THE SUCCESS AND FAILURE OF PRODUCT DEVELOPMENT IN THE DANISH FOOD SECTOR

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EXECUTIVE SUMMARY

1. Quality, as a strategic instrument in overall management of companies, is one of the decisive elements in the competitiveness of companies, and methodologies in the area of TQM are seen as leading means in helping business solve current problems, but even more important in anticipating future changes and need for new products. A key factor in quality is customer information and ability to use such information.

2. Defining and doing quantitative survey of success in product development is a difficult task. It is generally agreed that the measurement of success in product development should include factors such as: market share, sales objectives, profit objectives, technical aspects, impact on the company and company reputation and timing of the product development process. The main aim of the survey is to analyse the relationship between success in product development and the ability to collect, process and translate customer information into the product development processes.

3. As a preliminary step the population was defined as Danish food processing companies with 20 or more employees ($N=300$). Next, qualitative surveys in eight companies were carried out in order to find the central issues and questions to be investigated in a quantitative survey. 121 Danish food processing companies were contacted, and 55 companies agreed to participate. The person responsible for the product or the marketing manager in the individual company filled in a questionnaire during a meeting at the company. This procedure was used to ensure a high validity of the answers given to the questions in the questionnaire.

4. The main aim of this paper is to demonstrate mathematically, graphically and empirically how success rates of new products and launching rates of prototypes may depend on learning. Learning is assumed to have a positive impact on the quality of prototypes being developed by the individual company, and the mathematical derivations in this paper show that there is reason to believe that there is a linear relationship between the launching rate and the success rate.

5. The empirical results concerning applied success criteria of new products in Danish food processing companies show that increase in market share and increase in earning capability are the most dominant criteria, and criteria such as reputation and technological advantages have a much lower priority, but in general the companies use several success criteria for new products. A preliminary analysis of the relationship between success rate of new products and launching rates shows a significant linear dependency.

6. More detailed analyses of the success rate of new products are based on a regression model. In this model, the launching rate together with several other third variables, considered to be important in analysing the success rates, are used as explanatory variables. The final model shows a significant linear dependency between the success rate and the launching rate. The model also shows that eight other variables explain the success rate of a new product. The eight other significant variables (third variables) are: company perception of the concept: a new product, use of trade fairs in launching new products, production

methods sensitive to variation in the quality of raw materials, top-management participation in the product development stage, use of customer complaints, use of qualitative market research, constant exchange of sales information from customers in order to assess future demand, and finally the usage of buying frequency analyses in order to assess the likelihood of success of a new product.

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INTRODUCTION

In February 1995 the European Commission, DGIII, Industry issued a working document A European Quality Promotion Policy. In this document they launch the following view on quality:

Quality, as a strategic instrument in the overall management of companies, is identified today as one of the decisive elements in the competitiveness of companies.

The document continues by concluding that:

The use of the new methodologies of total quality management is for the leaders of the European companies a leading means to help them in the current economic scenario, which involves not only dealing with changes, but especially anticipating them

This view on quality is very interesting and very important. According to the Commission, quality is a question of creating a system of early warning in the company. This means that building quality into the product and consequently qualified product development becomes one of the most important aspects of modern management if companies want to stay in business. The future success of companies will increasingly become a question of their ability to handle the process of product development. It therefore becomes more and more important for researchers to study the causes of success and failure of product development.

At the moment there is considerable pressure on Western companies from the East. The average time that for instance Japanese companies have for marketing is much shorter than Western companies have (Clark, 1989). A previous study by Kristensen, Dahlgaard and Kanji (1995) concludes that considerable differences can be observed between the East and the West when it comes to the organization of product development:

- 1) Sophisticated techniques to analyse market data are used far more in the East than in the West
- 2) Much more use of structured techniques like QFD in the East
- 3) Far more top management participation in the process in the East

The above study was not tailor-made neither for product development nor for the food sector. We therefore decided to analyse in more detail the situation of product development in food companies in order to uncover some of the causes of success or failure of product development within this particular sector.

1. AIMS OF THE STUDY

Defining success in product development is very difficult. Much literature, eg Cooper (1994), Constantineau (1992) and Brown and Eisenhardt (1995), addresses the subject. It is generally argued that measurement of success in product development should include factors such as: market share, sales objectives, profit objectives, technical aspects, impact on the company, impact on

company reputation and timing of the processes from the initial stages of development to launching of the new product on the market.

