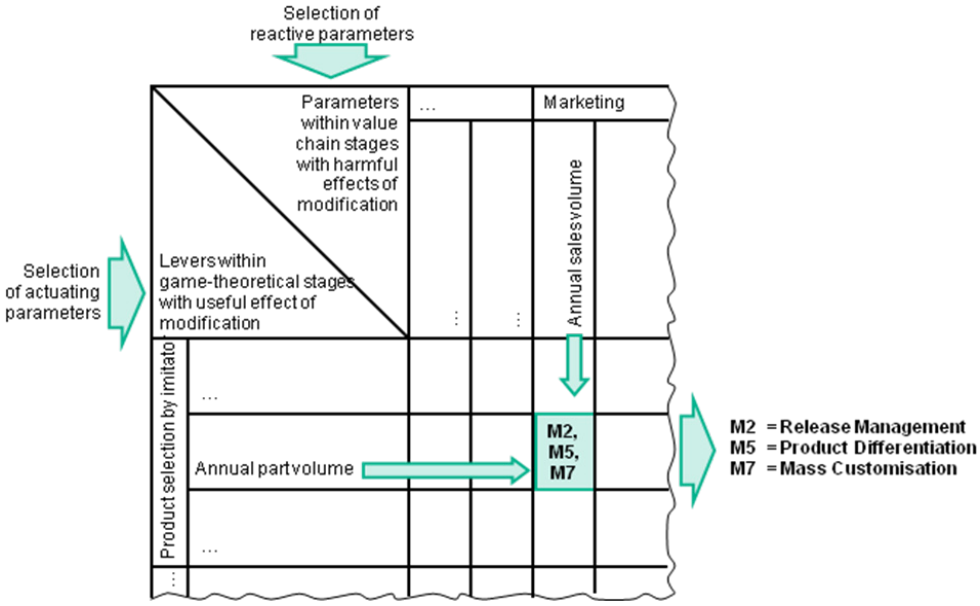

Figure 5: Exemplary application of the PPC Matrix

As a manufacturer of medical devices for various surgery applications, the company was going to release a new product in a few months. There was grave suspicion that the product could be slavishly imitated, i.e. identically replicated including the copy of the brand mark, by Chinese low-cost manufacturers for the fast growing Chinese market. As the product was still in its development phase, the existence of imitations could be excluded. Also there was little probability, that critical technical know-how of the product – especially about constructive lightweight solutions and a controlling panel device – had already left the boundaries of the company. Consequently, most relevance for taking protective action was given to the approach to lower the product's attractiveness for imitation.

After discussions with the sales department as well as R&D, the parameter „product complexity" was determined as an essential useful parameter: By increasing the product complexity, the attractiveness towards Chinese product imitators was intended to be lowered. However, there were also restrictions stemmed from R&D: An increase in complexity should not postpone the completion of the development project and on no account have affect on other already set-up product functionalities. Additional functional elements were undesirable as the R&D department had already submitted a design freeze and was not willing to realise further design modifications or alterations. Hence, the parameter „product complexity" – although identified as a useful parameter in the first place – also represented an essential fixed parameter because any modification of it would cause harmful effects within the value chain.

Using the PPC Matrix for this particular issue, the existing conflict can be described as illustrated in Figure 5. The resulting cell contains the two abstract mechanisms with the identification codes T6 und M2; these abbreviations correspond to the TOM principles „fake black boxes" and „release management".

Fake black boxes aim to make potential imitators believe that a black box contains a disclosed functionality. Yet in reality, the black box is a mock-up, furnished with all obvious external features (for instance electrical connections, pressure pipes etc.). Ideally, potential imitators are discouraged by the apparent complexity of the product, which would significantly impede product analysis. In general, the application of fake black boxes is limited to low-quality imitators, as most of them can be recognised by well-trained engineers who have in-depth know-how concerning both the product structure and according production processes [2].

"Release Management" as a protection mechanism is based on a deliberate increase of the relative lead time, i.e. the product development time in relation to the product life cycle of the original product manufacturer. In practice, this can be achieved by combining incremental innovation steps to create a market-effective product release in the perception of customers. The individual releases must be submitted at relatively short intervals; thus imitators are deterred from analysing and reproducing the product by its high dynamics and complexity in R&D [2].

In our corporate example, the highest potential was allocated to the principle „fake black boxes" and subsequently, more detailed feasibility checks were initiated. The R&D department was finally designated to implement the principle in close cooperation with all departments potentially affected by the product alteration. As it turned out, R&D was able to implement a fake black box in the product without touching the already set-up total product design. There is realistic hope, that the imitation attractiveness of the product thus has been lowered significantly by implementing the black box.

5. Reflexion and outlook

As described above, the PPC Matrix has proved successful in a number of consulting projects conducted by Fraunhofer IPT. First and foremost, the approach can be regarded as a basic framework for companies that so far have little idea concerning the range of solution principles and their application potential. Furthermore, the PPC Matrix can provide valuable guidance for companies in validating mechanisms previously identified.

Clearly, the Matrix does not claim to deliver „turnkey solutions" for a concrete piracy problem; in analogy to the contradiction table, it generates ideas in the sense of abstract principles, stimulates creativity and forms the basis for further validation, implementation and from a more academic perspective, by analysing in detail the coherences and determining factors of protection mechanisms, the matrix represents an important step in structuring this novel field of research. In this sense, the matrix represents a comprehensive compilation of expert knowledge concerning the applicability of non-legal principles in preventing product piracy.

In the future, Fraunhofer IPT will continually supplement the 26 TOM principles and update the matrix accordingly. Although the set of principles can already be considered highly comprehensive, the initial set must be extended mainly triggered by experiences gained in concrete industrial applications. This process has not been

finalised and will be continued on an ongoing basis, thus ensuring the up-to-date status and capability of the methodology.

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