# Bankruptcy prediction: the case of Belgian SMEs

Loredana Cultrera
*Department of Finance, UMONS, Mons, Belgium, and*
Xavier Brédart
*Comptabilité, UMONS, Mons, Belgium*

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## Abstract

**Purpose** – The aim of this paper is to develop a bankruptcy prediction model for the Belgian small- and medium-sized enterprises (SMEs) through the building of a logit model that includes a selection of financial ratios.

**Design/methodology/approach** – Using a sample of 7,152 Belgian SMEs among which 3,576 were declared bankrupt between 2002 and 2012, the model, which includes control variables such as firm size and age, aims to test the predictive power of ratios reflecting the financial structure, the profitability, the solvency and the liquidity of firms.

**Findings** – The results report a satisfactory prediction accuracy and show that ratios as profitability and liquidity are excellent predictors of bankruptcy for Belgian SMEs.

**Research limitations/implications** – Although the results seem to be conclusive, it could be noted that the healthy sample was not paired with the bankrupt sample. Other studies show that the use of paired samples makes it possible to increase the already good prediction rate. Also, further research could focus on intra-sectorial analysis.

**Practical implications** – Beside its contribution to the academic literature on bankruptcy prediction of Belgian SMEs, this study may be of interest for investors or managers to help them to anticipate bankruptcy risks. It can also be useful for banks and other credit institutions in the assessment of credit risk of firms. Thanks to such models, they could better identify firms with a higher risk of failure in their lending decisions.

**Social implications** – Given the increasing number of SMEs in Belgium, their significant role in the economy, the specific characteristics of the country in terms of political decision making, the institutional differences between regions and the current uncertain economic circumstances, bankruptcy prediction seems to be a necessity for the country.

**Originality/value** – The originality of this paper lies in the fact that Belgian SMEs have been studied. This study may also be of interest to investors or managers because it may help them highlight accounting measures they should closely follow up to avoid bankruptcy.

**Keywords** Bankruptcy, SMEs, Business failure, Default risk, Logistic regression, Failure prediction

**Paper type** Research paper

## 1. Introduction

For more than 70 years, business failure has been one of the most discussed topics in the financial literature (Balcaen and Ooghe, 2006). Business failure matters a lot for many stakeholders: customers, suppliers, creditors and, of course, the firm's workers (Daubie and Meskens, 2001). Bankruptcy leads, on the one hand, to catastrophic macroeconomic consequences for the overall societal well-being and, on the other hand, to disastrous

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microeconomic consequences for the different partners of the affected firms, which explains the academic appeal of this topic (Charest *et al.*, 1990).

Since the pioneering work of Fitzpatrick (1932), several investigations have been conducted on the subject of bankruptcy prediction. These studies (Beaver, 1966; Argenti, 1976; Ohlson, 1980; Altman, 1984; Guilhot, 2000; Daubie and Meskens, 2001; Ooghe and De Prijcker, 2006; etc.) generally consist in developing prediction models that allow to predict bankruptcy based on accounting ratios. Such models are particularly useful for actors of the banking sector, as they allow them to screen the financial situations of their borrowers to prevent "bad investments" (Altman and Hotchkiss, 2005). However, most of these studies focus on large firms; very few concern bankruptcy prediction for small- and medium-sized ones (Peel and Peel, 1987; Storey *et al.*, 1987; Keasey and Watson, 1988; Altman and Sabato, 2007; Ciampi and Gordini, 2008; Crutzen and Van Caillie, 2009). This is due to the diversity of small- and medium-sized enterprises (SMEs) and to the lack of access to their comprehensive financial data (Van Caillie, 2000). Belgian SMEs do not, in fact, have to publish every detail of their financial accounts (as larger firms have to) and they can, therefore, use a multitude of presentations of their annual accounts.

In Belgium, the number of bankruptcies is constantly evolving. Indeed, 12,306 firms went into bankruptcy over the course of the year 2013, which means that 1 in 80 active firms filed for bankruptcy. This represents an increase of 11.35 per cent compared to the previous year (Graydon, 2013). In Belgium, the phenomenon of bankruptcy primarily affects small- and medium-sized firms (hereafter, SMEs) which represent the majority of the Belgian economic landscape. Indeed, SMEs contribute to Belgium's gross domestic product by more than 70 per cent and generate more than 41 per cent of employment (ICHEC, 2009).

Predicting bankruptcy for Belgian SMEs is a hard task because of the specific behaviours and fundamental characteristics (Crutzen and Van Caillie, 2010) that distinguish them from larger firms. For instance, SMEs are able to react more quickly and to find more creative solutions in times of uncertainty. They are able to reach market segments that are difficult to reach for larger firms. Their main advantage lies in their personal character in all aspects of the management structure (Ciampi and Gordini, 2008). However, managing an SME also means dealing with a large amount of information, too many decisions to take and too many skills to handle (Ciampi and Gordini, 2008). Peacock (2004) also points out that the smallness, the higher rate of turnover and the higher failure rate are issues related to SMEs, while Julien (1997) and Van Caillie (2010) highlight the dominant position of the manager, the centralization of the organization and the high level of dependence to its working environment (i.e. toward its clients, suppliers, funds providers, etc.). Finally, SMEs suffer a lack in their financial structure as they mainly depend on short-term credits and have difficulties accessing medium and long term credits (Ciampi and Gordini, 2008). When investigating the Belgian case, it turns out that Belgium represents an interesting field of research. Indeed, even though only one bankruptcy code is applied in Belgium thanks to the law on bankruptcy adopted in 1997, the specific structure of the country's institutions, symbolized by its three regions (i.e. Wallonia, Brussels and Flanders), three levels of decision-making (i.e. the federal, the regional and the community level) and two main different cultures (i.e. Walloon and Flemish culture), raise the question of how "classical" bankruptcy prediction models can deal with these specificities.

