*A classification model for firm growth on the basis of ambitions, external potential and resources by means of decision tree induction**

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ABSTRACT

The model that was presented by Ahlström (1998) is a simple basic growth model in which three pillars of firm growth are identified, namely growth competence and resources, growth potential and growth ambitions. In this article, this model will be empirically tested using quantitative data from annual reports of a sample of Belgian SMEs as well as qualitative data from a mail survey. The model is empirically tested by means of a datamining technique, namely decision tree induction.

In our empirical model, the three pillars of Ahlström's model are present. The goodness-of-fit measures clearly indicate that the model is good. Validations of the model for other time periods show that the model can be considered as stable over time. All hypotheses of the Alhström model are confirmed in the expected direction with a high hit ratio of 77.7%. Profitability and solvency (which were used to measure the resources and competence factor) turned out to be the most important growth related variables. The relationship between profitability and firm growth is positive, while solvency seemed to be negatively related to growth. The relationship between (perceived) growth potential (measured by a benign environment factor) and firm growth turns out to be positive. Growth ambitions are also positively related to firm growth. If the average profitability (measured over a period of 6 years) is above a certain percentage, firms are classified as strongly growing firms. If the average profitability is below this percentage, firms with the right conditions for resources and competence as well as for potential are classified as weakly growing firms when the growth ambitions are low and as strongly growing firms when the growth ambitions are high.

Key words: company growth , growth enablers, growth disablers, decision tree induction, pecking order theorem

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1. Introduction

A lot of economic research has gone into the identification of factors that are related to firm growth. According to Crijns and Ooghe (1997), firm growth is often considered as the most important measure for performance in literature. Firm growth can be considered as the consequence of a number of factors. A lot of authors have presented growth models in which a number of these growth enablers and growth disablers are incorporated.

The model that was presented by Ahlström (1998) is a simple basic model in which three pillars of firm growth are identified, namely growth competence and resources, growth potential and growth ambitions. In this article, this model will be empirically tested by means of a datamining technique, namely decision tree induction.

This article will start with a literature review concerning growth factors. After a discussion of the growth model of Ahlström (1998) and some comparisons to other publications in this field, we will present an overview of literature concerning each of the three pillars of this model (namely growth competences and resources, growth potential and growth ambitions). In the following sections of the paper the research sample, the research method (i.e. decision tree induction) and the variables that are used to test the model will be discussed. Next, the empirical results of the model, the goodness-of-fit and a discussion of the content of the model are presented. A conclusion and a number of policy implications is added at the end of this paper.

2. Literature Review

2.1. Growth factors and the Ahlström growth model

Firm growth is generally accepted as one of the most important measures of firm performance. A lot of researchers have tried to identify factors that are related to growth. As such, a lot of growth models have been presented in numerous articles. The objective of these growth models is to structure the way factors are related to growth. Bogaert et al (1999) state that these growth models often include motives, enablers, disablers and consequences of growth.

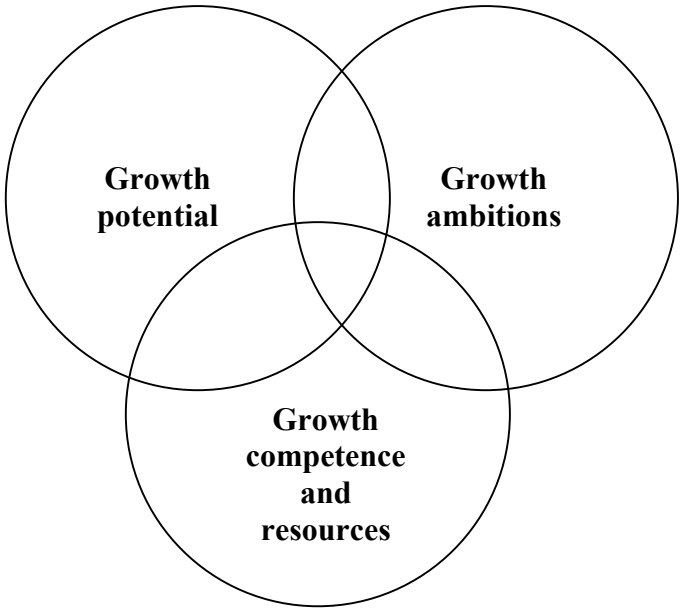
The relationship between the size of the company and growth is examined frequently by other authors. Assuming that there exist determinants of growth essentially means that one refutes the stochastic growth process of Gibrat's Law. According to this hypothesis, the growth rate or the proportionate growth of firms is independent of the current size of the firm. Numerous studies have been able to refute this law by detecting a negative growth/size relationship (Evans, 1987; Wagner, 1992; Variyam & Kraybill;1992; Hart & Oulton, 1996; Becchetti, 2002; Correa, 2003). This controversy has lasted until today.

Drivers of growth are frequently related to personnel factors, CEO-characteristics (experience, gender, education) (Sexton et al., 1997; Birley and Westhead, 1990), research and development (McCann, 1991), governmental incentives (Bergström, 2000; Koevoets, 2000; Elias et al., 2000), firm location (peripheralty) (Copus, 2001), demography (Venne, 2001). Klette and Griliches (2000) presented a fully specified theoretical model of endogenous growth with R&D and innovations being the engines of growth.

