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PRODUCT ELIMINATION IN GERMAN INDUSTRIAL COMPANIES: A COMPARISON STUDY WITH US AND UK INDUSTRIAL COMPANIES

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Abstract

This paper focuses on the product elimination in German industrial companies, especially in the mechanical engineering sector. The Product Life Cycle (PLC) theory is based on the typical curve, which shows the different stages a product experiences over the time. The last stage, the so-called decline or elimination phase, is characterized with decreasing sales figures, low market share and shrinking profits. Therefore, it sounds logical that such products should be eliminated. This study is analyzing if these indicators really are the only reasons to start the elimination process of a product, or if there are other reasons triggering this decision too. This paper is based on results of personal structured interviews (n = 102) with representatives of German mechanical engineering companies. The data was processed with use of statistical software SPSS, mean values and standard deviations were calculated, and Spearman's rank order correlation value analysis was applied. The results of this study were then compared with other earlier studies: Avlonitis (1984), Hart (1988), and Mitchell *et al.* (1998). The main findings suggest that the data from the new German study are highly correlating with the data from the United States (Mitchell *et al.*, 1998) and the United Kingdom (Avlonitis, 1984; Hart, 1988). The results show that the reasons to phase out a product have not changed over the time; neither are the reasons different in different economics.

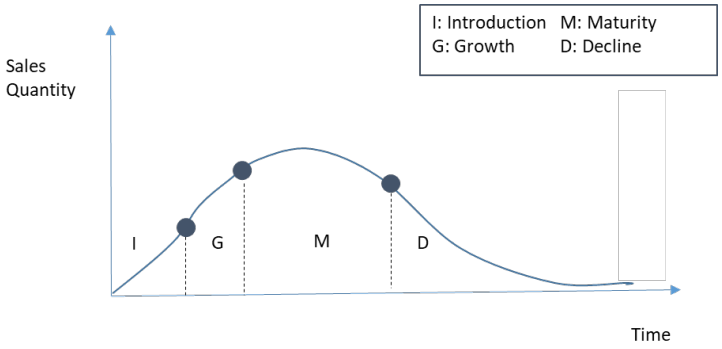
Keywords: product elimination, product deletion, product phase out, product life cycle, product management, engineering companies, Germany

INTRODUCTION

The reason for this study is to provide findings from research focused on a process of product elimination in German mechanical engineering companies. It aims to provide answers to questions: Which reasons trigger the decision to eliminate a product? Is the decision only based on shrinking sales values and profit figures?

According to Meffert *et al.* (2008) the products of a company are always in competition to each other. The products are competing against scarce resources like production capacity, marketing budget or financial budget. It is necessary to make objective-based decisions. They can be based on external factors like shortage of raw material or technology developments as well as internal factors like profit or company image.

One of the oldest economic models is the product life cycle concepts (Fischer, 2001) which describes the various phases a product experiences. Fisher (2001) connects the origin of the product life concept to Dean and Patton, both practitioner in the 1950's. Fisher (2001) states that Patton defines the PLC as time reference, systematic development of



1: *Product Life Cycle.*
Source: Schmalen (2013)

I: *PLC Models*

Four-phase model (e.g. Ayal, 1981)	Five-phase model (e.g. Komninos *et al.*, 2002)
1. Introduction	1. Introduction
2. Growth	2. Growth
3. Maturity	3. Maturity
4. Decline	4. Saturation
	5. Decline

products based on the evolution of living creatures. The PLC has a critical characteristic, it is a dynamic consideration of a product and not an analysis of a specific situation (Kuss *et al.*, 2007).

"The term 'lifecycle' generally indicates the whole set of phases, which could be recognised as independent stages to be passed/followed/performed by a product" (Terzi *et al.*, 2010, p. 364). In the literature different models can be found, some of them divide the PLC in four, others are using a model with five phases.

No matter which model will be used it always describes a product by sold volume and revenues over the time (Terzi *et al.*, 2010).