The main aim of this study is to analyse the relationship between success in product development and the abilities to collect, process and translate customer information into the product development processes. However, it is important to control the many factors that may influence the relationship such as:

- Market form (export/home markets, number of competitors)
- Marketing (activities and methods used to promote new products)
- Economic abilities (financial situation of the company, investment in R&D)
- General competence (logistics, quality management, partnership, educational level in the company, production equipment)
- Internal organization of the stages in the product development processes (cross-functional involvement of departments and management and external involvement)

Apart from these factors, it is also important to include characteristics of the products being produced and sold by the companies, but in a study of food producing companies it is difficult and costly to include customer perceptions of the product characteristics because of the many different products and markets.

2. METHODOLOGY AND DATA COLLECTION

At an early stage it was decided that a survey should be carried out among Danish food processing companies with 20 or more employees. Database research revealed that the target population included about 300 companies with a number of employees ranging from 20 to approximately 6000 employees.

2.1 Qualitative study

In order to prepare the design of a quantitative survey, qualitative interviews were carried out in eight companies.

In the selection of the eight companies the intention was to find as high a degree of heterogeneity as possible in terms of size of company, types of products being produced and types of markets etc. The underlying assumption was that a great heterogeneity in the qualitative survey might reveal a variety of different ways of undertaking product development and launching products onto the market, which could give inspiration to the design of the quantitative survey.

The qualitative study was based on personal interviews with either persons responsible for product development or the marketing manager, and the interviews took place in the company.

The interviews revealed a number of different ways of doing product development, introducing and launching products onto the markets, definitions of what

the companies perceived as “a new product” and an insight into the success criteria applied by the companies.

The more general conclusions reached from the qualitative study were:

- the collection of information from end-users of the product was limited
- the level of application of more advanced statistical techniques was generally very low
- the inspiration for developing new products or/and demand for new products often came from the purchasers in chain stores, with whom the companies often discussed new product proposals
- companies often found that in developing a new product, the new product had to meet certain price/cost demands from purchasers
- some companies found no difficulty in developing new high quality products, but launching and marketing such products often were very difficult, because of the required higher prices for such products
- smaller companies producing highly technological products often found it difficult to start manufacturing new products because of the huge investments in new production equipment required
- smaller companies generally tried to modify existing products, although they were very vulnerable to competition from larger domestic or foreign companies.

Some of these findings were anticipated and in good accordance with results obtained by Harmsen (1996).

2.2 The quantitative survey

Based on the qualitative study and a review of the literature, a questionnaire was developed, which ended up being of a length of 18 pages containing 38 questions.

The size of the questionnaire and the sensitivity of the issue gave no reason to believe that it would be possible to obtain a reasonably high response rate if a postal survey was carried out.

Therefore the survey was done in the following way.

A sample of 121 companies was drawn from a database of Danish companies. We ensured that the sample gave a picture of companies in the population in terms of size of companies as valid as possible. We also tried to ensure that the sample was representative in terms of main production activities. However, the industrial codes of the companies gave some problems, because many companies had several codes referring to different parts and activities of the food manufacturing industry, and some companies even had activities not directly related to the food industry. This made it difficult to obtain a full representation of main activities in the food processing companies.

The persons responsible for product development in the selected companies were contacted by telephone and asked whether they and their companies were willing to participate in the survey. If the company had no product development manager, we contacted either the marketing manager or the managing director. If the key person agreed to participate, a meeting in the company was scheduled with the purpose to fill in the questionnaire.

Questionnaires were filled in in the following way. During the meeting at the company, the respondent had a copy of the questionnaire in front of him so that he could read the questions as we went along, and he was able to ask questions regarding the content of the individual questions and make supplementary comments to the questions and answers given. The person responsible for the interview filled in the answers and comments on a similar questionnaire. This procedure is expected to produce answers of high validity and few missing values.

2.3 Sampling frame, sample and response rate

55 of the selected 121 companies agreed to participate. Table 1 shows the basic statistics for the sampling frame, the number of responses and response rates as a function of the size of the company.

