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Measuring innovative intensity

Scale construction

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Contents

1 Introduction

1.1 Motivation

Many small companies work in an environment of changing consumer preferences, increasing competition and changing technological requirements. To achieve business goals like profit and growth, it is necessary to have a continuous flow of successful innovations. Buijs (1988) states that innovations are a necessary condition for an organization to survive. Small companies with a high innovative intensity perform better than small companies with lower innovative intensity (Geroski, 1995; Banbury and Mitchell, 1995; Soni, Lilien and Wilson, 1993). The strategic position of a small company depends on its ability to offer high-quality products and services that fit the needs of the market. A permanent flow of innovations is therefore of significant importance.

As a consequence, Dutch policy makers have started to recognise the importance of innovations for small companies as well. For instance, the Dutch Ministry of Economic Affairs will initiate various activities to improve the numbers of innovations by Dutch enterprises (Ministerie van Economische Zaken, 2000).

1.2 Objective

Many entrepreneurs and policy makers will be interested to know how they can increase the innovative intensity of their company and the Dutch economy. The first problem that one encounters is that innovative intensity is a latent concept and therefore not directly measurable. Van der Valk (1998b) mentions that one must tackle the problem of measuring innovative intensity before one can investigate how to improve it. According to Wolfe (1994) many different measures are employed, which make a significant contribution to the prevailing confusion. Different measures do not make it any easier to discuss the innovative intensity of small companies.

Therefore, the objective of this research report is to develop, test and validate a measurement scale for the innovative intensity of a small company. The measurement scale must be applicable for all sectors of the economy.

The content of this report is as follows:

- In chapter 2 we present a simple model to measure innovative intensity and give an overview of some recent studies in which measuring innovative intensity is investigated.
- In chapter 3 the outline of our empirical investigation to test our model and develop a measurement scale for the innovative intensity of a small company is discussed.
- Chapter 4 presents our findings and we test and validate the measurement scale.
- Finally, in chapter 5 we describe the results and make some suggestions for future research.

2 Background

2.1 Definition

Schumpeter (1926) made a distinction between the concepts of invention and innovation. An invention is an idea or model for a new or improved product, process or technology. An innovation is a new or improved product, process or technology, which is commercially successful on the market. Therefore, commercial success is a necessary condition for an invention to become an innovation.

Innovation can be defined in several ways. A few examples:

- 'Introduction of something new; technological, industrial renewal' (van Dale, 1992)
- 'The development and successful introduction of new or improved products, services, work processes; innovation also includes organizational changes, new markets and improved leadership styles' (Timmerman, 1985)
- 'Every renewal that is designed and implemented to strengthen the position of an organization with regard to its competitors and that in the long run creates competitive advantage' (Vrakking en Cozijnsen, 1992).

Innovation is often seen as successful renewal. It is traditionally seen as the development of new products. From this technological viewpoint we find various narrow definitions of innovation. However, we must remember that an innovation is not about new product development only. According to Cozijnsen and Vrakking (1992) an innovation can apply to various subjects, like new or improved products, markets, (work) processes, etc. For our present purposes we choose a broader definition of innovation:

- 'An innovation is the development and successful implementation of a new or improved product, service, work process or market condition, aiming to gain a competitive advantage.'

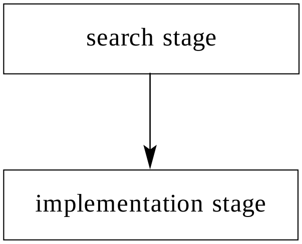
2.2 The innovation process

An innovation is developed and implemented in a process, which consists of various stages. Wolfe (1994) concludes that it is frequently not clear to what part of the process a study is limited. Moreover, there are several models to describe the innovation process. Buijs (1987) mentions some of these models. Below, we shall discuss the activities step model and the transformation model. These models are commonly used in studies, such as van der Valk (1998a).

Activities step model

An activities step model simply describes the activities necessary to develop an innovation. Buijs (1987) employs a simple version of the activities step model to describe the innovation process. The models of Cooper (1990) and Booz, Allen and Hamilton (1968) can be considered as more detailed variants of his model. Buijs (1987) simply divides the innovation process into two stages (figure 1):

figure 1 activities step model



Source: Buijs (1987).

In the search stage the organisation recognises a need for innovation, generates ideas, makes a first selection of promising ideas by looking at the market potential and production possibilities, and determines the objectives for further development. Next, in the implementation stage the idea is developed into a tangible product, tested and introduced to the market. When the idea concerns a process innovation (like new work processes), a reorganisation or training programme is usually part of the implementation stage. This stage then focuses on the management of change.

Transformation model

Buijs (1987) also discusses the transformation model. In this model the development of an innovation is considered to be a process in which innovative inputs are transformed into innovative outputs (figure 2).

figure 2 transformation model

Innovative inputs are transformed into innovative outputs. In other words, financial means, human knowledge and labour are transformed into new or improved products, services, work processes, etc.

The ultimate innovative results (output) also depend on the degree of innovation in the internal organisation (process), in which the innovative inputs are transformed into innovative outputs. The transformation process itself is not described in detail: it is considered as a black box so there is little focus on the actual work processes themselves.