Different financial factors have been stressed as being key determinants for the growth process of businesses such as profitability (Penrose, 1959; Marris, 1964), productivity (Giannakas et al., 2000; Seurat, 1999), cash flow (Carpenter-Petersen, 1998), capital structure and solvency (Durinck et al., 1997; Becchetti, 2002a). Another factor is availability of financial resources for SME's (the so-called financial gap) and the way companies are financing their growth. According to the Pecking Order Theory, firms finance their needs hierarchically. They first use internally generated funds, then debt financing and finally external equity financing. Direct empirical testing of the Pecking Order Theory is limited and inconclusive. Some studies support the Pecking Order Theory (Watson and Wilson, 1998, Jordan et al., 1998); other studies reject it (Klein and Belt, 1994). Moreover their exists some evidence of a reluctance of small firms to move down the Pecking Order (Gowling et al., 1991). This phenomenon is attributed to the fear of losing control (Binks, 1991, Cosh and Hughes, 1994). The financing order of a lot of small firms thus resembles a truncated Pecking Order rather than the Order described by Myers (1984). Since the attitude towards external equity financing in small firms is frequently a personal one, changes in conditions of supply will not affect the willingness to move down the Pecking Order (Howorth, 2001). This way the individual preferences or demand for finance may be a more powerful constraint on the growth of small firms than the supply of finance (Kotey, 1999). Howorth (2001) indeed found evidence of a truncation of the Pecking Order at the point of long-term debt for some firms and at the point of external equity financing for some other firms.

In this article, one of these growth models, namely the model presented by Ahlström (1998), will be empirically tested. According to Ahlström (1998) a firm can only grow if it has growth potential, growth ambitions and growth competences and resources. He describes the model as in figure 1.

Figure 1
The growth model of Ahlström (1998)



From a theoretical point of view based on this model, a firm can only obtain growth if it is situated in the intersection of the three circles. Here, the firm has enough growth potential, growth ambitions and growth competence and resources to obtain growth. Firms in other positions in the model than the intersection of the three circles have to improve their position by working on the missing factor. In this way, different strategies are in order, depending on which essential pillars are missing. The three factors of this model are interdependent: they do not only influence growth in a separate way, but they can also have an effect on each other. The factors that are presented in this model can also be found in the model of Chandler and Hanks (1994). According to these authors, venture performance is linked to resource-based capabilities, strategy and opportunity. The internal and the external environment influence each of these factors. Willem et al (1997a) present a growth model in which resources, external factors and organizational and strategic factors have an impact on the growth potential of a firm. This growth must then be activated by means of managerial or entrepreneurial skills leading to growth and successful performance. So managers must utilize resources, determine optimal organization and strategy and use the external opportunities. Although the growth model presented above is quite straightforward, the difficulty lies in measuring the three growth-inducing factors and Ahlström (1998) himself does not provide clear definitions of each of the factors. In the following paragraphs, each factor will be looked at in some more detail.

2.2. Growth Competence and Resources

Ahlström (1998) claims that a firm needs resources and competences to be able to make use of the existing growth potential. A lot of authors wrote about the importance of competence and resources for firm growth. As such, Brown and Kirchhoff (1997) claim that lack of access to or availability of resources can be seen as perhaps the most important constraint of growth and survival. Chandler and Hanks (1994) state that resource-based capabilities organizations have at their disposal allow them to take advantage of recognized opportunities. When resource-based capabilities are abundant, firms survive easily, grow more rapidly, are more profitable and have more organization slack. The resource-based perspective of firm growth, which focuses on the internal strengths of the firm, stems from the seminal work of Penrose (1959). Penrose argues that the relationship between

performance and growth has to do with management's desire to maximize firm profits. The profits (remaining after payment of dividends to the owners and salaries to the managers) are reinvested into the firm, which allows the firm to obtain additional resources and growth. Growth, Penrose argues, thus originates from the expansion of assets controlled by the firm. The growth rate of the firm is then limited to the rate at which the firm can obtain enough managerial capacity to manage these new assets, often referred to as the 'Penrose effect' (Marris, 1964).

Another important variable in the context of resources and competences, according to the pecking-order theory (Myers 1984), is solvency. In former research of the authors (Limère et al, 2001) this variable appeared to be very significant in logit and discriminant analysis discriminating between fast and weak growing companies. Other Belgian research (Durinck et al., 1997) has shown the financing hierarchy of Belgian companies to be in line with the one proposed by the Pecking Order Theory. Based on Belgian company accounts of 370 SMEs generating growth levels exceeding sustainable growth, Durinck et al. (1997) showed that the faster the growth, the less firms used retained earnings and the more firms used external financing. The amount of external equity financing however did not show a significant increase. Certain truncation effects are thus at work certainly for small and medium sized firms. Also Voordeckers (1999) found faster growing small firms to substitute self-financing with supplier credits and subsequently long term loans.

2.3 Growth Ambitions

Ahlström (1998) claims that it might be difficult to introduce growth in a firm if the ambitions for growth do not exist. Also, Simon (1996) identifies ambitious goals as one of the critical success factors of multinationals. According to Ahlström (1998), a lot of firm owners (especially SME's) lack growth ambitions.

Hay and Kamshad (1994) investigated the managerial objectives and ambitions of approximately 400 SME's in the UK. The authors make a difference between companies striving at profit maximalisation and companies striving at sales growth. These companies thus make a trade-off between profitability and growth, as investing in future growth usually requires forgoing some of the current period's profits. According to Hay and Kamshad (1994), there are companies that are not keen to grow their business. One possible reason is that the decision-maker (mostly the owner in this case) does not want to change the ownership structure of his firm because he does not want shareholders interfering in his decision-making. Other respondents that do not strive at growth would like to maintain control on every key decision that is being made at every level of the firm. Naturally, this is only possible when the firm size stays rather small.

Hay and Kamshad (1994) also indicate possible reasons for CEO's to strive at growth. A difference is made between "empire builders" and "value builders". Companies in this last group would like to grow only to increase viability and long-term value, which they hope to realize by eventually selling off the firm. Empire builders on the other hand, would like to grow and build a business that they would continue to direct. These companies value growth highly and are willing to exchange some degree of dilution of control in exchange for further growth.

2.4. Growth Potential

Growth potential will be used here to incorporate the external potential for growth of a firm, the environment, in the growth model. All possible external factors that may influence a company's success are presented in the model of Porter (1985). The effect of the environment on firm growth is examined in a lot of articles. As such, Covin and Slevin (1989) state that external environmental factors may have a strong impact on firm viability and performance. Also, Simon (1996) states that external opportunities form one group of

success factors for multinationals. Basically, there are two ways of incorporating environmental effects, namely by measuring the objective environment on the one hand and by measuring the subjective environment on the other hand.