Table 1. Sampling statistics as a function of size of the company

Number of employees	Sampling frame	Selected	Response (response rate)
20-49	121	46	14 (30%)
50-99	54	22	16 (73%)
100-199	51	23	9 (38%)
200-499	31	16	8 (50%)
500-999	17	9	4 (44%)
1000+	11	5	4 (80%)
Total	291	121	55 (45%)

Note: response rate is calculated by comparing the number of employees mentioned during the interviews with the figures from the sample drawn from the database.

Comparing the number of employees according to the database and the information on the number of employees found during the interviews, it was discovered that some differences existed between the actual number of employees in the companies and the figures in the database, especially among the smaller companies.

We found that according to the database a substantial number of the companies participating were listed as having between 20 and 49 employees, but actually had 50-99 employees, while a number of companies listed as having around 100 employees had less than 100 employees. This is partly the explanation for the high response of companies in the group 50-99 employees. In the remaining groups there was good correspondence between the database information and the actual figures.

Despite these inaccuracies, it is fair to conclude that the response rate is significantly lower in the group of companies with less than 50 employees. The major reason for this low response rate is that many companies of that size during the telephone prenotification indicated that they did not have any product development activities at all, and therefore did not have any reason to participate in an interview concerning product development. Another reason mentioned by the companies was that product development took place in departments or companies outside Denmark.

22 (33%) of the 66 not participating companies had no product development activities at all, 19 (29%) claimed they did not have the time necessary to participate, 18 (27%) companies simply refused to participate and finally 7 (11%) companies had either been sold to other companies or had been closed.

Main production activity of the company has been another factor of special interest in the survey. Table 2 gives basic sampling statistics concerning this factor.

Table 2. Sampling statistics, – main activity of company

Main industrial activity	Sampling frame	Selected	Response (response rate)
Manufacturing and processing of meat	44	18	10 (55%)
Manufacturer of dairy products	19	9	3 (33%)
Manufacturer of fish products	58	16	5 (31%)
Manufacturer of bread	13	7	6 (86%)
Manufacturer of cakes and biscuits	14	9	2 (22%)
Manufacturer of sugar and chocolate	19	7	2 (28%)
Manufacturer of beverages	19	10	3 (30%)
Manufacturer of other products	67	31	16 (52%)
*Grocery	38	14	8 (57%)
Total	291	121	55 (45%)

Note: response rate is calculated on the basis of information from the database.

* companies having grocery as main activity also have manufacturing activities within the foodstuff area.

There is reason to believe that the willingness to participate in the survey to some extent depends on the main activity of the company, but the tendencies are not that clear, especially when we consider the fact that there is a dependency between the main industrial activity and the number of employees. For instance companies in the fish industry are much smaller compared to meat manufacturing companies.

Finally it should be emphasised that seven small companies participating in the survey had so few product development activities that part of the questionnaire could not be filled in by these companies.

3. AIM OF THE ANALYSIS

This paper concentrates on formulating a model explaining the success rate defined, as the proportion of successful launches of new products over the past three years. We concentrate especially on how the success rate depends on learning abilities, measured by the proportion of prototypes being launched over the past three years.

Because it is the company itself that evaluates the degree of success, it is obviously important first to analyse which success criteria the companies apply, when they evaluate the proportion of successful launches of new products.

Secondly, in order to isolate the effect of the learning abilities on the success rate of new products, the effects of third factors on the success rate are considered.

3.1 Theoretical and mathematical considerations on the relationship between success rates of new products and the launching rate of prototypes

The following theoretical and mathematical considerations are made:

Let: n_0 = # successes

N_0 = # launches

N = # prototypes

Assume that the profit can be described as:

$$\pi = \varphi(\xi N_0) - \psi(cN_0 + d \frac{N^2}{N_0}) \quad (1)$$

Where ξ is the success rate, n_0/N_0 , φ is the revenue function, and ψ is the cost function.

The rationale behind φ is obvious and the only assumption is that revenue is an increasing function of ξN_0 .