Compared to other models describing the innovation process, the transformation model has some major advantages. Most models present the development of an innovation as a very logical and structured process. However, in reality the development is usually rather unstructured and vague. The transformation model not only overcomes this drawback, but it is very suitable for making comparisons between organisations. When measuring the innovative intensity this is a distinct advantage. Therefore, we have chosen the transformation model as a framework for our measurement scale. It consists of three factors: innovative input, innovative process and innovative output.

2.3 Literature

In this section we shall discuss some recent studies that attempted to measure the innovative intensity of small companies or specific sectors. Successively we shall discuss Nagel (1992), Gosselink (1996), van der Valk (1998a) and van der Valk (1998b). These studies use many indicators for the innovative intensity. We shall also state how each study contributes to our measurement scale.

Nagel (1992)

Nagel (1992) concludes that many organisations have a need to summarize their innovative behaviour in a simple, meaningful way. For this purpose he developed a questionnaire with three objectives:

- the questionnaire measures the ability to make product innovations. So compared to our study the focus is narrow: there is no specific attention for other types of innovation;
- the questionnaire is short and simple to complete;
- the members of an organisation's management team should be able to answer the questions. It should not be necessary to hire an innovation expert.

The questionnaire consists of a set of ten items. Five items consider the organisation's strategy (for instance: does the management provide explicit guidelines for new product development?) and five items deal with innovative conditions (for instance: does the organisation have enough financial means to develop new products, and is any use made of an external network consisting of universities, competitors, etc.?). Each item is graded 1 point for ‘yes’, 0 points for ‘no’, and 0.5 points for doubtful cases. The answers to each item can be combined into a general score for the innovative intensity.

In our opinion, Nagel’s method (1992) has a number of limitations. First, questions seem to be selected rather arbitrarily. They do not seem to cover the innovation process in full detail. Second, many question items are very subjective. If the innovative intensity is assessed again by completing the questionnaire again after some years, there is a restriction against allowing the same person to make the assessment. For this reason, the general score is not very suitable for making any comparisons between different organisations.

For our study, some of Nagel’s question items do seem to be relevant. For instance, the item ‘Is there any use of an external network (universities, competitors, consultants)?’ can be relevant for the process factor of our transformation model. Likewise, the item about financial means to develop new products can contribute to our input factor. We also consider Nagel’s way of questioning will appeal to entrepreneurs because of its simplicity form. We shall also use dichotomous items for our measurement scale.

Gosselink (1996)

Gosselink (1996) discusses two ways to make the innovative intensity measurable and recognisable:
- the direct method, and
- the indirect method.

The direct method attempts to measure the innovative intensity by measuring the quality of a number of ‘innovative dimensions’. He discusses a number of these dimensions, such as the innovative strategy, staff, financial means, etc. By analysing these dimensions one obtains an impression of the strengths and weaknesses of a small company’s innovative intensity. The direct method enables the entrepreneur to judge his current innovative position. Should there be a gap with the desired position, this can be the start of many interventions.

The indirect method aims at measuring the output-oriented innovative results only. In this method, one can think of measuring the number of new products introduced to the market in the past few years, number of requested patents, number of new markets, etc. These indicators are all visible innovative results.

For our study, Gosselink's direct method provides some indicators that can be employed in our measurement scale, for instance, the innovative strategy seems to be relevant for our process factor. Gosselink's indirect method is also very important for our purpose because it focuses on innovative results. This is a major contribution to our output factor. Measuring the number of new products, requested patents, etc. will be at the heart of this factor.

Van der Valk (1998a)

Van der Valk (1998a) describes the degree of innovation of small Dutch manufacturing companies. He takes into account no less than 13 industrial sectors and does not employ one single measurement scale to describe the innovative intensity but instead presents a large number of innovative indicators. Many of these indicators are specific for industrial companies.

Van der Valk uses the transformation model – as described by Buijs (1987) – to categorise the innovative indicators. First he discusses the input factor by presenting the following indicators:

- percentage of companies with their own R&D-staff
- percentage of companies working with highly advanced production means
- percentage of companies using Dutch technology subsidies
- percentage of companies using European technology subsidies
- expenditure on new machines as a percentage of production value
- expenditure on computers as a percentage of production value
- expenditure on software as a percentage of production value
- expenditure on outsourcing R&D as a percentage of production value.

Then the process factor is discussed. Van der Valk emphasises that the ability to transform innovative inputs into innovative results is a very important aspect of the innovation process. He mentions the quality of the internal work processes within the organisation and co-operation with other companies as two major contributors to the innovative intensity. Some examples of the process indicators he presents are:

- percentage of companies having an innovative business strategy
- percentage of companies that changed their organisational structure in the past three years
- percentage of companies investigating customer satisfaction
- percentage of companies that co-operate with other companies or research centres.

Finally, van der Valk presents the output factor. He does not focus on the number of new products only, so that the following output indicators are presented:

- percentage of companies possessing patents
- average percentage of turnover from new products
- percentage of companies introducing products new for the sector
- percentage of companies introducing products new for the Netherlands
- percentage of companies introducing products new for Europe.

For our measurement scale, it is important to note that van der Valk points out that the indicators should describe the whole spectrum of the innovative process. Therefore, a composite measurement scale should pay attention to all the factors of the transformation model. Although many of the indicators van der Valk presents are specific for industrial sectors (like the percentage of companies using technology subsidies), some indicators are very suitable for our general measurement scale (for instance, the average percentage of turnover from new products).