Marketing literature (e.g. Meffert *et al.*, 2008; Kuss *et al.*, 2007; Lennertz, 2006) is describing the dynamic of the PLC as typically, after successful development and testing, the product is launched into the market (*introduction*). At this stage special promotion and marketing activities support the growing sales. If the product experiences increasing sales figures, it enters the *growth* phase. At a certain point of time the sales volume stabilizes which indicates that the product entered the third phase, the so-called *maturity*. If the sales figures decrease for a certain longer period of time the product enters the decline phase and may need to be eliminated from the product portfolio. The length of each stage depends very much on the profit situation. A product will be offered longer to the market if the production costs are low and the demand is high, as this will lead to high revenues. If the production costs are high and the demand is low, it can be expected that the product will have a short product life.

In general, the marketing literature much more focuses on the product launch/product introduction phase and not so much on the deletion phase (Herrmann *et al.*, 2000). *"New products tend to have 'glamour' while the deletion of existing products is often regarded as 'drab business' as a firm wrestles with those products that have served it well over time"* (Mitchell *et al.*, 1998, p. 9).

Only a few researchers (e.g. Avlonitis, 1984; Hart, 1988; Mitchell *et al.*, 1998) have focused their work on the decline stage. Hart (1988) as well as Avlonitis (1984) analyzed in different studies in the 1980's that not all weakly performing products are ready for elimination, nor were elimination candidates. Only those items with low profitability and declining sales (Mitchell *et al.*, 1998). Avlonitis (1984) and Hart (1988) analyzed the British manufacturing companies, whereas Mitchell *et al.* (1998) focused their study on American manufacturing firms to compare their results with the ones of Avlonitis and Hart.

But not only in the literature the last phase is treated neglected, also the companies themselves seem to have their problems. *"For some reason, the natural conclusion to the life of a product seems to be a major challenge for many firms. Product and portfolio managers don't take product discontinuation seriously, nor do they typically make it an important part of product life cycle management decision options"* (Heines, 2009, p. 619).

In early 80's, Avlonitis (1984) analyzed whether declining sales and profits, which are the main indications of the decline phase, are the only reasons to eliminate products. Or if other reasons can be found. He (*ibid*) was one of the first to investigate the elimination process in the UK engineering industry.

Avlonitis (1984) grouped them into 4 factors:

1. Financial considerations (Factor 1);
2. Resources released and external pressures considerations (Factor 2);
3. Marketing considerations (Factor 3);
4. Managerial (alternative opportunities) considerations (Factor 4).

Hart (1988) published *'The causes of Product Deletion in British Manufacturing Companies'*.

II: *Avlonitis' 15 Circumstances of Product Elimination*

1	Product's elimination effect on “full-line” policy
2	Product's elimination effect on corporate image
3	Product's elimination effect on sales of other products
4	Product's elimination effect on customer relationships
5	Product's elimination effect on profitability of other products via production overhead allocation
6	Product's elimination effect on profitability of other products via selling overhead allocation
7	Product's elimination effect on profitability of other products via distribution overhead allocation
8	Product's elimination effect on the fixed and work capital
9	New product potential
10	Reallocation of capital and facilities to other opportunities
11	Release of executive time spent on the product
12	Product's elimination effect on employee relationships
13	Existence of substitutes to satisfy the customer
14	Competitive moves in case the product is eliminated
15	Organized intervention (i.e., trade unions)

Source: Avlonitis (1984)

Her study focused on the British industry, both industrial B2B and B2C business. Five industry sectors were selected for her study:

1. fast moving consumer goods,
2. industrial operating supplies,
3. consumer durables,
4. industrial components and
5. capital equipment.

III: *Hart's 17 Circumstances of Product Elimination*

1	Government policies and regulations
2	Operational problems
3	Third-party decisions
4	Competitive activity
5	Development of a new product
6	Company resources required elsewhere
7	Problems associated with raw materials/parts
8	Variety reduction policy
9	Decline in market potential
10	Poor sales performance
11	Poor profit performance
12	Poor quality or design
13	Poor fit with company capabilities or strategic plans
14	Rationalization due to mergers and acquisitions
15	Poor fit with company image
16	Parent company decisions
17	Change in exchange rate

Source: Hart (1988)

Her results were based on interviews with 31 companies as well as a mail survey to 922 companies (response rate 18%, 166 surveys).

