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DECISION SUPPORT FOR THE SELECTION OF ANTI-COUNTERFEITING MEASURES BASED ON MODELING DAMAGE AVOIDING FUNCTIONS

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ABSTRACT
Manufacturers are confronted with a rising number of counterfeits and imitations of their original products, causing both financial and brand damages most of them are not willing to accept. There are many different useful ways of fighting such imitations, depending on the particular situation. In recent years, first models for decision support in selecting the appropriate scope of countermeasures have emerged from academia as well as consulting companies. However, all of them share a common downside: Very large numbers of relevant influence factors are restricting the general applicability of such models to a very low level. This paper presents a different approach focusing on classifications of both potential damage by imitations and potential mechanisms to prevent those damages. By mapping damages to prevention mechanisms and prevention mechanisms to single counter measures, a decision support system can be obtained that is less analysis-prone than existing ones are, and thus more generally applicable. System design and application example will be described in this contribution.

Keywords: decision support, function modeling, damage, counterfeiting, product imitation

1 INTRODUCTION
German industrial and plant manufacturing companies are confronted with several different kinds of damages caused by imitations of their products and additional forms of unwanted know-how drain [1-4]. These damages range from drops in sales and earnings [5, 6] to decline of corporate image [7] and product liability claims for harmful products that have not been manufactured in the company brought to trial [1, 5, 6]. On the long term, the most threatening damages result from know-how drain towards emerging markets induced by counterfeiting and imitating activities [8, 9]. Some sources predict damage potentials of up to 20 percent of affected companies' total turnover [2, 10], whereas others emphasize a threat to affected manufacturers' existence [6, 11].
To prevent the damages described above, very different measures or strategies can be adopted, which are purposeful in different situations [1, 5, 6, 12]. The terms "measure" and "strategy" are, however, not clearly distinguished throughout the reviewed literature, and thus used strongly intersecting if not synonymously. Several sources offer libraries of various measures or strategies [13-15]. Some of these libraries are offered with very basic decision support algorithms. However these basic algorithms are of little use for manufacturers affected by damages caused by counterfeiting or imitations, as their decision support lies basically in classifying various measures according to their field of origin. Such fields of origin can be:

- Product design [6, 9, 16, 17]
- Manufacturing processes [14, 16, 18, 19]
- Operational and organizational structure [1, 4, 6, 7, 10-12]
- Protection technologies [1, 4, 5, 20]
- Information handling [21-25]
- Legal protection [12, 26-28]

In accordance with certain situations of the affected manufacturer, appropriate single measures from the origins stated above can be selected. Such situations are described by various characteristics. These characteristics have been researched in a review and are specified below:

- Strategy of imitators or counterfeiters [7, 17]

- Affected objects (products, components, business models, et cetera) [6, 16, 29, 30]
- Damages caused by imitations or counterfeits [4, 7, 16]
- Objective of anti-counterfeiting measures [7, 17, 30]
- Location of counterfeit or imitation appearance [16, 31]
- Competencies (organizational, manufacturing, service, et cetera) of affected company [4, 8, 9]

For companies affected by imitations or counterfeits, it is essential to know which measures provide effective protection against imitations or counterfeits of their products. Literature indicates that only a purposeful combination of measures provides powerful protection [4, 6, 8-10, 12, 16, 29, 30]. Whether a combination of measures is helpful depends on the situation described by values for the characteristics stated above.
Accordingly, selecting and combining the few most helpful measures out of the vast range of possibilities is a complex task, and calls for decision support. Early decision support systems for manufacturers have been presented in [27], [32] and [1], however on a rather superficial level regarding algorithms for measure selection. Decision support systems especially fitted to the needs of German manufacturers are offered in [4] and later in several research efforts [10, 29, 30] funded by the German Federal Department of Education and Research.

2 STATE OF THE ART

The state of the art described in the following focuses on contributions that propose decision support systems for the selection of anti counterfeit measures especially fitted to the requirements of German manufacturers. Consequently, many of the standard publications on the subject anti counterfeiting are not mentioned [6, 12, 28], as they are limited to describing the problem of counterfeiting and possible counter measures or not particularly fitted to the needs of German manufacturers.