Van der Valk (1998b)

Van der Valk (1998b) recognises the growing importance of innovations for small companies. He did some comprehensive literature research, with the objective of developing a universal measure for the innovative intensity of a small company. The investigation focuses first on the state-of-the-art literature on innovation in six countries. After that, in a group session with a number of sector experts an attempt was made to determine innovation indicators for five different sectors: trade, commercial services, personal services, manufacturing and construction. Again, the transformation model was used as a framework to categorise the indicators.

Van der Valk's investigation has some interesting implications. First, the Danish literature showed a number of additional innovative indicators. For our input factor, the presence of company training programs could be a relevant question item. Van der Valk also mentioned the importance of network activities: the presence of co-operation, outsourcing and/or information gathering from other companies can contribute to the process factor.

As second, it is significant that van der Valk mentions that one single indicator is not enough to describe the innovative intensity of a small company; a composite index is a better solution. This is consistent with Churchill (1979) who claims that the reliability and validity of a composite index is better. Finally, van der Valk recognises that many innovative indicators are specific for certain sectors. When developing a universal measurement scale for the innovative intensity, indicators that are universally applicable should be used.

3 Design, questionnaire and data collection

3.1 Design

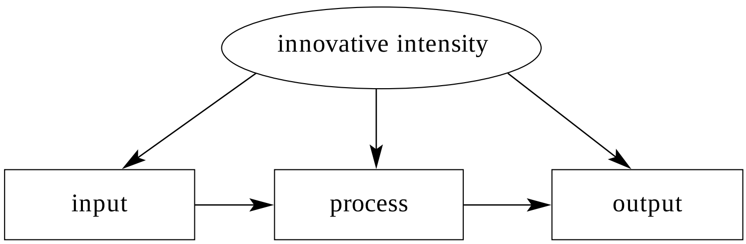
The population of our study consists of all the small companies in the Netherlands. Using the transformation model as a basis for the development of our measurement scale, we shall investigate whether the innovative intensity of a small company can be described by combining its innovative input, processes and output.

A three-stage procedure was used to construct the measurement scale:

1. construct single-dimensional scales for the innovative input, process and output of a small company. For each scale we use several indicators.
2. perform a confirmatory factor analysis to check if the scale scores can be combined into a single score for the innovative intensity.
3. judge the validity of the final measurement scale.

In the second step, we have estimated a model in which the three scales for inputs, processes and outputs are determined by a single, latent factor: the innovative intensity of the small company. This model is shown in figure 3.

figure 3 factor model



3.2 Questionnaire

One of our basic principles is that a questionnaire to measure the innovative intensity must be universally applicable. Therefore our measurement scale questionnaire does not contain any question items that are sector-specific. For instance, the expenditure for outsourcing R&D is not part of our questionnaire because it is relevant for the industrial sector only.

Initially, we selected 17 indicators for the innovative intensity of a small company: 4 output indicators, 8 process indicators and 5 input indicators. These indicators are discussed in Nagel (1992), Gosselink (1996), van der Valk (1998a) and van der Valk (1998b). See table 1.

table 1 initial indicators for the innovative intensity (variable code in brackets)

factor	indicator
output	introduction of products/ services new for the company in the past three years (OUT1)
	introduction of products/ services new for the sector in the past three years (OUT2)
	introduction of products/ services new for the Netherlands in the past three years (OUT3)
	possession of patents (OUT4)
process	introduction of new/ improved work processes in the past three years (PRO1)
	enduring renewal is a part of the business strategy (PRO2)
	enduring renewal is recorded (for instance in the business plan) (PRO3)
	knowledge management is a part of the business strategy (PRO4)
	use of an external network to exchange information (for instance with universities, suppliers, competitors, etc.) (PRO5)
	co-operation with other companies to develop innovative projects (PRO6)
	measurement of customer satisfaction (PRO7)
	performing or outsourcing market research (PRO8)
input	presence of co-workers being involved in renewal efforts in their daily work (INP1)
	availability of financial means to develop new products/ services (INP2)
	presence of co-workers attending training funded by the company in the past year (INP3)
	use of national or European subsidies in the past three years (INP4)
	possession of a quality certificate (e.g. ISO) (INP5)

Every indicator corresponds to a particular question. The full questionnaire is presented in the appendix of this study. Because one of our objectives is that the questionnaire should be easy for an entrepreneur to complete, all items are dichotomous (yes/no) questions.

It should be mentioned that our questionnaire contained some routings. For instance, item OUT2 (‘Did your company introduce any products or services that are new for the sector in the past three years?’) has a conditional character. The answer will be ‘no’ by default when the answer to item OUT1 (about new products and services) is ‘no’. So this question is asked only when the answer to the previous question is ‘yes’. The same applies to items OUT3 (condition OUT2 is ‘yes’), PRO3 (condition PRO2 is ‘yes’) and INP1 (condition OUT1 or PRO1 is ‘yes’).

3.3 Data collection

The population of our study consisted of all the small companies in the Netherlands, and therefore our measurement scale will be relevant for small companies only. When defining a small company, the number of employees in a company is often used as a guideline. In the Netherlands, a small company is defined as a company with no more than 100 employees[1].