The most important circumstances were ‘poor sales performance’, ‘poor profit performance’ and ‘decline in market potential’. But Hart (1988) noticed that none of the 17 factors scored a mean exceeding 3.8; therefore, she assumed that there is a relationship among the 17 circumstances. She used the principal component analysis and identified 6 groups of circumstances.

Hart (1988) analyzed whether there were significant differences among the 5 industry sectors (based on Miracle's 1965 product typology). Her result was that there are no significant differences concerning four of the deletion types: externally led, image/quality-led, resource-led and performance-led. However, endgame deletion seems to have greater importance for the capital equipment industrial sector. Hart included companies working in the following areas as the ‘capital equipment sector industrial’:

1. milling machines;
2. excavating equipment, cranes;
3. pumps;
4. elevators and escalators;
5. industrial saws;
6. electronic communication test measurement equipment.

Hart (1988, p. 341) explained in her paper that *“in the capital equipment industry, the nature of the products and their high unit value means that the products have long working lives. Similarly, the heavy R&D burden of their development serves to prolong the product life cycle of the entire category of products”*.

IV: *Types of Product Elimination Decisions*

Factor name	Variables on factor
1. Externally led deletion	Government policies and regulations
	Third-party decisions
	Rationalization due to mergers and acquisitions
	Parent company decisions and policies
	Change in exchange rate
2. Endgame deletion	Competitive activities
	New product development
	Variety reduction policy
	Declining market potential
3. Quality of product and effect on firm's image deletion	Poor product quality
	Poor fit with company image
	Problem with raw materials and parts
	New product development
4. Resource-led deletion	Resources required elsewhere
	Poor fit with corporate strategy
	Variety reduction policy
5. Performance-led deletion	Poor sales
	Poor profits
6. Logistics-led deletion	Operational problems
	Third party decisions

Source: Hart (1988)

Mitchell *et al.* (1998) analyzed in their study whether the 17 circumstances Hart found in her study are also valid for the American industry. He found high correlation values between their and Hart's study. Mitchell and the team then used the factor analysis to group the 17 circumstances, like Hart did. They found a similar correlation and a great deal of consistency with the results obtained by Hart (1988). Mitchell *et al.* didn't split the examined US industries in sectors. Therefore, they could not examine if the 'endgame deletion factor' had higher importance for the capital equipment industry, like Hart analyzed. Both studies (Hart, 1988) and (Mitchell *et al.*, 1998) isolated the factor 'Externally-led deletion' as the largest one.

Avlonitis (1990) investigated in his 'Project Dropstrat' the product elimination and the PLC concept. His study focused on the British manufacturing industry, he included both B2C and B2B companies. He found that there were different circumstances why companies eliminate products and that these circumstances differed with the stage of the PLC. Avlonitis' data showed the elimination process depends on the stage of the PLC. In the introduction stage a product is mainly eliminated due to operational problems and low sales numbers. At the growth stage a product will be phased out from the market due to poor quality or design problems as well as due to operational problems. In the mature phase products are eliminated because of increasing competition and decline in market potential. These two reasons are also valid in the decline phase, additionally two more precipitating circumstances which are associated with this particular stage, namely, 'development of a variety reduction policy' and 'poor sales performance', are likely to initiate the product elimination process (Avlonitis, 1990, p. 66).

Avlonitis (1987) noted that a separate study for consumer and industrial products would be necessary and that his study was only the beginning, it needed to be validated and replicated. Later studies of Avlonitis *et al.* (2000) or other researchers (Argouslidis and McLean, 2003; Argouslidis and Baltas, 2007; Gounaris *et al.*, 2006; Harness and Harness, 2004; Harness and Harness, 2012; Harness and Harness, 2007) focused on the finance sectors, service (Somosi and Kolos, 2017), B2C goods (Argouslidis *et al.*, 2014; Muir and Reynolds, 2011), and human resource sector (Wagner *et al.*, 2017).