Objective environment deals with objective measures of the intensity of competition and uncertainty in a market. A lot of measures are used to account for the objective environment. Crijns and Ooghe (1997) state that the most used variables to measure the impact of environment on firm growth are: market segment, number of clients, proportion of export activities, knowledge of competitors and characteristics of the environment (infrastructure, labor market, …). Roure and Keeley (1990), in their search for factors that influence success in new technology based ventures, investigate the impact of the level of competition, the projected market share and the level of buyer concentration. The structure of the industry, according to Sandberg and Hofer (1987) can be measured by its stage of evolution, presence or absence of disequilibria and its barriers to entry.

On the other hand, subjective measures of the environment deal with the perception of the entrepreneurs of the environment. According to Brown and Kirchhoff (1997), subjective environment is more important than objective environment, as a manager can only know his or her environment via his or her perception. For this reason and for the reason of lacking data about objective environment, in this article only measures for subjective environment will be used. Chandler and Hanks (1994) also measure the impact of environment on firm performance by means of subjective measures.

One of the most cited concepts related to subjective environment is environment hostility. According to Khandwalla (1977), a hostile environment is one that is risky, stressful and dominating. The opposite of a hostile environment is a benign environment, which is safe, rich in profitable opportunities and manipulable or controllable by the organization. According to Covin and Slevin (1989), environment hostility, by definition, serves as a threat to firm viability and performance. Reasons for perceived environment hostility could be severe price competition, stringent budgets, governmental actions and community acceptance (Khandwalla, 1977). Khandwalla (1977) claims that if the organization experiences hostility on a number of important fronts, it will tend to regard the environment as quite hostile. The concept of hostility should be considered as a variable that ranges all the way from hostile to benign. Many organizations operate in a neither hostile nor benign environment, but rather in a moderately hostile environment.

3. Research sample

3.1. Dataset

The data used in this article are a combination of quantitative financial statement data and qualitative data from a large-scale survey in April 2001. The quantitative data originate from a huge dataset of 21.640 Flemish companies that met the following criteria:

- they survived the whole of the period 1993-1999
- they didn't change their legal status within this period
- from 1996 on they published their social balance sheet
- their published financial statements (accounting closing date: 31 December of each year) were available for the full 7 years.

This dataset includes about 18 percent of all incorporated Flemish companies (1997) and proved to be representative for the whole population of Flemish companies in terms of size, economic activities and location. A constant sample approach is required to be able to measure and quantify growth over time. The qualitative data were gathered through an extensive survey. This survey contains 48 questions structured along seven themes: general characteristics of the firm, features of the CEO, ownership, external contacts, environment, financial resources, planning and control. This article is focused on a number of characteristics of the firm (growth competence and resources), growth ambitions and the

environment of the firm (growth potential). Companies were selected with an employment of at least 5 full-time equivalent employees in 1998, because the authors are convinced that only firms with a minimum scale would have the possibilities and incentives to respond to the rather extensive questionnaire. 8367 companies of the original dataset met these requirements and were sent a survey. The mailing was addressed to the President of the firm, the CEO or the Financial Director. 840 filled-out questionnaires were valid for research.

3.2. Representativeness and non-response bias

The hundred earliest and hundred latest respondents were compared with respect to their answers to the questionnaire. Chi square tests, t-tests and Mann-Withney tests revealed no statistically significant differences between the early and late respondents.

Further chi square analyses were conducted to detect bias between the respondents (839 firms) and non-respondents (7444 firms) with regard to employment and asset size of the company, sector, location of the business and growth performance.

Employment and asset size was found to be significantly (< 1%) larger for the respondents compared to the non-respondents. With respect to the scale of companies our sample thus demonstrates an under-representation of small companies and an over-representation of large companies (sign. < 1%) compared to the non-respondents. In our opinion this kind of bias is inevitable in survey research.

Almost all economic activities are included in the sample. In our sample (839 firms) the services sector is however rather underrepresented and the production sector rather over-represented compared to the 7444 non-responding firms (sign. > 1%). Something is of course explained by the restriction of the sample to a minimum employment of 5 full-time equivalents. The distribution over the provinces of the identifiable respondents and the non-respondents is quite similar. No significant differences are found.

4. Research Method: Decision Tree Induction

The purpose of a decision tree is to classify cases for a dependent variable on the basis of a set of rules for the independent variables. In this paragraph, the decision tree induction technique will be explained briefly. For more information on the technique, the authors refer to numerous specialized articles and books (amongst many others: Witten and Frank (2000) and Berry and Linoff (1997)).

A decision tree is built by means of recursive partitioning. This means that the sample is split up in different subsamples and these subsamples are further split up etc. The technique uses two sets of data, namely a training set and a test set. A decision tree is built on the basis of the training set and is tested by means of the test set. In each stage of the building of the decision tree, the algorithm behind the technique will choose the best splitter, which is the variable that splits up best the data in subsamples where one certain class of cases dominates. To determine which is the best splitter, the c4.5 algorithm (Quinlan, 1993) will try every possible split of each variable. For each subsample, the best splitter will then be specified. This process proceeds until further splitting up would not cause a significant improvement of the model.

After the decision tree is built, it will be pruned to avoid over fitting. The algorithm splits up the data set in subsets that will be smaller and smaller and the final subsets will be no longer representative for the population. As such, the model will incorporate structures that are found in the data set on which the model is estimated, but that are not representative for the population. To prevent this from happening, the tree will be pruned, which means that branches of the tree will be deleted. The test set is then used to find the best tree.

The main advantage of data mining techniques when compared to the more classical data analysis techniques (as for example regressions) is that there are no assumptions for the underlying distribution of the data. The advantage of decision tree induction to other data mining techniques is that it clearly shows which rules (and thus which variables) are used to classify the cases. As such, the importance of all variables in the classification of the cases can clearly be identified.