We collected our data through the Small Company Policy Panel. This panel was set up and is controlled by the economic research company EIM. Its major objective is to collect information about the knowledge, attitude and opinion of entrepreneurs about various (government) policy-related issues. The data were collected in October 1999 by means of computer assisted telephone interviewing (CATI). Answers were provided by the entrepreneur or the general manager of the company.

The Small Company Policy Panel consists of a disproportionately stratified sample of 2.042 small companies. This sample covers all sectors of the Dutch economy. The strata are defined by distinguishing nine sectors (construction, financial services, trade & repairs, manufacturing, accommodation & catering, non-profit, other services, rental & real estate, transport & communication) and three company sizes (0-9 employees, 10-49 employees and 50-99 employees). In table 2 we show how the Small companies are distributed in our sample and in the population.

1 This is very different from many other countries, where a small company is defined as a company with a maximum of 250 employees and/or on the basis of the total turnover.

table 2 number of companies in the population* and the Small Company Policy Panel** per sector and company size, 1999

	company size					
	0-9 employees		10-49 employees		50-99 employees	
sector	population	panel	population	panel	population	panel
construction	38.900	108	5.815	72	685	87
financial services	10.945	105	725	81	105	24
trade & repairs	146.579	132	11.015	95	1.075	79
manufacturing	34.300	70	7.726	96	1.455	80
accommodation & catering	35.671	113	1.915	71	125	13
non-profit	178.929	103	8.258	86	1.820	95
other services	20.597	90	630	72	64	4
rental & real estate	82.874	84	4.569	77	606	44
transport & communication	20.595	78	2.850	57	442	26

* Source: Bliss, EIM, 1999.
** Source: Small Company Policy Panel, EIM, 1999.

Because the Small Company Policy Panel is a disproportionately stratified sample we used a weighting factor in our analysis to make our data representative for the Dutch small company population as a whole.

4 Empirical findings

4.1 Step 1: constructing single-dimensional scales

Mokken procedure

Starting with the indicators mentioned in chapter 3, we constructed single-dimensional scales for the innovative input, process and output. For each scale we used several indicators. Literature mentions various procedures to construct a single-dimensional scale from several indicators. The most famous one is the Likert procedure as described by Swanborn (1993). However, this procedure is not very suitable for our purpose. Swanborn mentions that multiple answer categories (i.e. more than 4 categories) are necessary to construct a Likert scale, but our data set consists entirely of dichotomous questions. Therefore, we have used the Mokken procedure which it is designed especially for dichotomous questions to combine our indicators into single-dimensional scales. For a detailed description of the Mokken procedure we refer to Swanborn (1993).

Criteria for construction

In scale construction it is not necessary to maintain all the indicators from our initial questionnaire. We can select those indicators that make the best estimate of the underlying latent concept. When constructing a Mokken scale, the homogeneity coefficient is of major importance. This coefficient – often called the H-value – provides us with information about the extent to which the indicators satisfy the requirements of a Mokken scale.

Swanborn (1993) discusses three kinds of homogeneity coefficients to judge the quality of a Mokken scale:
1. the H-value between indicator I and indicator J
2. the H-value for each indicator
3. the H-value for the entire scale of the underlying latent concept.

Ad 1 The H-value between indicator I and indicator J (H_{IJ})
We computed a H_{IJ}-value for each pair of indicators. According to Swanborn all H_{IJ}-values must be positive. If any H_{IJ}-value is negative, this indicates a violation of the necessary conditions of a Mokken scale. In this case, one or more indicators should be removed.

Ad 2 The H-value for each indicator (H_I)
H_I is computed for every indicator compared to the other indicators in the scale. Actually this is the counterpart of the item-rest correlation when following the Likert procedure. Swanborn mentions that H_I should have a value of at least 0.30. If not, this is a reason to remove the indicator from the scale. Swanborn provides the following rules for interpreting H_I (see table 3):

table 3 rules for interpreting the homogeneity coefficient H_I

contribution to the scale quality	H_I
good	> 0.50
sufficient	0.40 – 0.50
acceptable	0.30 – 0.40
insufficient	< 0.30

Source: Swanborn, 1993.

Ad 3 The H-value for the entire scale (H)
Finally, we can compute a homogeneity coefficient for the entire scale. This H-value can be considered as a measure for the internal consistency of the scale. It evaluates the model fit: the amount in which the indicators are related to a single underlying concept[1]. Swanborn gives the same rules for interpretation as mentioned in table 3.

Output

Our initial scale for the innovative output consisted of four indicators. First, we computed the homogeneity coefficient for every pair of indicators (H_{IJ}). In table 4 we present the results.

table 4 homogeneity coefficient H_{IJ} for each pair of indicators in the output scale

		I		
		OUT1	OUT2	OUT3
	OUT2	1.00		
J	OUT3	1.00	1.00	
	OUT4	0.73	0.56	0.59

1 Actually, this is the counterpart of the internal consistency measure Cronbach's Alpha if the Likert procedure is followed.