From this point, some incremental contributions on this topic may be settled to understand the bankruptcy phenomenon. First, previous empirical studies on the subject tend to show that a country-specific prediction model allows developing more accurate bankruptcy predictions than a generic and global one. Second, given the economic and social consequences of bankruptcies, developing a specific bankruptcy prediction model for Belgium by taking the specific characteristics of the country into account allows to fill a gap in the bankruptcy prediction literature.

The originality of this paper lies in its goal: to build a one-year bankruptcy prediction model suitable for Belgian SMEs. To do so, it relies on a sample of 7,152 SMEs, among which 3,576 were declared bankrupt between 2002 and 2012, and on the existing literature to select a range of ratios that differentiate failing firms from healthy ones. A logit model is then constructed to determine the probability of a firm experiencing a failure based on the previous year's finances.

The rest of this paper is organized as followed: Section 2 outlines the theory of bankruptcy, brings key studies together and describes the variables and research hypotheses. Section 3 explains the data and methods and Section 4 presents the empirical results. The last section concludes and discusses our findings.

## 2. Literature review

There are four approaches related to the prediction of bankruptcy: the economic approach (Marco, 1989; Guilhot, 2000), the strategic approach (Laitinen, 1991; Van Caillie and Dighaye, 2002), the organisational and managerial approach (Argenti, 1976; Daigne, 1984; Cormier *et al.*, 1995), and the financial approach. This paper is focussed exclusively on the financial approach, as it allows to identify the relevant financial ratios, generally gathered into four families (i.e. liquidity, solvency, profitability and structure), that help to predict bankruptcy in a given time horizon with the use of statistical tools or appropriate mathematics (Beaver, 1966; Altman, 1968; Wilcox, 1973; Collongues, 1977; Dambolena and Khoury, 1980). The use of this approach is also validated through its importance in the literature and its low use in the prediction of bankruptcy of SMEs, particularly in Belgium. In the past two decades, a few papers have investigated bankruptcy prediction models for SMEs. Altman and Sabato (2007) develop a one-year default prediction model for US SMEs and measure its effectiveness compared to a more generic model. Their results show that the specific model outperforms the more generic ones by 30 per cent. Ciampi and Gordini (2008, 2009) construct two bankruptcy prediction models for Italian SMEs: the first one by implementing discriminant analysis; the second one by resorting to a logit model. Both models show a highly satisfactory prediction accuracy rate, but the authors also show some market improvements in the accuracy of the model when analyses are done separately depending on firm size. Yazdanfar (2011) investigates the main prediction variables of bankruptcy in Sweden by using a logit model and states that the ratio of short-term debts to total assets, total leverage, change in total assets from the previous year, financial expenses to total debt, return on assets and firm size were significant bankruptcy predictors.

As far as the financial approach of failure prediction is concerned, different prediction techniques can be found in the literature. Among them, discriminant analysis and logistic regression are the most used (Ooghe *et al.*, 2005; Balcaen and Ooghe, 2006; Altman and Sabato, 2007; Ciampi and Gordini, 2008, 2009; Yazdanfar, 2011). Multiple

discriminant analysis uses a model made up of a linear combination of variables, whereas the logit model refers to a conditional probability one with the probability of bankruptcy estimated based on a series of firm characteristics. It has been shown that these two techniques are equally efficient (Press and Wilson, 1978; Platt and Platt, 1990; Ooghe and Balcaen, 2002; Ooghe *et al.*, 2005). However, several authors emphasise the superiority of logistic regression, as it requires less restrictive and simpler statistical assumptions. Furthermore, the logit model allows to integrate non-linear parameters and better fits the characteristics of the failure prediction problem, where the dependent variable is binary, where the groups are discrete and identifiable and with no possibility for a firm to overlap (Ohlson, 1980; McFadden, 1973; Lo, 1986; Aziz *et al.* 1988; Bell, 1997; Altman and Sabato, 2007).

In general, and regardless of the methods used, authors rely on a combination of financial ratios to predict bankruptcy of firms. Table I lists the main authors who investigate the topic of business failure and the financial ratios they use. Table II has the same purpose, except that it focuses solely on the case of Belgium.

These tables show that, regardless of the model used, the country studied or the period investigated, authors systematically use ratios of profitability, solvency and liquidity, and sometimes ratios of added value or structure.

Therefore, the choice of ratios for this case is justified by their recurrence in the Belgian (Ooghe and Van Wymeersch, 2000) and international literature (Altman, 1968; Taffler, 1982; Frydman *et al.*, 1985), as well as by their relevance to the problem of failure in Belgian SMEs. The resulting financial health is influenced by the level of added value created by the firm, its structure, profitability, solvency and liquidity. Therefore, our study uses the following ratios.