The rationale behind the cost function is as follows: The first element states that there is a variable cost c in launching a product N_0 and the second element represents a cost that will be an increasing function of the number of prototypes, N . However, it is assumed that due to learning effects it will be a decreasing function of the acceptance rate N_0/N , since the larger the acceptance rate the smaller the waste. This means that the explanatory variable of the function will be:

$$\frac{N}{N_0/N} = \frac{N^2}{N_0} \quad (2)$$

For given N the optimum profit as a function of N_0 will be given by the first order condition:

$$\begin{aligned}
\frac{\delta\pi}{\delta N_0} &= \varphi' \xi - \psi' [c + d \frac{-N^2}{N_0^2}] = 0 \Leftrightarrow \\
\varphi' \xi &= \psi' c - \psi' \left(\frac{1}{N_0/N}\right)^2 \Leftrightarrow \\
\xi &= \frac{\psi'}{\varphi'} c - d \frac{\psi'}{\varphi'} \left(\frac{1}{N_0/N}\right)^2
\end{aligned} \tag{3}$$

In order to obtain a simple expression let:

$$\begin{aligned}
\frac{\psi'}{\varphi'} c &= \alpha \\
d \frac{\psi'}{\varphi'} &= \beta \\
\frac{N_0}{N} &= x
\end{aligned} \tag{4}$$

This means that (3) may be written as:

$$\xi = \alpha - \beta \left(\frac{1}{x}\right)^2 \tag{5}$$

By a Taylor expansion around $x=1$ we get:

$$\begin{aligned}
\xi &= f(x) = f(1) + f'(1)(x-1) + R \\
&= \alpha - \beta + 2\beta(x-1) + R \\
&= \alpha - 3\beta + 2\beta x + R \\
&= \alpha_0 + \beta_0 \frac{N_0}{N}
\end{aligned} \tag{6}$$

Which will provide us with a simpler representation.

To sum up, what we have found is that conditional on the description in (1) and conditional on N we expect to find the following relationship between success rate and acceptance rate:

$$\frac{n_0}{N_0} = -\beta \left(\frac{1}{N_0/N}\right)^2 \tag{7}$$

Alternatively we may express the relationship through the first order approximation:

$$\frac{n_0}{N_0} = \alpha_0 + \beta_0 \left(\frac{N_0}{N}\right) \tag{8}$$

The more of the considered products a company launches, the more experienced the company becomes in designing products with the potential of becoming a success. Further empirical evidence on this relationship will be given in paragraph 4.2.

3.2 A graphic illustration of the effect of learning and the quality of products launched

In order to give a visual insight into the relationship between success of new products and learning and launching rates, figure 1 provides insight:

Figure 1. Relationship between quality and learning

It is assumed that the product development process in a company produces prototypes with quality attributes, which by nature are probabilistic, and for instance may be described by a normal distribution. The quality level, Q , of an attribute of a prototype is evaluated against a minimum quality requirement, R , and in case the minimum requirement is met, the prototype is launched, otherwise the prototype is not launched.

Furthermore it is assumed that:

- Learning increases company ability to develop products with high quality:
 $E(Q1) < E(Q2)$
- $V(Q1) \approx V(Q2)$
- Minimum quality requirement $R = \text{constant}$
- Increase in $Q \Rightarrow$ Increase in success rate: $\frac{n_0}{N_0}$

Under these assumptions, we investigate launching rates and quality levels of launched products.

We start by assuming that a company at a given time develops prototypes with quality level described by the stochastic variable $Q1$. Under this condition it is possible to state the probability of launching as:

$$P(L1) = \frac{N_{0,Q1}}{N} = P(Q1 \geq R) = \int_R^{\infty} f(Q1)dQ1 \quad (9)$$

and it is possible to find the expected quality level of launched products as:

$$E(Q1 | R) = \frac{\int_R^{\infty} Q1f(Q1)dQ1}{P(L1)} \quad (10)$$

This expected quality level is the expected value in the tail of that part of the distribution which is above the minimum requirement line, R, and in figure 1 it is denoted $E(Q1 | \text{LAUNCH})$

Further we assume that the company learns more about how to development its new products, which means that the quality of the prototypes can be described by the stochastic variable Q2. Under this new condition and assuming that R is constant, it is possible to find the new probability of launching:

$$P(L2) = \frac{N_{0,Q2}}{N} = P(Q2 \geq R) = \int_R^{\infty} f(Q2)dQ2 \quad (11)$$

and the expected quality level of launched products becomes:

$$E(Q2 | R) = \frac{\int_R^{\infty} Q2f(Q2)dQ2}{P(L2)} \quad (12)$$

The implications of learning are:

- Higher launching rates: $P(L1) < P(L2)$
- Higher quality of launched products: $E(Q1 | R) < E(Q2 | R)$

Using the assumption that higher quality leads to higher rates of success, the following conclusion can be found:

$$\Rightarrow \text{Higher rates of launching: } \frac{N_0}{N} \Rightarrow \text{Higher rates of success: } \frac{n_0}{N_0}$$

Increases in the minimum quality requirement, R, and changes in the variance of the quality of prototypes can undermine this conclusion.