Decision model for selection of protective mechanisms (RWTH Aachen)

Neemann [4] considers an ideal combination of different measures to be indispensable for obtaining adequate protection through the deployment of those measures. The need for decision support regarding the selection of anti-counterfeiting measures derives from this conclusion. In Neemann's decision model, information required comes from different areas. So, the selection of measures depends on information acquired and processed in several sub-models. The sub-models describe the affected company and its external environment, protection mechanisms and damage mechanisms on a generic level, and the measure selection system. Results of the decision support system, i.e. purposeful measures and their purposeful combination, are generated by specific links between the information acquired and processed in the sub-models.

Holistic, active approach to protection against counterfeiting (Ruhr-Universität Bochum)

Meier et al. [10] present a "holistic, active approach to protection against counterfeiting". Compared to protection concepts exclusively focusing on IP protection rights or labeling techniques, they anticipate a higher level of protection through adoption of their approach, due to its focus on preemptive protection in earlier phases of product life cycle. Meier et al. declare a necessity of "coordinated" deployment of different measures, and suggest three "columns" of an integrated protection concept: Operational and organizational structure, protection technologies and knowledge distribution management. For each column, single measures are listed exemplarily. In order to attain adequate protection against counterfeiting, multiple measures are deployed – either all coming from one column or from all columns. "Maximum" protection is only promised for intertwining use of all three columns, whereas measures taken from one of the columns are predicted to provide less protection. The presented approach's aims lie in delaying market entry of counterfeiters by knowledge distribution management, and in decreasing loses in sales by operational and organizational structure, and protection technologies.

Process oriented organization of anti-counterfeiting (Chinabrand Consulting)

Fuchs and Wu [7] emphasize the importance of a process oriented approach for anti-counterfeiting actions. In order to pursue an according course of action, they suggest a concentration of all anti-counterfeiting actions in a special task-force, which itself composes from piracy relevant functions within the affected company. The proposed approach provides the task-force with 16 "standard strategies" applicable and purposeful in different situations: waive market entry, laissez-faire, intellectual property rights strategy, protection technologies, reactive legal measures, attack, tolerance, compensation, one step ahead, fight fire with fire, cut distribution channels, certificates, cooperation and integration, lobbying, promotion by law claims, brand strength. Each of these strategies requires – partly identical – process steps to be performed sequentially. The strategies are, however, not assigned to certain situations, in which their application is considered reasonable. Following an analysis determining purposeful strategies for a case, each strategy is allocated to a process owner. The process owner pushes strategy implementation and is held responsible for the strategy's success in regular audits.

Holistic protection of machinery spare parts (TU Kaiserslautern)
Aurich et al. [30] consider information acquisition a crucial factor to base decisions on the selection of purposeful anti-counterfeiting measures on. Accordingly, they propose an information acquisition and management system as one of three columns in their suggested model for the "holistic protection of machinery spare parts". Columns two and three are formed by a Counterfeiting analysis and evaluation model and a pool of possible anti-counterfeiting measures. Each of the columns is fed by an internal and external organizational network that provides required resources and methods for implementing the columns. The presented approach aims at the completion of a control loop, allowing for selection and implementation of purposeful measures based on information acquisition and procession. In the loop, information is gathered and classified on potentially endangered components and potential imitators and their tactics. Using these classifications, links to single measures in a pool of measures are established. A selection of purposeful measures is possible via these links. Selected measures are implemented using the resources provided by the network mentioned above.

Optimum combination of measures for protection of machine tools (TU Darmstadt)
Abele et al. [29] suggest a three-step selection process for determination of the most purposeful anti-counterfeiting measures. In the first step, one of three protection profiles is selected according to the considered type of product. These types of products are: "standardized mass product" (synonymously described as "Type I: single part"), "integrated module" ("Type II: "module") and "complete system" ("Type II: "final product"). This first step in the decision process aims at an increase of efficiency in measure selection. The second step includes an evaluation of measures. Measures are deposited in a database as well as evaluation results. Evaluation criteria are generation of costs, customer approval and influence on the risk of products being counterfeited. Values for the evaluation criteria are determined by applying cost prediction methods, quality function deployment and scenario analysis. The second step aims at increasing effectiveness of measure deployment later-on. In a third and final step, management selects out of a pool iteratively constricted to the most purposeful measures, taking aspects of corporate policies and strategies into account. The final decision step aims at attaining sustainable measure deployment by selecting those complying with corporate strategies.