### *2.1 $X_1$ – Current ratio*

The *current ratio* is a liquidity ratio that is calculated by dividing current assets by current liabilities. The concept behind this ratio is to ascertain whether a firm has the ability to pay back its short-term liabilities with its short-term assets over the next 12 months. The value of this ratio is a good predictor of the financial health of the firm, which explains why it is widely used for business failure prediction (Mossman *et al.*, 1998):

*H1*. A higher liquidity ratio decreases the probability of bankruptcy at one year.

### *2.2 $X_2$ – Earnings before interest and taxes/total assets*

This ratio is a profitability ratio that represents the general profitability of the firm's assets. Because a firm's ultimate existence is based on the earning power of its assets, Altman (1984) found that this measure continually outperforms other profitability measures in assessing the risk of corporate failure:

*H2*. A higher profitability ratio decreases the probability of bankruptcy at one year.

### *2.3 $X_3$ – Equity/total assets*

This ratio is a ratio of structure that indicates the relative proportion of equity used to finance a firm's assets. This ratio of debt structure measures the proportion of the total outstanding debt payable in the current year or in the next accounting period against the total assets of the firm. When this ratio increases, the firm's financing is generally less

**Table I.**
General study for assessing bankruptcy

| Study | Country | Data | Estimation method | Ratios | Results (*) (%) |
|---|---|---|---|---|---|
| Beaver (1966) | USA | 1954-1964 Industrial firms | Univariate statistical | Cash flow/total debt; net income/total assets; total debt/total assets; working capital/total assets; debt ratio and no-credit interval | Global 87 |
| Altman (1968) | USA | 1945-1965 Industrial firms | Linear discriminant analysis | Working capital/total assets; sales/total assets EBIT/total assets; retained earnings/total assets Market value equity/book value of total debt | D 94<br>ND 97 |
| Deakin (1972) | USA | 1962-1966 Industrial firms | Univariate statistical | Cash flow/total debt; net income/total assets; total debt/total assets; current asset/total assets; quick assets/total assets; working capital/total assets; | Global 80 |
| | | | Linear discriminant analysis | Cash/total assets; current assets/current liabilities; quick assets/current liabilities; cash/current liabilities; current assets/sales; quick assets/sales; working capital/sales; cash/sales | Global 87 |
| Bilderbeek (1979) | The Netherlands | 1950-1975 Industrial and trade companies | Linear discriminant analysis | Net return on equity after taxes; sales/total assets; accounts payable/sales; gross added value/total assets; (accumulated profits + retained earnings)/total assets | Ranges from 70-80 |
| Ohlson, 1980 | USA | 1970-1976 Industrial firms | Logistic regression | Log (total assets/GNP price level index); total liabilities/total assets; working capital/total assets; current liabilities/total asset; net income/total assets;1 if total debt > total assets, 0 otherwise; Funds provided by operation/total liabilities 1 if net income is negative for the past two years, 0 otherwise; (Nit–Nit − 1)/(NIt + Nit − 1) where NI = net income | D 79.8<br>ND 91.4 |
| Taffler (1982) | Great Britain | 1963-1973 Industrial firms | Linear discriminant analysis | EBIT/total assets; total liabilities/capital employed; quick assets/total assets; working capital/net worth stockturn | D 87.9<br>ND 100 |
| Zavgren (1983) | USA | 1972-1978 American companies | Logistic regression | Inventory/sales; amounts receivable/inventory; (cash + ST investment)/total assets; quick ratio; Net return on equity after taxes; sales/total assets; (liabilities–accrued charges and deferred income)/equity | D 89<br>ND 76 |
| Frydman *et al.* (1985) | USA | 1971-1980 | Recursive partitioning | Cash flow/total debt; cash/total sales; market value of equity/total capitalisation quick assets/total assets; total debt/total assets; log(interest coverage + 15) | Global 85 |
| Frydman *et al.* (1985) | USA | 1971-1980 | Linear discriminant analysis | Net income/total assets; current assets/current liabilities; log(total assets); current assets/total assets; market value of equity/total capitalisation; cash flow/total debt; quick assets/total assets; EBIT/total assets; quick assets/current liabilities; Log(interest coverage + 15) | Global 96.3 |
| Gloubos and Grammatikos (1988) | Greece | 1977-1985 Greek enterprise | Logistic regression | Net working capital/total assets; long-term liabilities/total assets; gross return on total assets before taxes | D 83.4<br>ND 90 |
| Platt and Platt (1990) | USA | 1972-1986 Industrial firm | Logistic regression | Sales growth; cash flow/sales; net fixed/total assets; total debt/total assets; ST debt/total debt; (output × cash flow)/sales; (output × total debt)/total assets | D 85<br>ND 88 |

(*continued*)

Table I.