MATERIALS AND METHODS

The objective of this paper is to analyze the product deletion process of German mechanical engineering companies. Especially whether the product deletion reasons (Avlonitis, 1984; Hart,

1988; Mitchell *et al.*, 1998) identified for industrial UK and US companies are valid for German companies. The paper will analyze if all products which reach the decline stage are typically eliminated, or whether they stay long term in the product portfolio. It will be analyzed who is involved in the product elimination process and whether companies develop a formal process to eliminate products from their product portfolios, or if there is a need for such.

The study was based on an empirical analysis based on 102 interviews with German mechanical engineering companies' representatives with a structured questionnaire.

In the literature different research methods can be found. The quantitative research method approach with personal interviews and structured questions are used if existing research studies will be replicated and to compare the results with statistical methods (Flick *et al.*, 2011).

The questionnaire was divided into 3 sections; the first section collected general information about an analyzed company and an interviewed person. The study was done without noting the name of the company, nor the interviewed person.

The second section of the questionnaire covered the product elimination in general and referred to specific elimination cases the interviewed person was involved in in the last three years. In which stage of the product life cycle the product was and if each product which entered the decline stage was eliminated. If not, why it stayed longer/permanently in the product portfolio. Who was involved in the elimination process, who was the decision maker and whether the company had a formal process to eliminate products? Furthermore, it was analyzed if the company faced problems during the process.

The third part started with the importance ranking of the factors Avlonitis (1984) and Hart (1988) identified in their studies. In the end, there was an open question to analyze if the German mechanical engineering companies had additional elimination reasons which were not included in Avlonitis' and Hart's list of circumstances.

The first contact and several interviews were conducted during the international trade fair 'Hannover Messe' (April 23–27, 2018) where many German engineering companies with international focus participated with their own booth. It is the world's leading exhibition for industrial technology innovations. In order to ensure that interviewed persons had the necessary knowledge and experience to discuss the product elimination process the focus was mainly on product managers and on all other company employees who were involved in the past three years with the product elimination process in their company. Some of the persons interviewed needed more time (either they were too busy during the exhibition or they needed to look up elimination cases in their documentation, or the right contact person with experience was at the moment not available during the exhibition); thus, an arrangement was set to interview them after the exhibition via skype and email.

The interviewed persons were working in the following branches (Tab. V).

The annual sales turnover question was not answered by the interviewed persons, but they gave the following split regarding the size of the company (measured in number of employees) – see Tab. VI, and number of products in their portfolios – see Tab. VII.

The respondents rated the relative importance of each precipitating circumstance originally identified by Hart (Hart, 1988) on their particular product elimination decision of reference on a 5-point Likert scale (1 = of little or no importance to 5 = extremely important). Hart reported the relative frequency of occurrence in her study. The same is done here to compare both the results of both studies. The data is presented in descending order of importance.

V: *Distribution of the Interviewed Persons over the Branches*

Branch of the industry	Frequency	Relative frequency (in %)
Automation	18	18
Power Transmission	18	18
Industrial Supply	35	34
Mechanical Engineering	31	30
Total	102	100

Source: Interviews, April 2018, n = 102

VI: *Number of Employees of the Interviewed Companies*

Number of employees	Frequency	Relative frequency (in %)
1–100	14	14
101–500	49	48
501–4999	35	34
5000+	4	4
Total	102	100

Source: Interviews, April 2018, n = 102

VII: *Number of Products in the Product Portfolio of the Interviewed Companies*

Number of products in product portfolio	Frequency	Relative frequency (in %)
10–50	48	47
51–100	20	20
101–200	22	22
201–500	9	8
501+	3	3
Total	102	100

Source: Interviews, April 2018, n = 102

RESULTS

Hart's Product Elimination Factors

The variable with the greatest influences for product elimination shows the highest relative influence. Among German mechanical engineering companies, poor profit and sales performance as well as development of a new product and decline of market potential were identified as the reasons with the major influence for product elimination decisions.