Analysis of state of the art
The reviewed contributions to the state of the art were analyzed according to four different criteria:

- Configuration effort: Describing the amount of resources and time necessary for building up the decision support system within a company to a degree it can be utilized
- Analysis effort for execution: Describing the amount of resources and time necessary for executing the decision support system to the point where result are obtained
- Degree of formalization: Describing the degree to which the decision support system requires the adherence of previously defined handling instruction
- Level of detail of result: Describing the amount of information included in the result of the decision support system application
-

Possible values of the different criteria are "very high", "high", "medium", "low" and "very low".
The assignment of values to the criteria for the different contributions to the state of the art is described in Figure 1.

	NEEMANN	MEIER ET AL.	FUCHS&WU	AURICH ET AL.	ABELE ET AL.
Configuration effort	↑	↘	↗	↗	↗
Analysis effort for execution	↗	↗	↑	↑	↑
Degree of formalization	↑	↘	→	↗	→
Level of detail of result	↑	→	↗	↗	↗

Figure 1: Analysis of state of the art

3 NEED FOR RESEARCH

Various damages caused by product imitations and counterfeiting can only be countered adequately by deploying a mix of different measures [1, 6, 12]. Currently, more than 80 of these measures, coming from various fields of origin, have been identified and published [14]. Given the large number of these measures, high efforts in time and resources are necessary for the selection of the few purposeful measure that are able to help an affected company in a certain situation (compare chapter 1). Affected companies experience difficulties in providing the resources required for performing these analysis efforts, as they either imply a high allocation of work force or an expensive assignment of a specially qualified consulting company.

The research described in this paper aims at the creation of a decision support approach for the selection of anti-counterfeiting measures, requiring less effort in system configuration as well as execution than the approaches described in the state of the art. Therefore, selectable measures will no longer be linked directly to values of different characteristics describing a “situation” of affected companies and further factors, other than described in the state of the art [4, 10, 29, 30]. Instead, our approach is linking from damages caused by product imitations or counterfeiting to so-called damage avoiding functions to single anti-counterfeiting measures, aiming at the reduction of analysis efforts described above.

4 DAMAGE FUNCTIONS

The reviewed literature describes many different damages caused by product imitations or counterfeits. Many of those sources name sales and margin losses as gravest short term consequences [1, 5, 6, 20]. Additionally, different costs caused by counterfeiting are stated, exemplarily through product liability claims [3] or investment in anti-counterfeiting measures [6]. Know-how drain [9, 10, 16] and damage to the economic situation of the original manufacturers [2, 3, 11] are described as the gravest long term consequences.

During the research described in this paper, damage cases from various sources were analyzed and assigned to different damage functions. A damage function is defined by a noun and a verb, eventually supplemented by a short describing passage, in the form “[verb] [noun] ([description])”. Examples for damage functions are “decrease sales” or “decrease sales by five percent”. More than 40 damage function of this kind were identified in the analysis of damage cases. In order to facilitate easy handling, a lower number of damage functions appeared to be reasonable. Therefore, damage functions were assigned to more abstract, superordinate function in the form “[verb] [noun]”. Seven superordinate functions were defined, and are depicted in Figure 2. This set of superordinate damage functions aims at comprehensively covering all possible damages caused by product imitations and counterfeiting on a functional, abstract level. By constricting the number of functions for handling reasons, a trade-off with respect to the independence of the superordinate damage functions is accepted.