| Study | Country | Data | Estimation method | Ratios | Results (*) (%) |
|---|---|---|---|---|---|
| Keasey and McGuinness, 1990 | UK | 1976–1984 UK companies | Logistic regression<br>Logistic regression | Equity/liabilities; purchases/accounts payable; profit or loss before taxes/sales; sales/total assets; inventory/sales; net working capital/total assets; net return on operating assets before taxes; net return on equity after taxes; quick ratio | D 86<br>ND 86 |
| Luoma and Laitinen (1991) | Great Britain | Industrial and Retailing firms | | Return on investment ratio; cash flow/sales; average payment period for accounts payable; shareholders capital/total capital; logarithmic net sales official expenses/corrected expenses; | D 73.5 ND 70.6 |
| | | | Linear discriminant analysis | Return on investment ratio × average payment period for accounts payable | D 64.7 ND 76.5 |
| Espahbodi (1991) | USA | 1981–1982 Banks | Logistic regression | Total loan revenue/total operating income; interest income on state and local government obligations/total operating income; interest paid on deposits | D 84 ND 82 |
| | | | Linear discriminant analysis | Total operating income; total time and savings deposits/total demand deposits | D 83 ND 75 |
| Shah and Murtaza (2000) | USA | 1992–1994 Computer and merchandising industry | Neural network | Current ratio; EBIT/interest expenses; receivable turnover; total debt/total assets; total assets/equity; net income/net sales; sales/cash net income/common equity; sales/total assets | Global 73 |
| Becerra *et al.* (2005) | Great Britain | 1997-2000 British corporations | Neural network | Working capital/total assets; EBIT/total assets; accumulated retained profit/total assets; book value of equity/book value of total equity; Sales/total assets | Global 83 |

**Table II.**
Belgian study for assessing bankruptcy

| Study | Data | Estimation method | Ratios | Results (%) |
|---|---|---|---|---|
| Moreau (1978) | 1973-1978 Public limited Company | Linear discriminant analysis | Log (total assets); working capital/total assets; operating profit or losses/total assets | Global 77.3 |
| Ooghe and Verbaere (1982) | Belgian enterprises | Linear discriminant analysis | (retained earnings + accumulated profit or loss)/(equity + liabilities);<br>overdue taxes and social security debt/short-term debt;<br>liquid assets/restricted current assets; (work in progress, finished goods and contracts in progress)/current working assets;<br>ST financial debt to credit institutions/ST debt; | D 76.8<br>ND 68.9 |
| Ooghe *et al.* (1991) | 1985-1990 Belgian enterprises | Logistic regression | ROA – average interest rate of debt (1 if > 0, 0 if < 0);<br>(accumulated profit or loss + retained earnings)/(equity + liabilities – accrued<br>Charges and deferred income); ST financial debt/ST debt;<br>overdue taxes and social security charges (1 if > 0, 0 otherwise);<br>(inventory + AR – AP – taxes – advances received on contracts in progress)/total assets; cash and ST investments/total assets<br>debts guaranteed/total debt; net return on operating assets before taxes; | D 85.3<br>ND 77.6 |
| Van Wymeersch *et al.* (1992) | 1984-1985 Non-financial firms | Linear discriminant analysis | Cash flow/total assets; variation of financial debt/total assets | D 75.6<br>ND 73.5 |
| Ooghe and Van Wymeersch, 2000 | 1977-1978 Belgian enterprises | Linear discriminant analysis | Overdue debts to the tax authority and the ONSS/debt; cash flow/debt;<br>Overdue debts to the tax authority and the ONSS/taxes, wages and social liabilities;<br>Retained profit/total assets; income tax expenses/earnings before tax<br>EBIT/total assets; EBITDA/total assets; debt/total assets; cash flow/total assets;<br>(current assets–stock–debt)/(non-cash expenses income tax expenses + profit) | D 84.8<br>ND 93.1 |
| Gaeremynck and Willekens, 2003 | 1995-1996 Private firms | Logistic regression | Cash/current assets; ST debt/total debt; operating profit = 1, operating loss = 0;<br>(cash + ST investments–ST bank debt)/total assets; return on equity;<br>If firm has overdue tax and social security liabilities = 1, 0 otherwise;<br>(retained earnings + reserves)/total assets; likelihood of non-clean opinion | Global 72.4 |
| Dewaelheyns and Van Hulle, 2004 | 1996-2001 Non-financial limited liability corporations | Logistic regression | (current assets–inventory and W.I.P)/current liabilities;<br>(reserves + retained earnings)/total assets; operating profits (losses)/total assets;<br>(ST debt + LT debt)/total assets; sales/total assets | Global 83 |

**Notes:** (*) = model accuracy at one year; D = failing firms; ND = non-failing firms

dependent on borrowed capital. On average, for firms in Belgium, this ratio reaches about 30 per cent:

*H3*. A higher debt structure ratio decreases the probability of bankruptcy at one year.

*2.4 $X_4$ – Fiscal charges/added value*

This ratio is an added value ratio that assesses the productivity of the firm by indicating how much added value has been created in comparison to the fiscal charges. This ratio indicates that the share of fiscal charges to added value plays a vital role on the balance of corporate management. As taxes in Belgium are high, it can be assumed that healthy firms (with profit) are more taxed than firms in bankruptcy (usually with negative results) because they are not concerned with the tax burden:

*H4*. A higher ratio of fiscal charges on added value decreases the probability of bankruptcy at one year.