5. Identifying variables and formulation of hypotheses

5.1. Dependent variable: Firm growth

The purpose of this paper is to find factors that are related to the growth of firms. Growth can be seen as a very important measure of firm performance. In this paper the identification of growth-related factors will be done by seeking classification rules in order to discriminate between strongly and weakly growing firms.

In this paper, growth is measured by the average growth rate of total assets over the period 1993-1999[4]. The use of growth rate of total assets as a measure for firm growth has already been used in a lot of Belgian research (a.o. Limère et al, 2001 and Ooghe, Verbaere & Croucke, 1988). The authors prefer using the average growth over a number of years to using only the growth percentage of one year because growth percentage can fluctuate strongly from one year to another.

The Flemish companies in the original quantitative data set of 8369 companies were ranked in increasing order of their arithmetic averages in total assets growth and were classified as strongly growing or weakly growing firms when their average total asset growth was located in the 25 percent strongest respectively 25 percent weakest growing firms. In this manner, 181 of the 840 companies that responded to the survey were classified as weakly growing firm and 217 were classified as strongly growing firm. The larger database was used to accord values for this binary growth variable to the firms that responded to the survey in order to make this variable representative for the population, as the larger database was more representative for the population.

The authors are convinced that the use of quartile values for defining a binary growth variable will accentuate the difference between strongly and weakly growing firms. After all, differentiation between these two groups with extreme growth numbers will be high, which makes it easier to identify variables that discriminate between these two groups of firms.[5]

5.2. Independent varables

5.2.1. Growth competence and resources

To measure growth competence and resources, two variables will be used, namely profitability and solvency. Both of these quantitative variables will be taken directly from the quantitative data set that is provided by the National Bank of Belgium.

Profitability is defined as the average return on equity after taxes during the period 1993-1999. This variable is only calculated when the measure for return on equity from the National Bank in each of the seven considered years is valid. In previous research (Limère et al, 2001) the authors found that profitability is positively related to firm growth. These findings are consistent with the theory of Penrose (1959). The same kind of positive relationship is expected in this study.

Solvency is the share of equity in total assets. The variable solvency that is used here is calculated as the average solvency during the period from 1993 until 1999. As was

[4] As such, six growth numbers will be averaged, namely growth in total assets in 1994, 1995, 1996, 1997, 1998 and 1999.

[5] This method is called "Polar extremes approach" (J. F. Hair et al., 1998).

the case for profitability, this variable is only calculated when the measure for solvency from the National Bank in each of the seven considered years is valid. In the same research that was quoted above (Limère et al, 2001), solvency was negatively related to firm growth. These findings are consistent with the pecking order theory[6]. The authors also expect to find a negative relationship of firm growth and the average solvency during the growth period in this research. Thus,

Hypothesis 1: There is a positive relation between growth and profitability.
Hypothesis 2: There is a negative relation between growth and the average solvency during the growth period.

5.2.2. Growth ambitions

According to Covin, Slevin and Covin (1990), growth intentions are measured by the existence in the company of strategies clearly aimed at pursuing growth. To measure the growth ambitions of the firm, the information from the survey is used. The authors acknowledge that there is a time lag between the growth period studied and the period in which the survey was held, which is due to the lack of reliable quantitative data of further periods at the moment of the redaction of this article. It is however assumed that change in general ambitions, such as the growth ambition, will be rather small, given the time lag in this case also can be considered as rather small.

Respondents were asked to answer the following question:

"Which objectives concerning sales growth does your company strive at?"

Respondents were asked to answer to this question by means of the following scale: 1 corresponds to no growth, 2 to slow growth, 3 means mediocre growth and 4 corresponds to fast growth. As was put forward by Hay and Kamshad (1994), there are indeed CEO's who do not strive at growth. About half of the respondents in the survey indicate that they have no or low growth ambitions (answer 1 or 2). Thus,

Hypothesis 3: Growth ambitions will be positively related to firm growth.

5.2.3. Growth potential

To measure environment hostility, a scale of three items was used, based on the scale used by Covin and Slevin (1989) [7]. The question asked in the mail survey is:

How would you characterize the external environment of your firm?

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[6] Limère et al (2001) used two variables to account for the pecking order theory, namely average solvency during the growth period (as is used in this article) and solvency at the beginning of the growth period. The model shows that solvency at the beginning of a growth period is positively related to growth, while the average solvency is negatively related to growth. These results are indeed consistent with the pecking order as firms will use first their own means to finance investments that are necessary to persist growth (thus a high solvency at the beginning of the growth period is required) and only in a later growth stage, the firm will call for external financing (which will decrease the solvency).

[7] Different specific growth enablers and disablers from the environment of the company were sounded out in our questionnaire, but were not separately retained as enough significant in the decision tree induction process to be included in the model. Still they are relevant for what it means the environment to be benign or hostile. They may also inspire the government for policy making purposes:

- Formal contracts with customers (+)
- High labor cost; labor unions (-)
- Lack of space (-)
- Mobility and infrastructure (+)
- Tax pressure (-)
- Availability and low prices of energy and raw materials (+)
- Financial environment (low intrest rates; availability of debt) (+)

Networking via service clubs, professional organisations and professional support (+)

The respondents had to give scores (min. 1 and max. 5) on three different items:

Very risky and unstable, one false step can mean my firm's undoing	1 to 5	Safe and stable, little threat to the survival of my firm
Few market opportunities	1 to 5	Rich in market opportunities
A dominating environment in which my firm's initiatives have very little impact	1 to 5	An environment that my firm can control