To compare these results with the previous studies (Hart, 1988) and (Mitchell *et al.*, 1998) the Spearman's rank-order correlation coefficient was used. The Spearman's rank-order correlation coefficient analyses the correlation of the ranks of the values between two sets (Daniel, 1992). Mitchell *et al.* (1998) has used this correlation coefficient to compare his results with Hart (1988). The calculations for the Spearman's value can be found in Tab. IX and Tab. X. The *n* for Hart's analysis equals 17.

The Spearman's rank order correlation value shows that the ranks of the variables of the studies have an extremely high positive correlation. The correlation value to (Mitchell *et al.*, 1998) results shows even a higher value than to the original study (Hart, 1988).

The high correlation value indicates a big consistency between the results of all three studies.

That displays that the variables found originally by Hart (1988) are also valid not only for the US, but also for German engineer companies. The variables used to make a product elimination decision are very similar between in the different countries UK, US and Germany analyzed.

Hart (1988) grouped the 17 factors into 6 groups (see Tab. IV), using the principal component analysis. The same was done with the new data to extract and compare the most important independent factors. The Kaiser-Meyer-Olkin measure of sampling adequacy was 0.461, which is a relatively low factor. But for comparison reasons the principal component analysis was conducted even with this low factor. The Bartlett's test of sphericity was significant ($p < 0.0051$), indicating that correlations between items were sufficiently large for performing a principal component analysis (Tab. XI).

The correlations and variable loading between the 17 factors show a different result than Hart's study (Tab. XII).

In Hart's study are only the variable loadings listed of the factors but not the complete list of results, so that further analysis with the data is not advisable. Maybe the Kaiser-Meyer-Olkin value was even at Hart's study low and it would have been better to use a different statistical calculation tool instead of the principal component analysis, or the companies see nowadays a different correlation between these factors.

VIII: *Relative Importance of Hart's Variables (Hart, 1988) of the Interviewed Companies*

Variable		Mean Value	Standard Deviation
A11	Poor profit performance	4.01	0.75
A10	Poor sales performance	3.94	0.76
A5	Development of a new product	3.43	0.84
A9	Decline in market potential	3.39	0.79
A4	Competitive activity	3.02	0.80
A6	Company resources required elsewhere	2.98	0.87
A13	Poor fit with company capabilities or strategic plans	2.95	0.85
A12	Poor quality or design	2.94	0.83
A2	Operational problem	2.63	0.86
A7	Problems associated with raw materials and/or parts	2.61	0.65
A8	Variety reduction policy	2.44	0.68
A3	Third party decision (i.e. major customer exits market)	2.33	0.80
A1	Government policies and regulations	2.21	0.95
A15	Poor fit with company image	2.03	0.88
A14	Rationalization due to mergers and acquisitions	1.68	0.72
A16	Parent company decision and policies	1.58	0.64
A17	Change in exchange rates	1.28	0.47

Source: Interviews, April 2018, n = 102

IX: *Spearman's Rank-Order Correlation Coefficient (Hart's Study)*

Variable		Rank today	Rank Hart	d	d²
A1	Government policies and regulations	13	15.5	-2.50	6.25
A2	Operational problem	9	5.5	3.50	12.25
A3	Third party decision (i.e. major customer exits market)	12	15.5	-3.50	12.25
A4	Competitive activity	5	5.5	-0.50	0.25
A5	Development of a new product	3	4	-1.00	1
A6	Company resources required elsewhere	6	10	-4.00	16
A7	Problems associated with raw materials and/or parts	10	13	-3.00	9
A8	Variety reduction policy	11	9	2.00	4
A9	Decline in market potential	4	3	1.00	1
A10	Poor sales performance	2	2	0.00	0.00
A11	Poor profit performance	1	1	0.00	0.00
A12	Poor quality or design	8	8	0.00	0.00
A13	Poor fit with company capabilities or strategic plans	7	7	0.00	0.00
A14	Rationalization due to mergers and acquisitions	15	17	-2.00	4.00
A15	Poor fit with company image	14	11.5	2.50	6.25
A16	Parent company decision and policies	16	14	2.00	4
A17	Change in exchange rates	17	11.5	5.50	30.25
				Sum	106.5