*2.5 $X_5$ – Cash flow/total debt*

This ratio is a solvency ratio that measures a firm's ability to meet its debts and other obligations. The cash flow to debt ratio provides an indication of a firm ability to pay its total debt with its yearly cash flow, which is not realistic but which corresponds to the bankruptcy scenario (Van Caillie and Dighaye, 2002). Indeed, a firm that would not be able to pay its total debt with its yearly cash flow would end up in bankruptcy:

*H5*. A higher solvency ratio decreases the probability of bankruptcy at one year.

## 3. Methodology

*3.1 Sample and data*

This article relies on a sample of 7,152 Belgian SMEs[1]. Out of this sample, 3,576 firms were declared bankrupt between the years 2002 and 2012. The decision was made to divide the sample into two parts. The first part includes 70 per cent of the observed group (5,006 firms) and acts as the training group. The rest of the sample (2,146 firms) represents the control group that is used to test the model obtained on the training group[2]. The Bureau Van Dijk (hereafter, BVD) database is used to obtain the lists of firms that had filed for bankruptcy between 2002 and 2012. This database is also used to collect those firms' accounting data and characteristics.

*3.2 Measures*

*3.2.1 Dependent variable*. For bankruptcy prediction models, it is common to use a dichotomous qualitative dependent variable. In this study, one single dependent variable is used: bankruptcy. Bankruptcy is a binary variable taking a value of 1 if the firm was declared bankrupt between 2002 and 2012 or the value of 0 otherwise.

*3.2.2 Independent variables*. Following both an international and a Belgian literature review and taking into account the specificities of SMEs, five financial ratios obtained from the BVD database are selected as key explanatory variables:

- *Current ratio (Curr)*: Measured as the value of the ratio current assets/current liabilities in the last accounting fiscal year before bankruptcy.

- *Return on operating assets before depreciation (Return)*: Measured as the value of the ratio Earnings before interests and taxes/total assets in the last accounting fiscal year before bankruptcy.
- *Global degree of financial independence (Fin_Indep)*: Defined as the value of the ratio total equity/total assets in the last accounting fiscal year before bankruptcy.
- *Proportion of gross value added allocated to tax expenses (AV_Tax)*: Measured as the value of the ratio tax expenses/added value in the last accounting fiscal year before bankruptcy.
- *Cash flow/total debt (CF_TD)*: Measured as the value of the ratio cash flow/total debt in the last accounting fiscal year before bankruptcy.

*3.2.3 Control variables.* Control variables are also recorded in last accounting fiscal year before bankruptcy. They allow to control for firm-related effects such as the *Region* of the business, its size (*ln(TA)*), its *age* and its *activity* field. Dummy variables are created for the "Wallonia" and "Brussels" regions; "Flanders" being the base category. The size of the firm is measured using the logarithm of the total assets in the last accounting fiscal year before bankruptcy. The *age* of the firm is reported in years. Finally, regarding the activity field, dummy variables [agriculture and industries (*NACE 1*), Production of energy water (*NACE 2*), Construction (*NACE 3*), Catering (*NACE 4*), Intellectual and administrative business activities (*NACE 5*), public and social activities (*NACE* 6) and Others (*NACE 7*)] were created using NACE codes, with *Transport* (*NACE 8*) being the basis category.

*3.3 Estimation*

As mentioned above, the bankruptcy phenomenon is not a sudden situation and some authors even define it as a failing "path" (Crutzen and Van Caillie, 2008). That is, the organizational and financial situations of the firm decline, leading to liquidity and solvency issues and, finally, to bankruptcy (Luoma and Laitinen, 1991). Considering this gradual degradation of the financial indicators, relying on a logit model that takes this dynamic situation into account seems appropriate.

Moreover, using a binary logit model is justified, as the dependent variable of our model, *bankruptcy*, is dichotomous, as is the case in many studies regarding the occurrence of bankruptcy filing (Ohlson, 1980; Premachandra *et al.*, 2009). A logit model describes the relationship between a dependent variable that can take the value of 1 (bankrupt firm) or 0 (healthy firm), and k other explanatory qualitative or quantitative variables $x_1, x_2, \ldots, x_k$. Because the dependent variable is binary, it follows the Bernoulli distribution, so that $P_i = P(y_i = 1)$ is the probability of bankruptcy and $1 - P_i$ is the probability of non-failure. The estimated model requires the endogenous variable to be a linear combination of exogenous variables:

$$y_i^* = \beta X_i + \varepsilon_i \text{ where } \varepsilon \text{ is the error term and } \beta \text{ the vector of coefficients} \quad (1)$$

and where:

$$y_i = 1 \text{ if } y_i^* > 0; y_i = 0 \text{ if } y_i^* \leq 0$$

The probability of non-default (*a posteriori*) of firm *i* is given by:

$$P(y_i = 0) = P(y_i^* \leq 0) = P(\beta X_i + \varepsilon_i \leq 0) = P(\varepsilon_i \leq -\beta X_i) = F(-\beta X_i) = 1 - F(\beta X_i) = 1 - P_i \quad (2)$$

Similarly, the probability of failure (a posteriori) of firm $i$ is represented by:

$$P(y_i = 1) = P(y_i^* > 0) = P(\beta X_i + \varepsilon_i > 0) = P(\varepsilon_i > -\beta X_i) = 1 - P(\varepsilon_i \leq -\beta X_i) = F(\beta X_i) = P_i \quad (3)$$

The logit model assumes that the errors follow a logistic distribution where the distribution function is:

$$F(x) = (1 + e^{-x})^{-1} \quad (4)$$

Therefore, it is possible to calculate the probability of non-default of firm $i$ as follows:

$$P(y_i = 0) = F(-\beta X_i) = (1 + e^{-\beta x_i})^{-1} = 1 - P_i \quad (5)$$

Similarly, the probability of the default of firm $i$ is:

$$P(y_i = 1) = F(\beta X_i) = (1 + e^{-\beta x_i})^{-1} = P_i \quad (6)$$

The $\beta$ coefficients are estimated using the method of maximum likelihood.