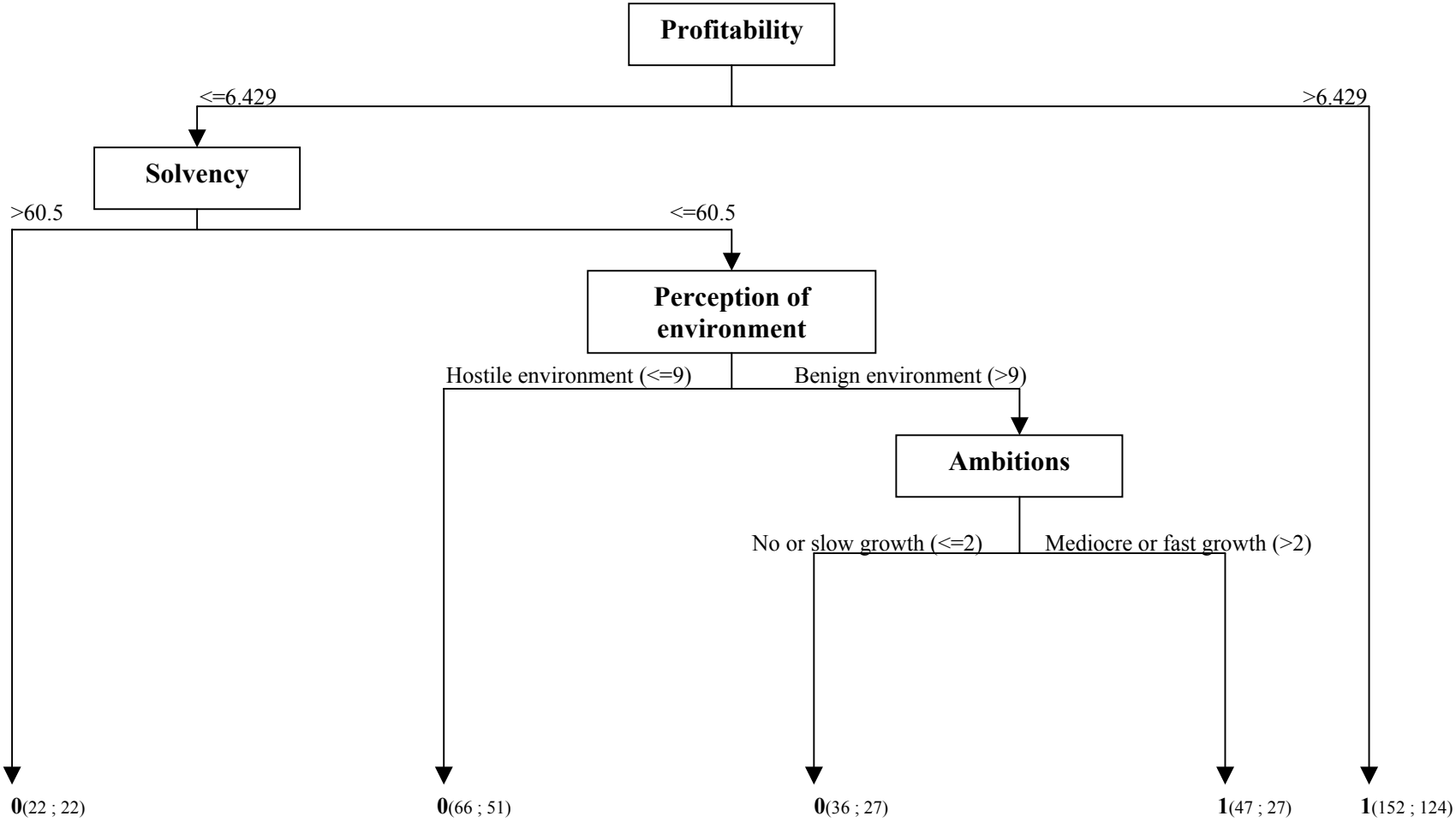
Scores of these items were summed up to form a full indication of the environment hostility. The higher the total score, the more the environment is perceived as benign. For this variable, the authors also acknowledge a small time lag between the time period in which the survey was carried out and the growth period considered in this article. However, it is assumed that the CEO's perception of the environment will not change significantly in such a small time lag. Thus,

Hypothesis 4: There is a positive relationship between a benign environment and firm growth.

6. Empirical results

When applying decision tree induction to the above described data and variables, the following tree is found (see figure 2). In the following paragraphs, the goodness-of-fit of this model as well as the content of the model will be described.

Figure 2
Decision tree



0=slowly growing firm;1=strongly growing firm.
Numbers between brackets correspond to respectively the number of cases that is classified with the decision rule and the number of cases that is correctly classified with the rule. For example, the last rule classifies 152 cases of which 124 are correctly classified.

Cross validation accuracy: 72.9; **Percentage of correctly classified** case: 77,71 percent

6.1. Goodness of fit of the model

6.1.1. Missing values

The method of decision trees is much less sensible to missing values than other, more classical, classification methods like logistic regression. This means that good models can also be estimated in the case of variables with a lot of missing values. However, cases with a lot of missing cases for important variables in the model cannot be classified. For this model, 75 cases of the 398 could not be classified. This is especially due to the great number of missing values for profitability[8].

6.1.2. Cross validation

When building a model, the decision tree induction algorithm splits the data into a training data set, on which a rule is built, and a test data set, on which the rule is validated. Parameters of the model are optimized until a specified accuracy is achieved. Cross validation is used when the data set is too small to retain a reasonable test set.

When cross validating, the data is divided into different combinations of train and test samples and the resulting accuracies are averaged. Thus the higher the cross validation result, the higher the accuracy of the model. For the model that is presented in this article, the cross validation results is 72.9, which is very good when taking into account the percentage of slowly growing and highly growing firms in the data set (45 percent respectively 55 percent)

6.1.3. Confidence levels of decision rules

From a decision tree, a set of decision rules can be specified. Each path from the top of the tree to the bottom of the tree via the branches then forms a rule. In table 1 the decision rules for the decision tree in figure 2 are shown. The two numbers between brackets correspond respectively to the size of the set of cases that are classified with the decision rule and the confidence level. The confidence level represents the proportion of records within this set that is correctly classified.