Because every H_{IJ}-value was positive there was no need to remove any indicators from this scale. We could proceed immediately with the computation of the homogeneity coefficients H_I (for each indicator) and H (for the scale as a whole). In table 5 we show the results.

table 5 homogeneity coefficients H_I and H for the output scale

H_I	value
OUT1	0.97
OUT2	0.94
OUT3	0.93
OUT4	0.61
general H	0.90

From table 5 we concluded that there was no need to remove any indicators. It is allowed to combine the indicators OUT1, OUT2, OUT3 and OUT4 (about introducing products and services new to the company, sector and Dutch economy, and the possession of patents) into a single-dimensional scale for the innovative output of a small company. The H-value of 0.90 indicates a very high internal consistency of these items.

Process

Our scale for the innovative processes of a small company initially consisted of eight indicators. Again we computed the homogeneity coefficient for every pair of indicators (H_{IJ}). In table 6 we show the results.

table 6 homogeneity coefficient H_{IJ} for each pair of indicators in the process scale

		I						
		PRO1	PRO2	PRO3	PRO4	PRO5	PRO6	PRO7
	PRO2	0.36						
	PRO3	0.44	1.00					
	PRO4	0.25	0.20	0.50				
J	PRO5	0.26	0.34	0.52	0.31			
	PRO6	0.28	0.34	0.40	0.30	0.35		
	PRO7	0.24	0.27	0.26	0.24	0.24	0.24	
	PRO8	0.49	0.51	0.35	0.27	0.33	0.32	0.28

All homogeneity coefficients were positive so there was no need to remove indicators at this stage. We proceeded immediately with the computation of the homogeneity coefficients H_I and H. In table 7 we show the results.

table 7 homogeneity coefficients H_I and H for the process scale based on eight indicators

H_I	value
PRO1	0.31
PRO2	0.38
PRO3	0.46
PRO4	0.29
PRO5	0.33
PRO6	0.32
PRO7	0.25
PRO8	0.35
general H	0.34

It appeared that the homogeneity coefficients of the indicators PRO4 (about knowledge management being part of the business strategy) and PRO7 (about investigating customer satisfaction) did not satisfy the critical value of 0.30. Swanborn (1993) recommends that these indicators should be removed. In table 8 we computed the homogeneity coefficients for the remaining indicators[1].

table 8 homogeneity coefficients H_I and H for the process scale based on six indicators

H_I	value
PRO1	0.34
PRO2	0.46
PRO3	0.52
PRO5	0.36
PRO6	0.34
PRO8	0.38
general H	0.40

In table 8 the H-value of 0.40 indicates an acceptable internal consistency of the process indicators. Besides, each indicator meets the critical value of 0.30. We were able to combine the indicators PRO1, PRO2, PRO3, PRO5, PRO6 and PRO8 (about introducing new or improved work processes, enduring renewal being part of the business strategy, renewal ambitions being recorded, the use of an external network, co-operating with other companies to develop innovative projects, and performing or outsourcing market research activities) into a single-dimensional scale for the innovative processes of a small company.

1 Removing PRO4 and PRO7 one by one gives the same result.

Input

Our initial scale for the innovative input of a small company consisted of five indicators. The homogeneity coefficient for each pair of indicators is presented in table 9.

table 9 homogeneity coefficient H_{IJ} for each pair of indicators in the input scale

		I			
		INP1	INP2	INP3	INP4
	INP2	0.13			
J	INP3	0.80	0.17		
	INP4	0.37	-0.11	0.31	
	INP5	0.50	0.14	0.53	0.16

It appeared that the homogeneity coefficient between INP2 and INP4 was negative. According to Swanborn (1993) this is a reason to remove one or several indicators from the scale. We chose to remove INP2 (about the possession of financial means to develop and introduce new products) because its H_{IJ}'s with the other indicators were quite low as well ($H_{23} = 0.17$ and $H_{25} = 0.14$).

After removing INP2 we computed the homogeneity coefficients H_I and H. In table 7 we show the results[1].

table 10 homogeneity coefficients H_I and H for the input scale based on four indicators

H_I	value
INP1	0.66
INP3	0.62
INP4	0.23
INP5	0.32
general H	0.46

Now it appeared that the homogeneity coefficient of INP4 (about the use of subsidies) did not satisfy the critical value of 0.30. After removing this one we were able to compute the homogeneity coefficients for the remaining indicators. See table 11.

1 The homogeneity coefficients H_{IJ} of the remaining indicators have the same value by default, so there is no need to compute these again.

table 11 homogeneity coefficients H_I and H for the input scale based on three indicators

H_I	value
INP1	0.72
INP3	0.71
INP5	0.52
general H	0.67

The H-value of 0.67 indicated a good internal consistency of the remaining input indicators. Besides, each single indicator met the critical value of 0.30. We were able to combine the indicators INP1, INP3 and INP5 (about the presence of co-workers being involved in renewal efforts in their daily work, the presence of co-workers that attended an education or training funded by the company, and the possession of a quality certificate) into a single-dimensional scale for the innovative input of a small company.

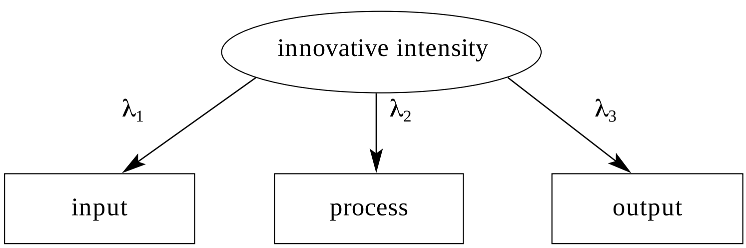
4.2 Step 2: confirmatory factor analysis

Factor model estimated with LISREL

In the previous step we constructed single-dimensional scales for the innovative input, process and output. For each scale we can compute a score by simply adding up the number of positive answers per respondent. For instance, a company can have a maximum score of 4 and a minimum of 0 for the innovative output.