Damages by counterfeiting		
	A	Increase know-how drain
	B	Degrade site-related factors
	C	Decrease sales
	D	Decrease margin
	E	Generate costs
	F	Decrease corporate image
	G	Decrease customer satisfaction

Figure 2: Damages caused by product imitations or counterfeiting

Each superordinate damage function is detailed below. “Increase know-how drain” (see Figure 1: A) summarizes all damages describable by unwanted access for company external persons to important internal competencies or knowledge. “Degrade site related factors” (B) comprises all damages worsening the economic situation for an industrial sector in certain regions. “Decrease sales” (C) describes damages influencing the amount of sales of affected products. “Decrease margin” (D) comprehends damages causing a diminishment of margin premium for an affected product. “Generate costs” (E) subsumes damages resulting from additionally necessary investment due to counterfeiting/imitations, exemplarily spent on anti-counterfeiting measures or falsely claimed warranties and product liability. “Decrease corporate image” (F) describes damages from influencing the perception of the affected company by external non-customers. “Decrease customer satisfaction” (G) describes damages from influencing the perception of the affected company by customers.

5 DAMAGE AVOIDING FUNCTIONS

Previous classifications of single measures out of a pool of anti-counterfeiting measures feature certain haziness in their class definition (compare [1, 6, 12-15]). The classification systems suggested allow multiple assignments of measures to classes caused by overlapping definitions of different classes. In order to avoid this shortcoming, we suggest an approach of defining damage avoiding functions on an abstract level, which are linked to damage functions on the one side and anti-counterfeiting measures on the other side.

For determination of a comprehensive and independent set of damage avoidance factors, a combined top down and bottom up approach was selected. Deploying hierarchical function modeling, three superior damage avoidance functions were determined in several meeting of the research team:

- Decrease number of current imitations
- Decrease future appearance of imitations
- Decrease market attractiveness of future imitations

On that basis, various sources of anti-counterfeiting measure application were analyzed and transferred to abstract function form, analogous to the description in chapter 4. These basic damage avoiding functions were assigned to the superior damage functions. Three additional basic functions were added to provide a comprehensive set of twelve damage avoiding functions (see Figure 3).

Damage avoiding functions											
Decrease number of current		Decrease future appearance of imitations							Decrease market attractiveness for future		
		Minimize know-how drain			Decrease attractiveness for imitator						
Impede market access for current imitations	Impede production of current imitations	Minimize know-how drain by product	Minimize know-how drain by sharing knowledge	Minimize know-how drain by illegal knowledge acquisition	Decrease motivation for imitation	Make imitation more expensive	Make imitation more expensive	Make imitation impossible	Sensitize (potential) custumers	Improve original products compared with imitations	Shorten market exposure of original products
A	B	C	D	E	F	G	H	J	K	L	M

Figure 3: Damage avoiding functions

For decreasing the absolute number of current imitations in a market, the original manufacturer - in abstract function representation - has two possibilities: Either making market access for imitations (see Figure 3: A) or the production of the imitations (B) more difficult. For certain kinds of damages by counterfeiting however the goal is a decrease of the probability of occurrence of future imitations. Therefore, to ways can be pursued: minimizing know-how drain or a decrease of original products' attractiveness to being counterfeited. Know-how drain can occur via original products (C), information sharing by staff or documentation (D) and illegal methods of information acquisition (E). So these three points provide possibilities to minimize know-how drain. A decrease of attractiveness for imitators can be reached by decreasing motivation for imitators (F). Further possibilities are impediment (G), increase in cost (H) and rendering impossible (J) of imitations. In case a prevention of future imitations seems impossible, at least their market attractiveness must be avoided. This can be effectuated by sensitizing customers and potential customers (K), an improvement of original products compared to imitations (L) or a shorter market exposure of original products (M).

6 DECISION SUPPORT SYSTEM

In the both research steps described in chapters 4 and 5, adequate functional descriptions of damages caused by imitations/counterfeiting and for damage avoiding functions were determined. Based on these functional descriptions, a selection of purposeful anti-counterfeiting measures shall be allowed for. Therefore, two link tables with respective link logic are required:

- Link table A: damage functions linked to damage avoiding functions (Figure 4)
  Logic: If damage function X appears, damage avoiding function Y is purposeful to apply
- Link table B: damage avoiding functions linked to single anti-counterfeiting measures (Figure 5)
  Logic: Damage avoiding function Y is performed by anti-counterfeiting measure Z

For determination of the links in link table A, each combination was discussed in research team meetings. After discussion a decision was executed in favor or against setting the link. For about twenty percent of the combinations, the wording of the damage function left room for interpretation, so decision on linking proved difficult. However, all decisions on linking were made by the research team, which at least allows for logic consistency in setting the links. The resulting link table A is depicted in Figure 4.