The higher the level of confidence, the better the rule classifies the data into slowly growing and weakly growing firms. When looking at the confidence levels for the rules that are specified in this model, two rules clearly stand out. The third rule that is used to classify slowly growing firms seems to have a perfect classification score. Of course, its confidence level of 1 is solely due to the small set of data to which this rule applies (only 22).
The first rule that is used to classify strongly growing firms however stands out in the negative way. It only has a confidence level of 0.574, which means that of the set of firms that fulfill the requirements for this rule (47 cases), only slightly more than half of them are correctly classified. When interpreting the content of the model, one should take into account the weakness of this rule. Confidence levels of all the other rules are around 0.75, indicating that about three fourth of the set of firms, that is looked at by the rule, is correctly classified.

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[8] This is due to the way of defining this variable. All cases that have at least one missing value for the measure of profitability in one of the seven considered years, is accorded a missing value for the average profitability. Each year, databases of the National Bank of Belgium have for about 15 percent of the firms a missing value for profitability.

Table 1
Decision rules

Rules for 0 (weakly growing firms)**:**

- ✓ ***Rule 1*:**
  IF *Profitability* <= 6.429
  AND *Solvency* <= 60.5
  AND *Perception of environment* <= 9,
  THEN -> 0 (weakly growing firms) **(66 cases; confidence 0.773)**

- ✓ ***Rule 2:***
  IF *Profitability* <= 6.429
  AND *Solvency* <= 60.5
  AND *Perception of environment* > 9
  AND *Ambitions* <=2,
  THEN -> 0 (weakly growing firm) **(36 cases; confidence 0.75)**

- ✓ ***Rule 3*:**
  IF *Profitability* <= 6.429
  AND *Solvency* > 60.5,
  THEN -> 0 (weakly growing firm) **(22 cases; confidence 1.0)**

Rules for 1 (strongly growing firms)**:**

- ✓ ***Rule 1:***
  IF *Profitability* <= 6.429
  AND *Solvency* <= 60.5
  AND *Perception of environment* > 9
  AND *Ambitions* > 2,
  THEN -> 1 (strongly growing firm) **(47 cases; confidence 0.574)**

- ✓ ***Rule 2:***
  IF *Profitability* > *6.429,*
  THEN -> 1 (strongly growing firm) **(152 cases; confidence 0.816)**

6.2. Discussion of Classification results

The percentage of correctly classified firms is 77.71 percent (see figure 2). This means that 77.71 percent of the 323 classified firms are correctly assigned to one of the two categories of firm growth (strongly growing and weakly growing)[9]. In the following table (see table 2), the detailed classification table is shown:

Table 2
Classification table

		Predicted		
		Slowly growing firm	***Strongly growing firm***	***Total***
Observed	***Slowly growing firm***	100 **(68 percent)**	48 **(32 percent)**	148 **(100 percent)**
	Strongly growing firm	24 **(14 percent)**	151 **(86 percent)**	175 **(100 percent)**

The classification table (see table 2) shows that the model especially performs well for strongly growing firms. No less than 86 percent of the strongly growing firms are classified as being strongly growing on the basis of the decision rules from the decision tree. The model performs somewhat weaker for the slowly growing firms. Only 68 percent of the slowly growing firms are classified as being slowly growing. However, the classification rate for this last category is still good when taking into account the percentage of slowly growing firms in the dataset (45 percent).

All of the goodness-of-fit measures that are indicated above show that the model is a good classifier for the firms in the dataset in terms of growth in total assets.

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[9] We also applied logistic regression to the same data-set, with the same significant variables. The hit ratio here was a little bit lower (66.8%). Further results of this regression were as follows:

Variables in the Equation

	B	S.E.	Wald	df	Sig.	Exp(B)
AMBITIONS	.164	.077	4.548	1	.033	1.178
PERCEPTION OF ENVIRONMENT	.543	.153	12.523	1	.000	1.720
SOLVENCY	-.021	.006	12.213	1	.000	.980
PROFITABILITY	.030	.007	19.030	1	.000	1.030
Constant	-.836	.391	4.576	1	.032	.434

Classification Table(a)

Observed		Predicted		
		0	1	Percentage Correct
Slow growing firm	0	93	70	57.1
Strong growing firm	1	50	148	74.7
Overall Percentage				66.8

a The cut value is .500

All signs of variables however were consistent with decision tree and with hypotheses

6.3. Validation of the model

The results in the previous paragraph show that the model is a good model for the given data. However, models should always be tested on their stability by means of validation on another set of data. While this is already built in in the used analysis technique by means of the cross validation, the authors prefer doing yet another validation on the here presented model.

Because of lack of data, it is not possible to test the model on a completely different set of data. However, quantitative data have been updated to the year 2001. In order to become quantitative data in the same size order, a period of seven years will be considered for each validation. As such the model will be validated for two different time periods, namely the period from 1994 until 2000 and the period from 1995 until 2001.

Growth categories for each of these time periods were calculated in the same way as the growth categories that were used to estimate the model. Profitability and solvency were also calculated as being the average profitability respectively solvency for the growth period that was studied. Because of lacking quantitative data, for some firms of the data set, average growth numbers could not be calculated. As such, for the period 1994-2000, 21 of the 840 firms have missing values for growth numbers in terms of total assets. For the period 1995-2001, things are much worse: for 107 firms no growth numbers could be calculated[10].

In the following table (see table 3), the classification results of the here presented model are given for the period from 1994 to 2000:

Table 3
Classification results for the period 1994-2000

		Predicted		
		Slowly growing firm	***Strongly growing firm***	***Total***
Observed	***Slowly growing firm***	94 **(62 percent)**	57 **(38 percent)**	151 **(100 percent)**
	Strongly growing firm	32 **(16 percent)**	166 **(84 percent)**	198 **(100 percent)**

The total percentage of correctly classified cases in this period is 74,5 percent. Despite the fact that this percentage is somewhat lower than the classification percentage of the original model, it can still be considered as rather high.