Source: Interviews, April 2018, n = 102 and Hart (1988)

$$Spearman´s\ value = 1 - \frac{6(Sum\ d^2)}{n(n^2 - 1)} = 1 - \frac{6(106.5)}{17(288)} = \mathbf{0.869} \quad (1)$$

$$Spearman´s\ value = 1 - \frac{6(Sum\ d^2)}{n(n^2 - 1)} = 1 - \frac{6(8)}{17(288)} = \mathbf{0.991} \quad (2)$$

X: *Spearman's Rank-Order Correlation Coefficient (Mitchell et al. study)*

Variable		Rank today	Rank Mitchell	d	d²
A1	Government policies and regulations	13	13	0.00	0.00
A2	Operational problem	9	8	1.00	1.00
A3	Third party decision (i.e. major customer exits market)	12	12	0.00	0.00
A4	Competitive activity	5	5	0.00	0.00
A5	Development of a new product	3	4	-1.00	1.00
A6	Company resources required elsewhere	6	7	-1.00	1.00
A7	Problems associated with raw materials and/or parts	10	10	0.00	0.00
A8	Variety reduction policy	11	11	0.00	0.00
A9	Decline in market potential	4	3	1.00	1.00
A10	Poor sales performance	2	1	1.00	1.00
A11	Poor profit performance	1	2	-1.00	1.00
A12	Poor quality or design	8	9	-1.00	1.00
A13	Poor fit with company capabilities or strategic plans	7	6	1.00	1.00
A14	Rationalization due to mergers and acquisitions	15	15	0.00	0.00
A15	Poor fit with company image	14	14	0.00	0.00
A16	Parent company decision and policies	16	16	0.00	0.00
A17	Change in exchange rates	17	17	0.00	0.00
				Sum	8.00

Source: Interviews, April 2018, n = 102 and Mitchell *et al.* (1998)

XI: *Principal Component Analysis*

	Component					
	1	2	3	4	5	6
Government policies and regulations	-0.334	0.116	-0.037	0.158	**0.521**	-0.200
Operational problem	-0.296	-0.200	-0.301	0.309	0.300	**0.419**
Third party decision (i.e. major customer exits market)	**0.665**	-0.059	0.046	0.485	0.052	0.172
Competitive activity	0.017	0.304	-0.015	**0.443**	0.379	-0.302
Development of a new product	-0.082	**0.506**	**-0.396**	-0.392	-0.070	-0.032
Company resources required elsewhere	-0.249	**0.495**	0.115	-0.039	0.207	0.333
Problems associated with raw materials and/or parts	0.065	0.091	**-0.522**	0.071	-0.439	0.179
Variety reduction policy	**0.715**	0.162	0.089	0.085	0.243	0.153
Decline in market potential	0.002	**0.546**	0.218	-0.044	-0.097	0.258
Poor sales performance	-0.194	0.277	0.087	**0.454**	-0.350	-0.276
Poor profit performance	0.238	0.108	0.063	0.234	**-0.348**	-0.332
Poor quality or design	-0.368	**0.411**	0.391	0.062	-0.223	0.228
Poor fit with company capabilities or strategic plans	0.222	**0.556**	0.100	-0.040	0.197	-0.029
Rationalization due to mergers and acquisitions	-0.281	-0.221	**0.557**	0.320	-0.229	0.312
Poor fit with company image	**0.511**	-0.033	0.026	-0.155	-0.017	0.399
Parent company decision and policies	-0.217	-0.299	**0.388**	-0.240	0.202	0.013
Change in exchange rates	0.334	0.004	**0.553**	-0.334	0.001	-0.274