Link table B had already been informally filled in during the bottom up determination of damage avoiding functions (see chapter 5). However, this informal dataset was not used for link table B, as it had been acquired by different people and thus lacks consistency in logic application. So, link table B was filled in further research team meetings. A differentiation of primary and secondary effects of several measures proved to be a challenge for a consistent linking process. Again, consistent linking was allowed for by providing a continuous linking process within research team meeting.

	Damage avoiding functions											
	Decrease number of current imitations		Decrease future appearance of imitations							Decrease market attractiveness for future imitations		
			Minimize know-how drain			Decrease attractiveness for imitator						
Damages by counterfeiting	Impede market access for current imitations	Impede production of current imitations	Minimize know-how drain by product	Minimize know-how drain by sharing knowledge	Minimize know-how drain by illegal knowledge acquisition	Decrease motivation for imitation	Make imitation more expensive	Make imitation more expensive	Make imitation impossible	Sensitize (potential) custumers	Improve original products compared with imitations	Shorten market exposure of original products
Increase know-how drain			X	X	X							
Degrade site-related factors			X	X	X					X	X	
Decrease sales	X	X				X	X	X	X	X	X	
Decrease margin	X	X				X	X	X	X	X	X	X
Generate costs	X	X								X		
Decrease corporate image	X									X	X	X
Decrease customer satisfaction	X									X	X	

Figure 4: Mapping of damages and damage avoiding functions

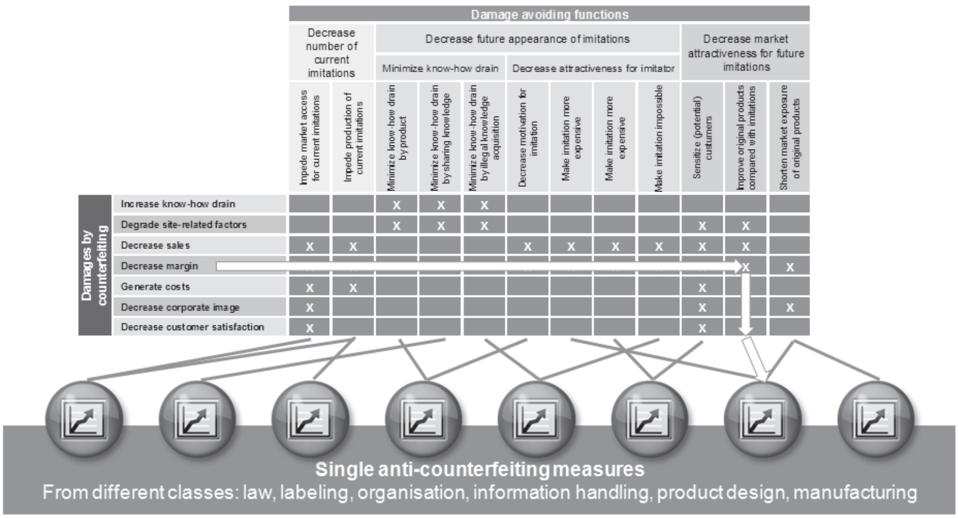

Figure 5: Mapping of damage avoiding functions to single anti counterfeiting measures

Using the two link tables presented above, affected companies can obtain a strongly constricted solution space of purposeful anti-counterfeiting measures in a few simple steps:

1. Determination of occurring damaged caused by counterfeiting or product imitations
2. Review of damage avoiding functions linked to the determined damages
3. Determination of desired damage avoiding functions
4. Review of anti-counterfeiting measures linked to the determined damage avoiding functions
5. Determination of desired anti-counterfeiting measures based on the suggested measures

Steps 1 to 4 can be performed without the considerable analysis efforts described in chapter 2. Performing step 5 requires analysis of further influence factors (compare [17]). However, regarding the constricted number of remaining measures at this point of the selection process, necessary analysis efforts can be focused and thus require less time and efforts. Steps 2 to 5 can also be deployed iteratively for different relevant damage functions in order to obtain a holistic protection concept in terms of [10], [17] or [30].