## 4. Results

### *4.1 Correlations and descriptive statistics*

Table III presents the correlations between the variables included in the model. All correlations are under 0.50, meaning that there are no problems with multicollinearity. Independent variables are also checked for multicollinearity via the analysis of variance inflation factors (VIF). The results reported in Table III show that VIFs are well under the suggested value of 10 with the mean VIF of 1.18, showing no issue of multicollinearity (Neter *et al.*, 1989).

Table IV presents the descriptive statistics for all the variables included in the logit model per category: bankruptcy and healthy groups. Regarding the key explanatory variables, it appears that all the ratios analyzed are better explanatory variables for the non-bankrupt firms. Moreover, Return, Fin_Indep and CF_TD ratios are considerably different for the two subsamples. The results show they are negative for the bankruptcy group and positive for the healthy group. Regarding the control variables, Table IV highlights that healthy firms are older and bigger than the bankrupt group. Differences can also be seen between the two subsamples regarding the activity field. The bankrupt group includes higher proportions of firms in the agricultural and industrial sector and in the construction and catering sector.

### *4.2 Logit model*

The results of the logit regression are presented in Table V.

When comparing the two models, improvements are shown between Models 1 and 2. Indeed, the chi-square value increases from 590.84 for Model 1 to 2,060.37 for Model 2. We also run likelihood ratio tests to evaluate the difference between the models. The

**Table III.**
Correlation matrix

| No. | Variable | VIF | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Curr | 1.26 | 1.00 | | | | | | | | | | | | | | | |
| 2 | Return | 1.16 | 0.16 | 1.00 | | | | | | | | | | | | | | |
| 3 | Fin_Indep | 1.39 | 0.38 | 0.32 | 1.00 | | | | | | | | | | | | | |
| 4 | AV_Tax | 1.01 | 0.07 | 0.00 | 0.08 | 1.00 | | | | | | | | | | | | |
| 5 | CF_TD | 1.1 | 0.38 | 0.11 | 0.17 | 0.02 | 1.00 | | | | | | | | | | | |
| 6 | brussels | 1.08 | −0.02 | −0.01 | −0.05 | 0.00 | 0.02 | 1.00 | | | | | | | | | | |
| 7 | wallonia | 1.07 | −0.03 | −0.03 | −0.07 | −0.03 | −0.03 | −0.22 | 1.00 | | | | | | | | | |
| 8 | ln(ta) | 1.24 | 0.07 | 0.02 | 0.17 | 0.00 | 0.00 | −0.04 | −0.03 | 1.00 | | | | | | | | |
| 9 | age | 1.19 | 0.13 | −0.03 | 0.24 | 0.04 | 0.02 | 0.03 | −0.05 | 0.31 | 1.00 | | | | | | | |
| 10 | d_agr_ind | 1.22 | −0.02 | −0.04 | −0.01 | −0.03 | −0.02 | −0.05 | 0.01 | 0.13 | 0.09 | 1.00 | | | | | | |
| 11 | d_energy | 1.02 | 0.00 | 0.00 | 0.01 | −0.01 | 0.00 | −0.02 | 0.00 | 0.10 | 0.01 | −0.02 | 1.00 | | | | | |
| 12 | d_constr | 1.32 | −0.01 | −0.02 | 0.02 | −0.05 | −0.02 | −0.07 | 0.02 | −0.09 | −0.04 | −0.18 | −0.03 | 1.00 | | | | |
| 13 | d_catering | 1.21 | −0.04 | −0.02 | −0.11 | 0.01 | 0.02 | 0.03 | −0.02 | −0.23 | −0.07 | −0.11 | −0.02 | −0.14 | 1.00 | | | |
| 14 | d_admin | 1.32 | 0.07 | 0.07 | 0.09 | 0.02 | 0.03 | 0.09 | −0.02 | 0.09 | −0.03 | −0.18 | −0.03 | −0.23 | −0.14 | 1.00 | | |
| 15 | d_soc | 1.18 | 0.07 | 0.16 | 0.16 | 0.03 | 0.03 | −0.01 | 0.03 | −0.02 | −0.02 | −0.09 | −0.01 | −0.12 | −0.07 | −0.12 | 1.00 | |
| 16 | d_other | 1.08 | −0.02 | 0.00 | −0.04 | 0.01 | 0.00 | 0.05 | −0.01 | −0.07 | −0.02 | −0.07 | −0.01 | −0.09 | −0.06 | −0.09 | −0.05 | 1.00 |