Source: Interviews, April 2018, n = 102

XII: *New Types of Product Elimination Decisions*

Factor	Variables on factor
1.	Government policies and regulations
	Poor profit performance
2.	Operational problem
3.	Third party decision (i.e. major customer exits market)
	Variety reduction policy
	Poor fit with company image
4.	Development of a new product
	Company resources required elsewhere
	Decline in market potential
	Poor quality or design
	Poor fit with company capabilities or strategic plans
5.	Competitive activity
	Poor sales performance
6.	Problems associated with raw materials and/or parts
	Rationalization due to mergers and acquisitions
	Parent company decision and policies
	Change in exchange rates

Source: Interviews, April 2018, n = 102

Avlonitis' Product Elimination Factors

In the study from 1984 Avlonitis (1984) identified fifteen product elimination factors. The respondents in this study rated the relative importance of each factor on their particular product elimination decision of reference on a 5-point Likert scale (from 1 = of little or no importance, to 5 = extremely important). Avlonitis reported the relative frequency of occurrence in his study. The same is done here to compare the results of both studies. The data is presented in Tab. XIII in descending order of importance. The *n* for Avlonitis' analysis equals 15.

Like the results of (Avlonitis, 1984) and (Mitchell *et al.*, 1998) the interviewed German engineering companies rated the relative importance of external relationship factors as more important than internal factors, e.g. the relationship to employees or the corporate image.

The Spearman's rank order correlation coefficient was used again to compare the ranking of Avlonitis' factors (Avlonitis, 1984) in the studies by Mitchell *et al.* (1998) and the new German study. The calculations for the Spearman's value can be found in Tab. XIV and Tab. XV.

The Spearman's rank order correlation value shows that the ranks of the product elimination variables of the studies have a high positive correlation. The high correlation value indicates a big consistency between the results of all three studies.

XIII: *Relative Importance of Avlonitis' Factors of the Interviewed Companies*

Variable		Mean Value	Standard Deviation
B3	Product's elimination effect on customer relationships	3.56	0.64
B8	Existence of substitutes to satisfy the customer	3.34	0.75
B1	New product potential	3.32	0.75
B2	Product's elimination effect on sales of other products	3.30	0.73
B5	Reallocation of capital and facilities to other opportunities	3.14	0.72
B4	Product's elimination effect on profitability of other products via production overhead allocation	2.99	0.83
B6	Product's elimination effect on 'full-line' policy	2.77	0.64
B12	Competitive moves in case the product is eliminated	2.48	0.66
B10	Product's elimination effect on profitability of other products via selling overhead allocation	2.37	0.58
B9	Product's elimination effect on the fixed and work capital	2.36	0.61
B13	Product's elimination effect on profitability of other products via distribution overhead allocation	2.28	0.69
B11	Product's elimination effect on corporate image	2.10	0.76
B7	Release of executive time spent on the product	1.81	0.71
B14	Product's elimination effect on employee relationships	1.63	0.64
B15	Organized intervention (i.e. trade unions)	1.18	0.41

Source: Interviews, April 2018, n = 102 and Avlonitis (1984)

XIV: *Spearman's Rank-Order Correlation Coefficient of Avlonitis' Factors (Hart Study)*

Variable		Rank today	Rank Hart	d	d^2
B1	New product potential	3	1	2	4
B2	Product's elimination effect on sales of other products	4	2.5	1.5	2.25
B3	Product's elimination effect on customer relationships	1	2.5	-1.5	2.25
B4	Product's elimination effect on profitability of other products via production overhead allocation	6	4	2	4
B5	Reallocation of capital and facilities to other opportunities	5	5.5	-0.5	0.25
B6	Product's elimination effect on 'full-line' policy	7	6	1	1
B7	Release of executive time spent on the product	13	7.5	5.5	30.25
B8	Existence of substitutes to satisfy the customer	2	7.5	-5.5	30.25
B9	Product's elimination effect on the fixed and work capital	10	10	0	0
B10	Product's elimination effect on profitability of other products via selling overhead allocation	9	10	-1	1
B11	Product's elimination effect on corporate image	12	10	2	4
B12	Competitive moves in case the product is eliminated	8	12.5	-4.5	20.25
B13	Product's elimination effect on profitability of other products via distribution overhead allocation	11	12.5	-1.5	2.25
B14	Product's elimination effect on employee relationships	14	14	0	0
B15	Organized intervention (i.e. trade unions)	15	15	0	0
				Sum	101.75