The classification result of the application of the model to the data from the period from 1995 to 2001 are presented in the following table (see table 4):

[10] This high number of missing values, however, is not unexpected. All financial statements of Belgian firms are recorded on a CD-rom of the National Bank of Belgium. On each of these Cd's, financial statements of three consecutive years are recorded. This means that each year will be recorded on three cd's. For 2001, numbers are only recorded for the first time. The authors know out of experience that a lot of financial statements lack, when they are recorded for the first time because a lot of financial statements were admitted too late. The data for 2000 are much more complete because here data are used from the cd where they are recorded for the second time.

Table 4
Classification results for the period 1995-2001

		Predicted		
		Slowly growing firm	***Strongly growing firm***	***Total***
Observed	***Slowly growing firm***	70 **(62 percent)**	43 **(38 percent)**	113 **(100 percent)**
	Strongly growing firm	28 **(16 percent)**	148 **(84 percent)**	176 **(100 percent)**

Again, the total percentage of correctly classified cases (75,4 percent) is somewhat lower than the percentage from the original model. It is however still rather high. For both periods, classification results are better for highly growing firms (where 84 percent is correctly classified) and weaker for the slowly growing firms (where only 62 percent is correctly classified). The same conclusions were made from the classification table of the original model.

Further, the confidence levels of the different decision rules, that are used here to classify the firms, were examined. In table 5 confidence levels for the five decision rules and number of cases classified with the rule are given for each period studied.

Table 5
Confidence levels of decision rules in the three periods studied

	1993-1999		**1994-2000**		**1995-2001**	
	Confidence level	**Number of cases**	**Confidence level**	**Number of cases**	**Confidence level**	**Number of cases**
Rule 0_1	0,77	66	0,65	62	0,67	51
Rule 0_2	0,75	36	0,78	36	0,64	25
Rule 0_3	1,00	22	0,93	28	0,91	22
Rule 1_1	0,57	47	0,56	41	0,59	37
Rule 1_2	0,76	152	0,79	182	0,82	154

Liu, Ma and Lee (2001) present in their article a way of comparing these confidence levels by means of a chi square test. According to these authors, a stable rule is a rule of which confidence levels do not vary significantly over time. All of the decision rules that are presented here turn out to be stable over time with a significance level of 0.05.[11]

[11] Chi square values for the different rules are 2.809 for rule 0_1; 1.522 for rule 0_2; 1.953 for rule 0_3; 0.091 for rule 1_1 and 1.401 for rule 1_2. All these values are below the critical value of 5.991, which proves that these

Since classification results of the model for the two periods studied are good and the confidence levels of the decision rules are statistically proven to be stable, the model can be considered as being stable over time.

7. Interpretation of results

Another important aspect of the description of a model is the interpretation of the content. The model shows that all three of the components of the growth model of Ahlström (1998) come back in the estimated model which indicates that all three of the components are indeed important when looking for factors that are related to growth.

The advantage of the decision tree induction technique to some of the other data mining techniques is that the format makes it clear which variables are having an impact on the classified variable. Further, it also gives information on the order of importance of the variables that are included. The most important variables in the classification can be thought of as those that divide the tree in its earliest stages. Thus the higher a variable is situated in the tree, the more important the variable is in the model. As such, the variables that were used to measure the resources of the firm (profitability and solvency) seem to be the most important classifiers of firms in terms of growth in total assets. The growth potential and the growth ambitions come respectively on the second and third place.

In the following paragraphs, each of the variables of the model will be looked at separately.

7.1. Profitability

Profitability comes first in the model, which means that this is the most important classifier for firm growth in this model. In fact, the rule for profitability indicates that all firms with an average profitability during its growth period that is high (> 6.429), is a strongly growing firm. This rule classifies 152 firms, of which 118 are correctly classified (confidence level of 0.816). This classification rule is thus very powerful and confidence levels of the two other periods studied indicate that this rule stays very powerful (see table 5). Cases that are not yet classified by means of this rule (average profitability <= 6.429), are classified by the other variables.

Indeed, data indicate that over 70 percent of strongly firms (that have a valid value for the average profitability) have an average profitability that is higher than 6.429. For weakly growing firms this is only 18 percent. Further, the number of 6.429 corresponds approximately to the mean of the average profitability of the 840 firms that responded to the survey.

When looking at the first branches of the tree, it can be concluded that profitability is positively related to firm growth (see hypothesis 1). Firms that have a high profitability (> 6.429), are directly classified as being a strongly growing firm. However, firms that do not have a high profitability are not excluded from being a strongly growing firm. For these firms, the classification will be based on the other variables in the model.

This model clearly shows that firms with high growth numbers do succeed in keeping a high level of profitability. This results contradicts the trade-off theory of Hay and Kamshad (1994) that was presented above. This theory claims that companies need to make a trade-off between profitability and growth as investing in future growth usually requires a decrease of current period's profits. When looking at the whole growth period that is considered here, average profitability of strongly growing firms turns out to be high.

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rules are stable over time. For details on the calculation of these values, the authors refer to the article of Liu, Ma an Lee (2001).

7.2. Solvency

Solvency is the second most important classifier in the model. The rule that only includes profitability and solvency, indicate that firms with a low average profitability (<= 6.429) and a high average solvency (> 60.5) are classified as being a weakly growing firm. This rule classifies 22 cases and all of these cases are correctly classified (confidence level of 1). The rule can thus be implied on only a few cases, but the confidence of the rule is perfect. Confidence levels for this rule drop a bit when applying it to the other two periods studied (see table 5), but they stay very high.

Results from exploring the data set indicate that only about 15 percent of the firms that responded to the survey, have an average solvency of 60.5 or higher. For the strongly growing firms this turns out to be only 3 percent of the cases, while for the weakly growing firms the percentage corresponds to the average percentage (15 percent). These percentages indicate indeed the difference in average solvency for strongly growing firms versus weakly growing firms.

The decision rule that is looked at here indicates that the average solvency is negatively related to firm growth when profitability is low (<= 6.429) (see hypothesis 2). Indeed, firms that have a low average profitability (<= 6.429) and a high average solvency (> 60.5) are directly classified as weakly growing firms. This confirms the results from previous research of these authors (Limère et al, 2001) and is consistent with the pecking order theory that was explained in one of the previous paragraphs.