4. EMPIRICAL RESULTS

We start by analyzing the success criteria that companies apply to their products. Next, we estimate a model linking launching rates to success rates. Finally, we integrate this relationship into a more comprehensive model explaining the success rate.

4.1 Analysis of success criteria

Above it was argued that the success of product development can be measured as n_0/N_0 , but when asking the companies how large a proportion of the launched products they considered a success, it is relevant first to investigate the importance of the different success criteria applied by the companies. In the questionnaire, companies were asked to evaluate eight indicators of success of new products on an importance scale ranging from 0 to 4, in which 4 is an indication of great importance.

Table 3. Ranking of the importance of success criteria of new products being launched

Rank	Importance of success criteria	Valid sample	Mean	Std. dev.
1	The new product can help increase the firm's market share.....	48	3.58	0.77
2	The new product increases the firm's earning capability	48	3.54	0.68
3	We think our customers will be pleased with the new product.....	48	2.75	1.16
4	The new product has lower costs than the existing products.....	48	2.40	1.16
5	The new product is a success if the cost of development and the resultant investment in plants and promotion are recovered within two years.....	47	2.30	1.40
6	The new product can improve the firm's reputation in society	48	1.94	1.37
7	The new product offers technological advantages.....	48	1.94	1.23
8	The new product will shut up those customers who have been demanding innovation for a long time.....	48	1.63	1.10

From table 3 it is clear that the two dominant success criteria relate to the economic performance of new products, while more soft aspects such as reputation and strategic impact have less importance, which indicates that the theoretical considerations regarding the number of successful launches and the number of prototypes being launched could prove valuable in a model explaining success rate by launching rates.

4.2 Launching rate and success

The relevance of learning ability can be empirically examined by looking at the scatter-plot showing the relationship between the percentage of successful product launches and the percentage of prototypes being launched.

Figure 2. Relationship between the percentage of considered products launched and the percentage of launched products being a success – average over past three years

Figure 2 clearly shows that there is a positive correlation between the percentage of products launched and the percentage of successful launches over the past three year.

5. A MODEL OF NEW PRODUCT SUCCESS

After these preliminary considerations and investigations, a model explaining the percentage of successful launches over the past three years is formulated, using the percentage of prototypes launched over the past three years as an explanatory variable.

In order to eliminate the effect of third variables, the following supplementary explanatory variables are included in the formulation of a multiple regression model.

The dependent variable:

Y: Percentage of launched products being a success ($n_0/N_0 * 100$)

Independent variables:

X₁: Percentage of considered products being launched ($N_0/N * 100$)

X₂: Agreement with statement: An adaption of an existing product is a new product
(1=Fully disagree ... 5=Fully agree)

X₃: Extent to which trade fairs and shows are applied to promote new products. (Timing of launching) (1=Never ... 4=Always)

X₄: Agreement with statement: Production is very sensitive to variations in quality of primary products
(1=Fully disagree ... 5= Fully agree)

X₅: Top-management participation in product development at development stage
(0=No, 1= Yes)

X₆: Extent of usage of customer complaints
(1=Never ... 4= At least once a month)

X₇: Extent of usage of qualitative market research in product development
(1=No, 2=Sometimes, 3=Yes, always)

X₈: Agreement with statement: Company is constantly kept informed about sales by customers, and the company use this information for assessing future demand for company products. (1=Fully disagree ... 5=Fully agree)

X₉: Extent to which analyses of buying frequency are made to access the likelihood of success of new product. (1=Never ... 4=Always)

The estimation of the model gave the following results:

Table 4. ANOVA

Model	Sum of Squares	df	Mean Squares	F	Sig
Regression	23421.11	9	2602.35	10.18	0.00
Residual	8689.12	34	255.56		
Total	32119.23	43			

$R^2 = 0,729$ $R_a^2 = 0,659$

Table 4 shows that a substantial part (72,9%) of the variation in the dependent variable has been explained.