In this section we shall check whether the scores on these scales (input, process and output) can be combined into a single score for the innovative intensity. We shall test a confirmatory factor model in which the scores on the input, process and output scales are determined by a single, overall factor: the innovative intensity of the small company. This model is shown in figure 4.

figure 4 factor model



We tested this model by estimating the effect parameters λ (factor loadings) between the innovative intensity and the input, process and output scales. We used the LISREL computer program (Jöreskog and Sörbom, 1996a) to make the estimation, because this program enabled us to deal with the latent status of the innovative intensity factor and measurement errors simultaneously.

Judging the model's quality

It is important to recognise that the indicators in our model (scale scores) are measured on an ordinal level. It is incorrect to analyse ordinal variables as though they are metric. According to Jöreskog and Sörbom this will generate wrong estimates of the factor loadings in our model. They mention that it is more suitable to compute a polychoric correlation matrix and to estimate the factor loadings with the Weighted Least Squares procedure (WLS). For this purpose the asymptotic covariance matrix of the polychoric correlations must be computed as well. For a detailed description of the WLS-procedure we refer to Jöreskog and Sörbom (1996a).

First, to estimate our model we computed the polychoric correlation matrix and its asymptotic covariance matrix. For this purpose we used the PRELIS program of Jöreskog and Sörbom (1996b). Next, we estimated our model using the LISREL program.

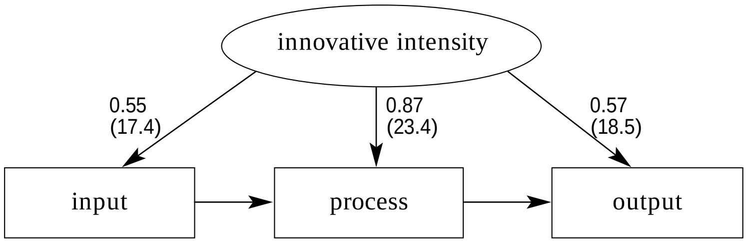
In the LISREL program's output a number of items are important. Verschuren (1991) discusses several ways to judge the quality of an estimation. In this study we shall use the significance of the factor loadings (λ's). Ideally, we want every factor loading to be statistically significant. In this case it is likely that every scale (input, process, output) will make a significant contribution to the innovative intensity. The LISREL program estimates a t-value for each factor loading. Absolute t-values below the usual critical value of 1.96[1] are treated as not significant and can be removed from our model[2].

Estimation results

In figure 5 we show the WLS-estimates of the factor loadings with their t-values placed in brackets. These parameters are taken from LISREL's completely standardised solution in which all indicators and factors have unit variance.

1 Belonging to a confidence level of 95%.
2 Verschuren discusses the use of goodness-of-fit-statistics as well. With these statistics one can judge the fit of a LISREL model as a whole. Because our model is 'saturated' (no degree of freedom) the use of goodness-of-fit-statistics is no option because a saturated model has a perfect fit by default. We refer to Verschuren (1991) for a detailed discussion on this subject.

figure 5 WLS-estimates of the factor loadings (t-values placed in brackets)



It appears that each scale (input, process, output) is influenced significantly by the latent factor innovative intensity. The t-values indicate that every factor loading is highly significant at a confidence level of 95 percent. We conclude that the correlation between the scales is good enough to combine them into a single score for the innovative intensity.

4.3 Step 3: assessment of scale validity

Introduction

In this section we shall look at the validity of our measurement scale. Validity is the extent to which a scale actually measures what it is intended to do. There are numerous ways to assess a scale's validity (Pelsmacker and Kenhove, 1997).

We should mention that the best way to assess validity is by investigating a scale's construct validity (Bagozzi, 1980). Unfortunately, we had no proper data for this purpose but to obtain an initial insight we looked at two other kinds of validity (Pelsmacker and Kenhove, 1997):

1. content validity
2. criterion validity.

Ad 1 Content validity

Content validity is about the extent to which the indicators of a scale cover all dimensions of the underlying concept one is trying to measure. Suppose that we want to develop a measurement scale for 'work variation'. In a literature review we find that work variation is about two things: the variety of one's tasks and the challenge in those tasks. We should take both dimensions into account in the measurement scale.

In practice there is no hard measure to assess the content validity of a scale. The best way to deal with it is to have a thorough look at the most recent literature when formulating the question items. This increases the probability that all underlying dimensions will be dealt with.

In our study, we used the transformation model as a basis for our measurement scale. This model is often used to describe the innovation process at micro level. Furthermore, we based our question items on a number of studies in which a comprehensive literature search was performed. This increased the probability that the content validity is sufficient. On other hand, because we wanted our measurement scale to be universally applicable, we did not use any question items that were sector-specific. This could decrease the content validity of our measurement scale when doing research in particular sectors. Future research should give a decisive answer to this.