7 APPLICATION SCENARIO

In 2006, a manufacturer of satellite TV receiver boxes found his actual top end product had been counterfeited by a Chinese manufacturer. Distribution of the counterfeits was organized by a Spanish retail company. The counterfeits very much resembled the original receiver box, externally as well as internally. Several intellectual property rights of the original manufacturer had been violated by the counterfeiter. However, the counterfeits failed by far to reach image or sound quality of the original receiver box [33]. A fictional application of the decision support system proposed in this paper is described below:

Step1

The most threatening damage functions of this case of counterfeiting are defined according to the list shown in Figure 2. The management board identifies “Decrease sales” as greatest potential threat, marketing prefer “Decrease corporate image”.

Step 2

For the damage “ Decrease sales ”, possible damage avoiding functions are: “Decrease number of current imitations”, „Decrease attractiveness for imitator“, „Sensitize (potential) customers“ and „Improve original products compared with imitations“. For the damage „Decrease corporate image“, possible damage functions are: „Impede market access for current imitations“ and „Decrease market attractiveness for future imitations“.

Step 3

Given limited financial resources, management decide to go for the damage avoiding functions “Impede market access for current imitations” and “Sensitize (potential) customers”. Both work for damages by „ Decrease sales “ as well as for damages by “Decrease corporate image”, so there is hope for synergetic effects.

Step 4

Filtering the anti piracy measures list of Technische Universität München for measures linked to the damage avoiding functions “Impede market access for current imitations” and “Sensitize (potential) customers” shows the following result (excerpt):

- Enlarge range of after-sales products
- Define inexpensive, particulate spare parts
- Inform (potential) customers regarding identification marks of original products
- Define high-value spare part modules
- Enforce IP rights
- Label products/packing
- Require product activation
- Require component/part authentication
- Integrate property protectable by IP rights

Step 5

- Three measures are selected. “Enforce IP rights” and “Inform (potential) customers regarding identification marks of original products” for an immediate response aiming at a stop of counterfeit sales and information of persons willing to buy an original product. “Label products/packing” was selected for application in the next product upgrade in order to provide potential customers with an identification mark that allows a near to 100% identification of original products.

The satellite receiver manufacturer did not dispose of a decision support system for the selection of anti counterfeit measures, by the time they had to take their decisions. This resulted in resource-prone analysis work in order to properly understand the counterfeit problem before being able to properly respond. The respective delay of several months caused significant financial and brand damage that could have been avoided by applying the decision support system proposed in this paper.

8 CONCLUSION

This paper presents an approach to supporting decisions for the selection of anti-counterfeiting measures in German manufacturers. Previously published decision support systems in this field require large analysis efforts both in configuration and application, and offer very high levels of formalization and result detail, which are not necessary in early decision phases. The presented approach eliminates these disadvantages by modeling a set of damage functions caused by counterfeiting, and a set of damage avoiding functions. Both sets of functions are invariably modeled on an abstract level. The decision support system works by linking damage functions to damage avoiding functions and damage avoiding functions to single anti-counterfeiting measures. By using those two simple link tables, manufacturers can very simply confine the amount of reasonable anti-counterfeiting measures by defining the most important damage functions in their case and the desired damage avoiding functions. The level of detail of the results, however, is far lower than for existing decision support systems. This makes additional analysis work necessary, but on a much smaller, constricted basis of eligible anti-counterfeiting measures, which will save resources and time.

9 OUTLOOK

The optimum trade-off between "required analysis effort" and "level of detail of results" considering decision support systems for selection of anti-counterfeiting measures has not been found yet. This contribution shows up a way requiring very low analysis capacities. In future research, ways will have to be found to define a decision support system that allows for high levels of result details based on the low-analysis approach presented in this paper.

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