The estimation results for the model are shown in table 5.

Table 5. Estimation results

Model	Coefficient	Standard Coefficient	T-value	p-value	VIF
Constant.....	-113.16		-4.57	0.00	
X ₁ : % Launched	0.32	0.37	3.54	0.00	1.36
X ₂ : Adaption.....	5.25	0.24	2.32	0.03	1.37
X ₃ : Trade fairs.....	-8.04	-0.29	-3.09	0.00	1.08
X ₄ : Product sensitivity	14.33	0.47	3.82	0.00	1.88
X ₅ : Management dev.....	13.02	0.23	2.39	0.02	1.11
X ₆ : Customer complaints	11.26	0.34	3.39	0.00	1.26
X ₇ : Qualitative M.R.....	10.90	0.37	3.48	0.00	1.38
X ₈ : Information exchange	3.72	0.20	2.19	0.04	1.08
X ₉ : Frequency analysis.....	7.22	0.31	2.90	0.01	1.39

Firstly, it is interesting to notice that the variance inflation factors (VIF) are very close to 1, which indicates that the model is not influenced by multi-collinearity. Therefore it is possible to interpret the coefficients as individual contributions to the success rate of new products launched, although the value of the prediction has to be within the range of 0 to 100, which is not guaranteed by the chosen functional form. Secondly, the standardized coefficients are given in table 5. It makes it possible to compare the relative importance of the explanatory variables for the success rate. Thirdly, nearly all the estimated coefficients in the final model have the expected signs. Compared to the grouping in Brown and Eisenhardt (1995), the final model includes effects of senior management support and product effectiveness measured as a fit of market needs and company competencies.

If adaption of an existing product is an acceptable definition of a new product, it leads to a higher success rate for the company. This result is not surprising. Obviously it is easier to work in a known product group than in a completely new area. The result shows that low-risk takers have higher successful launch rates than high-risk takers, and, together with the percentage launched, the result reflects the importance of company experience with the different phases of product development in order to achieve success. These two variables reflect aspects of product effectiveness in terms of fit with company competence. The character of the production equipment may also be seen as a more implicit aspect of firm competence. In our case the estimated coefficient is positive, and a possible explanation is that inflexible equipment fosters creativity.

Senior management support has been found to be a critical success factor in many studies. The study of Gupta et al (1990) showed that managerial commitment in terms of personal and financial resources was the most important form of support in the new product development process and a major factor of no delay in development. The optimal type of management involvement has been discussed in the literature (eg Cooper & Kleinschmidt, 1995) but it is never

questioned that active support from top management is needed to set the climate for innovative new product development programs. Therefore it is not surprising that the coefficient for management participation in product development is positive and significant although our data do not allow to judge the character of management support.

The remaining variables in the model refer to the interaction between the customer and the company and hence product effectiveness in terms of fit with market needs. Variables like customer complaints, qualitative market research and continuous information exchange with customers reflect to what degree customer information is used as input to the product development process. Buying frequency analysis is customer information applied to decide whether to launch or not to launch, and the use of trade fairs is a possible customer information channel. Ranking the standardised coefficients of the four variables, the coefficient for qualitative market research is the highest. Qualitative market research is an obvious tool to apply in the conceptual stage, and if the product development process is not market driven from this early stage, the risk of failure will be high. Qualitative market research is also an obvious condition for effective quantitative market research. According to table 3, the degree of market orientation in the product development process is by far the most important factor for product development success.

CONCLUSION

Three main conclusions may be drawn from this paper. Firstly, the quality concept combined with the concept of learning establishes a good theoretical framework for analysing and explaining the relationship between launching rates and success rates of new products. The second conclusion is that empirical research among companies in the Danish food industry shows that profit and market shares are the dominant success criteria. Finally, a regression model with success rate as dependent variable and launching rate and a number of controlling variables suspected to influence the launching and success rates proved that there is a significant dependency between the success rate and launching rate in the Danish food industry. The implication of the findings is that higher launching rates due to learning increase success rates and ultimately profit.

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