Source: Interviews, April 2018, n = 102 and Hart (1988)

$$Spearman\acute{}s\ value = 1 - \frac{6(Sum\ d^2)}{n(n^2 - 1)} = 1 - \frac{6(101.75)}{15(224)} = \mathbf{0.818} \quad (3)$$

XV: *Spearman's Rank-Order Correlation Coefficient of Avlonitis' Factors (Mitchell et al. study)*

Variable		Rank today	Rank Mitchell	d	d^2
B1	New product potential	3	3	0	0
B2	Product's elimination effect on sales of other products	4	4	0	0
B3	Product's elimination effect on customer relationships	1	1	0	0
B4	Product's elimination effect on profitability of other products via production overhead allocation	6	5	1	1
B5	Reallocation of capital and facilities to other opportunities	5	6	-1	1
B6	Product's elimination effect on “full-line” policy	7	7	0	0
B7	Release of executive time spent on the product	13	13	0	0
B8	Existence of substitutes to satisfy the customer	2	2	0	0
B9	Product's elimination effect on the fixed and work capital	10	10	0	0
B10	Product's elimination effect on profitability of other products via selling overhead allocation	9	9	0	0
B11	Product's elimination effect on corporate image	12	11	1	1
B12	Competitive moves in case the product is eliminated	8	12	-4	16
B13	Product's elimination effect on profitability of other products via distribution overhead allocation	11	8	3	9
B14	Product's elimination effect on employee relationships	14	14	0	0
B15	Organized intervention (i.e., trade unions)	15	15	0	0
				Sum	28

Source: Interviews, April 2018, n = 102 and Mitchell *et al.* (1998)

$$Spearman´s\ value = 1 - \frac{6(Sum\ d^2)}{n(n^2 - 1)} = 1 - \frac{6(28)}{15(224)} = \mathbf{0.950} \qquad (4)$$

That displays that the variables found originally by Avlonitis (1984) are also valid not only for the US, but also for German engineer companies. The variables used to make a product elimination decision are very similar between in the different countries UK, US and Germany analyzed.

DISCUSSION AND CONCLUSION

The product elimination decision process in German mechanical engineering companies was compared with data from UK and US studies. The relative importance of the factors analysed by Avlonitis (1984) and Hart (1988) in the UK are highly correlating with the data in the US and Germany. The studies in UK and US were carried out in the 80's, regardless this significant time difference between those studies and the German study the results show that problems that lead industrial companies to product phase out decisions as well as the data companies are using in making that decision are very much the same in UK, US and Germany. Which is somehow not surprising because the PLC model has not lost the relevance and is still valid. Some factors like B8 “Existence of substitutes to satisfy the customer”, got a different ranking (Tab. XIV), it looks like the threat of substitutes is today much more important than it was in the past. It seems like the international availability of products and, therefore, competition is now much more intense than it was during the 80's when Avlonitis and Hart conducted their studies. Which also explains the different ranking of B12 “Competitive moves in case the product is eliminated” (Tab. XIV).

The different results of the principal component analysis should be analysed further perhaps with a second study in Germany in a different industry sector or in a different country, to compare in detail the results and to have more data for analysing.

In the end of the questionnaire there was an open question to analyze whether the German mechanical engineering companies had additional elimination reasons which were not included in Avlonitis' and Hart's list of circumstances, none of the questioned German mechanical engineering companies provided an additional reason.

Decreasing sales figures, low market share and shrinking profit are the main indicators of the decline phase in the PLC and those factors show the highest relative importance ranking in the product elimination process. But they are not the only factors which trigger industrial engineering companies to eliminate products. Internal factors like low quality/design, cross profitability effects in operation or operational problems are also reasons to start the elimination process.
In the next step additional factor analysis will be carried out to analyse the data in more depth.

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