**Notes:** Where Curr is the current ratio; return is the return on operating assets before depreciation; Fin_Indep is the global degree of financial independence; AV_Tax is the proportion of gross value added; CF_TD is the cash flow over the total debt; ln(ta) is the log of total assets; age is the age of the firm; brussels is equal to one if the firm is located in Brussels; wallonia is equal to one if the firm is located in Wallonia; d_agr_ind is equal to one if the firm belongs to the agricultural and industrial sector; d_energy is equal to one if the firm belongs to the production of energy water sector; d_constr is equal to one if the firm belongs to the construction sector; d_catering is equal to one if the firm belongs to the catering sector; d_admin is equal to one if the firm belongs to the intellectual and administrative business activities sector; d_soc is equal to one if the firm belongs to the public and social activities sector; d_other is equal to one if the firm belongs to other sectors

**Table IV.**
Descriptive statistics

| | Bankruptcy | | | | | | Healthy | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Variable | Observations | Mean | Median | Minimum | Maximum | SD | Observations | Mean | Median | Minimum | Maximum | SD |
| Curr | 3,576 | 0.93 | 0.85 | 0 | 79.65 | 1.52 | 3,576 | 2.97 | 1.26 | 0 | 99.94 | 7.11 |
| Return | 3,576 | −1.52 | 2.37 | −600 | 652.5 | 35.37 | 3,576 | 30.17 | 16.83 | −774.06 | 957.85 | 67.16 |
| Fin_Indep | 3,576 | −5.21 | 1.55 | −100 | 99.41 | 31.49 | 3,576 | 33.50 | 30.55 | −99.77 | 100 | 33.17 |
| AV_Tax | 3,576 | 9.83 | 3.33 | 0 | 850.71 | 32.65 | 3,576 | 13.47 | 7.89 | 0 | 887.82 | 29.60 |
| CF_TD | 3,576 | −0.01 | −0.02 | −6.27 | 132.04 | 2.23 | 3,576 | 0.60 | 0.16 | −28.31 | 253.96 | 5.11 |
| ln(ta) | 3,576 | 5.94 | 5.88 | 1.95 | 10.99 | 1.34 | 3,576 | 6.33 | 6.16 | 1.71 | 13.58 | 1.44 |
| age | 3,576 | 12.07 | 9.00 | 1 | 97 | 10.97 | 3,576 | 15.76 | 13 | 0 | 111 | 13.16 |
| brussels | 3,576 | 0.17 | | | | 0.37 | 3,576 | 0.12 | | | | 0.32 |
| wallonia | 3,576 | 0.26 | | | | 0.44 | 3,576 | 0.21 | | | | 0.41 |
| d_agr_ind | 3,576 | 0.15 | | | | 0.35 | 3,576 | 0.09 | | | | 0.29 |
| d_energy | 3,576 | 0.00 | | | | 0.05 | 3,576 | 0.00 | | | | 0.07 |
| d_constr | 3,576 | 0.22 | | | | 0.42 | 3,576 | 0.17 | | | | 0.37 |
| d_catering | 3,576 | 0.09 | | | | 0.28 | 3,576 | 0.07 | | | | 0.25 |
| d_admin | 3,576 | 0.14 | | | | 0.35 | 3,576 | 0.24 | | | | 0.43 |
| d_soc | 3,576 | 0.01 | | | | 0.10 | 3,576 | 0.10 | | | | 0.30 |
| d_other | 3,576 | 0.03 | | | | 0.18 | 3,576 | 0.04 | | | | 0.19 |

**Notes:** Where Curr is the current ratio; return is the return on operating assets before depreciation; Fin_Indep is the global degree of financial independence; AV_Tax is the proportion of gross value added; CF_TD is the cash flow over the total debt; ln(ta) is the log of total assets; age is the age of the firm; brussels is equal to one if the firm is located in Brussels; wallonia is equal to one if the firm is located in Wallonia; d_agr_ind is equal to one if the firm belongs to the agricultural and industrial sector; d_energy is equal to one if the firm belongs to the production of energy water sector; d_constr is equal to one if the firm belongs to the construction sector; d_catering is equal to one if the firm belongs to the catering sector; d_admin is equal to one if the firm belongs to the intellectual and administrative business activities sector; d_soc is equal to one if the firm belongs to the public and social activities sector; d_other is equal to one if the firm belongs to other sectors

| Variable | Model 1 (Control variables) Coefficient | Standard error | Model 2 (All variables) Coefficient | Standard error |
|---|---|---|---|---|
| Curr | | | −0.09*** | 0.03 |
| Return | | | −0.01*** | 0.00 |
| Fin_Indep | | | −0.03*** | 0.00 |
| AV_Tax | | | −0.01** | 0.00 |
| CF_TD | | | 0.01 | 0.02 |
| brussels | 0.70*** | 0.09 | 0.61*** | 0.11 |
| wallonia | 0.30*** | 0.07 | 0.11 | 0.08 |
| ln(ta) | −0.13*** | 0.02 | −0.12*** | 0.03 |
| age | −0.02*** | 0.00 | −0.01*** | 0.00 |
| d_agr_ind | 0.34*** | 0.10 | 0.46*** | 0.12 |
| d_energy | −0.67 | 0.51 | −0.62 | 0.60 |
| d_constr | −0.04 | 0.08 | 0.24* | 0.10 |
| d_catering | −0.32** | 0.12 | −0.51*** | 0.14 |
| d_admin | −0.87*** | 0.09 | −0.61*** | 0.10 |
| d_soc | −2.77*** | 0.23 | −2.23*** | 0.28 |
| d_other | −0.53 | 0.17 | −0.71*** | 0.20 |
| cons. | 1.27*** | 0.15 | 1.78*** | 0.19 |
| Model Chi2 | 590.84***(11 df) | | 2,060.37***(16 df) | |
| Log likelihood | −3,173.95 | | −2,439.19 | |