7.3. Perception of the environment

The third variable of the model (in order of importance) is the perception of the CEO of the environment. Rule 0_1 indicates that if the average profitability and the average solvency are low (respectively <= 6.429 and <= 60.5), the firm is weakly growing if the environment is perceived as hostile (total score on items concerning the perception of the environment <= 9).

This rule classifies 66 cases with a confidence level of 0.773. However, the confidence level of this rule decreases when applying the rule to the two other periods (see table 5). The lowest confidence level for this decision rule in the three examined periods is 0.65. This means that for this period 65 percent of the cases that are classified by means of this rule are correctly classified, which is not so bad after all. Also, in the previous paragraph it was proven that this rule is stable over time and thus the confidence levels do not differ significantly.

This rule indicates that the perception of the environment (a benign versus a hostile environment) is positively related to firm growth (see hypothesis 4).

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[12] Different specific growth enablers and disablers from the environment of the company were sounded out in our questionnaire, but were not separately retained as enough significant in the decision tree induction process to be included in the model. Still they are relevant for what it means the environment to be benign or hostile. They may also inspire the government for policy making purposes:

- Formal contracts with customers (+)
- High labor cost; labor unions (-)
- Lack of space (-)
- Mobility and infrastructure (+)
- Tax pressure (-)
- Availability and low prices of energy and raw materials (+)
- Financial environment (low intrest rates; availability of debt) (+)
- Networking via service clubs, professional organisations and professional support (+)

7.4. Ambitions

The last variable in the model (in order of importance) is growth ambitions of the CEO. Two rules incorporate this variable (rule 0_2 and rule 1_1). If average profitability and solvency are low (respectively <= 6.429 and <= 60.5) and the perception of the environment is positive (total score > 9), then firms are classified as weakly growing firm if its growth ambitions are low (no growth or slow growth) and as strongly growing firm if its growth ambitions are high (mediocre or fast growth).

These rules classify 36 weakly growing firms and 47 strongly growing firms. Confidence levels for these classifications are respectively 0.75 and 0.57. Confidence levels for these stay approximately the same during the other two periods studied, except for rule 0_2 of which the confidence level decreases to 0.64 in the third period (see table 5). However, confidence levels of this rule have also been proven to be stable. As the confidence level for rule 1_1 is low, results concerning this rule should be treated with care.

These rules indicate that there is a positive relationship between firm growth and growth ambitions (see hypothesis 3). Firms with low solvency and profitability and with a good perception of the environment are classified as weakly growing firms when their ambitions are low. The confidence level of this rule is rather good. Firms that have these conditions in terms of resources and environment and that have high growth ambitions are classified as highly growing firms. However, the confidence level of this last rule is rather low.

8. Conclusion and policy implications

In economic research, a lot of attempts have been made to capture factors that have an impact on growth in growth models. In this article, one of these growth models, namely a model presented by Ahlström (1998), have been empirically tested by means of a datamining technique.

Ahlström (1998) presented a model in which firm growth is considered to be only possible when three important pillars are present in the firm, namely growth competence and resources, growth potential and growth ambitions. The same growth related factors can be found in the work of other authors as well (o.a. Chandler and Hanks (1994); Willem et al (1997a)).

This model has been tested by means of the decision trees induction technique, which resulted in the model that was presented in figure 2. In this model, the three pillars of Ahlström's model are present. The goodness-of-fit measures clearly indicate that the model is good. Validations of the model for other periods in time show that the model can be considered as stable over time.

Although the three pillars turned out to be important in the model, the order of importance of the three factors is different. As such, profitability and solvency (which were used to measure the resources and competence factor) turned out to be the most important growth related variables. The relationship between profitability and firm growth is positive, while solvency seemed to be negatively related to growth. The signs of these relationships correspond to the hypotheses that were made, based on previous findings in literature.

Growth potential, which was measured by the environment hostility scale of Khandwalla (1977), is second in the order of importance. As was expected, the relationship between (perceived) growth potential (or benignity of the environment) and firm growth turns out positive.

Growth ambitions, finally, also are positively related to firm growth. As such, firms with the right conditions for resources and competence and potential are classified as weakly growing firms when the growth ambitions are low and as strongly growing firms when the growth ambitions are high.

This article has shown that firm growth is indeed related to different factors. Firms that want to pursue growth have to take into account each of these factors. But this model has also implications for governmental actions. Khandwalla (1977) claims that one of the most important reasons for perceived hostility of the external environment is the government. This models shows that perceived hostility is negatively related to growth. The government thus should make sure that it does not perform actions that has a negative impact on the perception of the environment for a CEO. Still it can intervene by creating stable conditions in the field of education and labor markets, capital markets, available space for firms, mobility, infrastructure, reasonable taxes, availability of cheap energy and raw materials, in other words a benign environment with a lot of opportunities for business. The global picture of the environment as it is observed by the entrepreneur is important, not as such individual factors.

On the other hand, policy of firms themselves should be directed towards profitable investments, allowing them to create new funds that at least partly should serve financing of further investments and expansion in profitable area's. Profitability remains the main driver for growth and resulting employment. Important is the real entrepreneurial spirit.

This article was a first attempt to test growth models with a newer data analysis technique. Data mining and more specifically decision tree induction has a number of advantages of which most important are: (a) It shows an higher hit rate in our empiric study (b) It handles very well missing values by considering them as valid observations, used in the further analysis. This is particularly important in a survey where many questions didn't get a response or were considered to be irrelevant by some of the respondents. (c) Interpretation happens in a more balanced way in contrast with the more linear based reasoning in logistic regression and discriminantfunctions.

However, as with most research, also this study is limited by the small sample size that was available to test the model. The small number of cases that were included in the analysis constrains the number of variables that can be tested. The testing of more extensive growth would certainly be interesting as it could identify more factors that are related to growth. Further empirical research in foreign country settings is also warranted to see whether formulated hypotheses and the derived decision tree will also hold there.

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