Ad 2 Criterion validity

Criterion validity is about the relationship with an external criterion that logically should be related to the concept one is trying to measure. Assume: we have developed a measurement scale for work variation. Literature states that the degree of work variation is related to the amount of absenteeism due to illness. Therefore, we should find a negative correlation between the degree of work variation and the amount of sick leave for our measurement scale to be valid.

The Small Company Policy Panel database contains one question that is suitable as a criterion for assessing the validity of our measurement scale. This is a simple dichotomous question about the export status of the company. The exact question text is ‘Does your company export?’ with ‘yes’ and ‘no’ as answer categories.

The export status of a small company should show a positive correlation with the innovative intensity. One may expect exporting companies to be more innovative than companies operating solely on national markets, because those who export are likely to gather more information. Felder e.a. (1996) found a significant relationship between exporting companies and innovation intensities. Lotti and Santarelli (1999), however, point out that the causality could also be the other way around: companies are more likely to export as an outcome of innovative activities.

Although the causality is not clear this is no problem for our purpose, because we are interested only in the correlation between the two concepts. To evaluate the criterion validity we computed the correlation coefficient R between both concepts. The p-value of this coefficient should be lower than the usual critical value of 0.05[1] indicating a significant relationship between the innovative intensity and export status of a small company. It appeared that the correlation coefficient R had a positive value of 0.22 and was highly significant (p-value = 0.000). So, if we use the export status as a criterion our measurement scale for the innovative intensity seems valid.

Of course, when assessing a scale's validity one should consider various external criteria. We may not conclude that our measurement scale is valid because of its positive correlation with the export status only. In future research the relationship with other criteria (such as profit and sales growth) should be investigated to make the validity of our measurement scale more plausible.

1 Belonging to a confidence level of 95%.

5 Conclusions, limitations and future research

5.1 Conclusions

The objective of this research report was to develop and validate a measurement scale for the innovative intensity of a small company. This measurement scale should be usable for all small companies and in all sectors of the economy.

We used empirical research to develop this measurement scale. Its population consisted of all small companies in the Netherlands and we collected our data from the Small Company Policy Panel of EIM. The questionnaire consisted of 17 dichotomous questions; which were answered by the entrepreneur or the general manager of the company.

We used the transformation model as described by Buijs (1987) as a basis for our measurement scale. This model considers the development of an innovation as an unstructured process, in which innovative inputs are transformed into innovative outputs (figure 6).

figure 6 transformation model

A three-step procedure was used to construct the measurement scale. First, we constructed single-dimensional scales for the innovative inputs, processes and outputs by following the Mokken procedure (Swanborn, 1993). Second, we performed a confirmatory factor analysis to check whether these scales may be combined into a single score for the innovative intensity of a small company. Third, we investigated the validity of the final measurement scale.

It was found that the innovative intensity can be measured with a set of 13 dichotomous questions. This measurement scale can be used by policy makers and research companies to measure the innovative intensity of small companies. Four of its questions are related to innovative outputs, six to innovative processes and three to innovative inputs.

Output

- Did your company introduce any new products or services to the market in the past three years?
- Did your company introduce any products or services that are new for the sector in the past three years?
- Did your company introduce any products or services that are new for the Netherlands in the past three years?
- Does your company possess any patents?

Process

- Did your company introduce any new or improved work processes in the past three years?
- Is enduring renewal part of your business strategy?
- Is this ambition recorded in some way (e.g. in your business plan)?
- Does your company use an external network to exchange information (e.g. with universities, suppliers, competitors, etc.)?
- Do you cooperate with other companies to develop innovative projects?
- Did your company perform or outsource any market research activities in the past three years?

Input

- Does your company have any co-workers involved in renewal efforts in their daily work?
- Does your company have any co-workers who attended education or training funded by the company in the past year?
- Does your company possess a quality certificate (like ISO)?

An indication of the innovative intensity can be obtained by looking at the number of positive responses on these questions.

5.2 Limitations and future research

Validity

When assessing validity one should examine various external criteria. In chapter 4 we assessed our measurement scale's validity by looking at its relationship with the export status only. Although we found a significant positive relationship this is not definite proof. Future researchers should also look at the correlation with other relevant criteria (such as profit and sales growth) to make the validity more plausible.

Sector-specific questions

One of our basic principles was that the questionnaire should be universally applicable. It does not contain any questions that are sector-specific. This decreases the content validity of our measurement scale (dealing with all dimensions of the underlying concept) when one attempts to describe the innovative intensity of a specific sector. When doing research in particular sectors one should account for sector-specific indicators of the innovative intensity as well. For instance, the expenditures on outsourcing R&D could be part of a measurement scale that is designed for the industrial sector only. Future research should give an answer to the necessity of specific question items for particular sectors.

Transformation model

In this research report we used the transformation model as a basis for our measurement scale. Compared to other models to describe the innovation process, the transformation model has the advantage that the development of an innovation is considered a black box. This matches with the actual situation in many small companies. However, as a consequence there is little focus on the work processes themselves. Our measurement scale does not give an entrepreneur many opportunities to improve the innovative intensity in his own company. It is a challenge to find the determinants of successful innovation in future research.

Literature

Bagozzi, R.P. (1980), *Causal models in marketing*, New York: John Wiley & Sons.

Banbury, C.M., and W. Mitchell (1995), 'The effect of introducing important incremental innovations on market share and business survival', *Strategic Management Journal*, vol. 16, special issue.

Booz, Allen and Hamilton (1968), *Management of new products*, New York: Booz, Allen & Hamilton.

Buijs, J.A. (1987), *Innovatie en interventie*, Deventer.

Buijs, J.A. (1988), 'Innovatie, een bijzonder verschijnsel', M&O, *Tijdschrift voor Organisatiekunde en Sociaal Beleid*, vol. 42, no. 4, pp. 209-233.

Churchill, G.A. (1979), 'A paradigm for developing better measures of marketing constructs', *Journal of Marketing Research* 16, 64-73.

Cooper, R.G. (1990), 'Stage-gate systems: a new tool for managing new products', *Business Horizons*, May/June.

Cozijnsen, A.J., and W.J. Vrakking (1992), *Organisatiediagnose en organisatieverandering*, Alphen aan den Rijn.

De Pelsmacker, P., and P. van Kenhove (1994), *Marktonderzoek: methoden en toepassingen*, Garant: Leuven/Apeldoorn.

Felder, J., et al. (1996), 'Factors determining R&D and innovation expenditure in German manufucturing industries', in: Kleinknecht, A. (1996), *Determinants of innovation, the message from new indicators*, London: Macmillan Press Ltd, pp. 125-155.

Geroski, P. (1995), 'Innovation and competitive advantage', *Economics Department Paper* no. 159, Paris: Organisation for Economic Co-operation and Development.

Gosselink, F.J. (1996), 'Innovatiemanagement, een beschouwing over innovatieve slagkracht in bedrijven', in: Krosse, H.A.J., J. Paauwe and A.R.T. Williams (1996), *Shared Frontiers of Learning*, Delft: Eburon.

Jöreskog, K., and D. Sörbom (1996a), *LISREL8: user's reference guide*, Scientific Software International: Chicago.

Jöreskog, K., and D. Sörbom (1996b), *PRELIS2: user's reference guide*, Scientific Software International: Chicago.

Lotti, F., and E. Santarelli (1999) 'R&D, embodied technological change, producers-users interaction, and productivity at the firm-level: a Germany-Italy comparison', in: TSER work-shop (1999), *Innovation and Economic Change: exploring CIS micro data*, Delft.

Ministerie van Economische Zaken (2000), *Toets op het concurrentie-vermogen 2000, op de drempel van het nieuwe millennium*, Den Haag: SDU.

Nagel, A.P. (1992), *Verhogen van het strategisch productinnovatiever-mogen*, Eindhoven.

Soni, P.K., G.L. Lilien and D.T. Wilson (1993), 'Industrial Innovation and Firm Performance: a Reconceptualization and Exploratory Structural Equation Analyses', *International Journal of Research in Marketing*, vol. 10, no. 4, pp. 365-380.

Swanborn, P.G. (1993), *Schaaltechnieken: theorie en praktijk van acht eenvoudige procedures*, Amsterdam: Boom.

Schumpeter, J. (1926), *Theorie der Wirtschaftlichen Entwicklung*, zweite neubearbeitete Auflage. München: Ducker & Humboldt.

Timmerman, H. (1985), *Bedrijf, kennis en innovatie*, Amsterdam.

Van Dale (1992), *Groot Woordenboek der Nederlandse Taal*, Utrecht.

Van der Valk, W.D.M. (1998a), *De innovativiteit van de Nederlandse industrie: editie 1998*, Zoetermeer: EIM.

Van der Valk, W.D.M. (1998b), *Speurtocht naar maatstaven voor innovatie-intensiteit*, Zoetermeer: EIM.

Verschuren, P.J.M. (1991), *Structurele Modellen tussen theorie en praktijk*, Spectrum: Utrecht.

Vrakking, W.J., and A.J. Cozijnsen (1992), *Managementtechnieken bij effectief innoveren*, Deventer.

Wolfe, R.A. (1994), 'Organizational innovation review: critique and suggested research directions', *Journal of Management Studies*, vol. 31, no. 3.

Appendix: Questionnaire

answers: no = 0 points, yes = 1 point

variable	routing	question item
OUT1		Did your company introduce any new products or services to the market in the past three years?
OUT2	OUT1 = yes	Did your company introduce any products or services that are new for the sector in the past three years?
OUT3	OUT2 = yes	Did your company introduce any products or services that are new for the Netherlands in the past three years?
OUT4		Does your company possess any patents?
PRO1		Did your company introduce any new or improved work processes in the past three years?
PRO2		Is enduring renewal part of your business strategy?
PRO3	PRO2 = yes	Is this ambition recorded in some way (e.g. in your business plan)?
PRO4		Is the management of knowlegde part of your business strategy?
PRO5		Does your company use an external network to exchange information (e.g. with universities, suppliers, competitors, etc)?
PRO6		Do you cooperate with other companies to develop innovative projects?
PRO7		Does your company investigate customer satisfaction systematically?
PRO8		Did your company perform or outsource any market research activities in the past three years?
INP1	OUT1 or PRO1 = yes	Does your company have any co-workers involved in renewal efforts in their daily work?
INP2		Does your company have enough financial means to develop and introduce new products or services?
INP3		Does your company have any co-workers who attended education or training funded by the company in the past year?
INP4		Did your company use any national or European subsidies in the past three years?
INP5		Does your company possess a quality certificate (e.g. ISO)?

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