**Notes:** Partially significant at $p < 0.10$; *, **, *** indicate significance at $p < 0.05$, 0.01 and 0.001, respectively; the model is estimated on the training group Where Curr is the current ratio; return is the return on operating assets before depreciation; Fin_Indep is the global degree of financial independence; AV_Tax is the proportion of gross value added; CF_TD is the cash flow over the total debt; ln(ta) is the log of total assets; age is the age of the firm; brussels is equal to one if the firm is located in Brussels; wallonia is equal to one if the firm is located in Wallonia; d_agr_ind is equal to one if the firm belongs to the agricultural and industrial sector; d_energy is equal to one if the firm belongs to the production of energy water sector; d_constr is equal to one if the firm belongs to the construction sector; d_catering is equal to one if the firm belongs to the catering sector; d_admin is equal to one if the firm belongs to the intellectual and administrative business activities sector; d_soc is equal to one if the firm belongs to the public and social activities sector; d_other is equal to one if the firm belongs to other sectors

**Table V.**
Logit regression (dependent variable: bankruptcy)

results (Table VI) confirm that Model 2 fits the data significantly better than the more restrictive Model 1.

Therefore, only the results from Model 2 are discussed. First, the chi-square value is significant and thus reflects a good model specification. Second, regarding the direct effects, *H1*, *H2*, *H3* and *H4* are supported, as higher values for current ratio (*Curr*), return on operating assets before depreciation (*Return*), global degree of financial independence (*Fin_Indep*) and the proportion of gross value added allocated to expenses (*AV_Tax*) significantly decrease the probability of bankruptcy. The variable cash flow/

| Likelihood-ratio test | LR $chi^2$ | Prob > $chi^2$ |
|---|---|---|
| Between M1 and M2 | 1,469.52 | 0 |

**Table VI.**
Likelihood-ratio test

total debt (*CF_TD*) is not significant; therefore, *H5* is not supported. Third, it appears that firms from Wallonia and Brussels are more likely to go bankrupt than those from Flanders. Also, younger and smaller firms are more likely to go bankrupt. Differences can also be seen among the activity fields (Table VII).

The global prediction accuracy of the model, calculated on the control sample, shows that the model correctly classifies more than 80 per cent of the firms into one of the two categories (bankrupt or healthy). This result appears to be robust in comparison with others studies made in Belgium using the logit model (72.4 per cent for Gaeremynck and Willekens, 2003; 83 per cent for Dewaelheyns and Van Hulle, 2004). Moreover, if we consider the bankrupt group only, the model correctly classifies about 83 per cent of the firms.

## 5. Discussion and conclusion

Given the increasing number of SMEs in Belgium, the specific characteristics of the country in terms of political decision-making, the institutional differences between regions and the current uncertain economic circumstances, bankruptcy prediction seems to be a necessity for the country. However, the existing literature historically focuses on generic bankruptcy prediction, used for larger firms, instead of focusing on smaller, country-specific ones (Crutzen and Van Caillie, 2007, 2010). Over the past few years, only a few papers investigated that way (Altman and Sabato, 2007; Ciampi and Gordini, 2008, 2009; Yazdanfar, 2011).

The originality of this paper lies in the fact that we study Belgian SMEs instead of focussing on larger firms. Beside its contribution to the academic literature on bankruptcy prediction, this paper may also be of interest to investors or managers, as it may help them to anticipate bankruptcy risks. As Altman and Hotchkiss (2005) state, distress prediction-/credit-scoring models are also helpful for banks and other credit institutions in the assessment of credit risk of firms. Thanks to such models, they could better identify firms with a higher risk of failure in their lending decisions.

Therefore, the aim of this paper is to fill such a gap in the Belgian bankruptcy prediction literature by building a one-year bankruptcy prediction model suitable for Belgian SMEs.

To this end, we constructed a multi-dimensional model with different groups of ratios: profitability, solvency, liquidity, added value and debt structure ratios. By using a sample of 7,152 SMEs, among which 3,576 were declared bankrupt between 2002 and 2012, we built a logit model to assess the probability that the firm would go bankrupt based on its financial characteristics from the previous year.

Our results showed that nearly all hypotheses are validated. Indeed, we noticed that the probability of bankruptcy was higher for firms with lower liquidity, profitability, debt structure and added value ratios, providing evidence to Keasey and McGuinness

| | Observations | Status | % of good predictions | % of incorrect predictions |
|---|---|---|---|---|
| Training | 2,146 | Bankrupt | 82.97 | 17.03 |
| | | Healthy | 75.22 | 24.78 |
| | | Global | 79.23 | 20.77 |

**Note:** The prediction accuracy is calculated using the control group

**Table VII.**
Good classification rates

(1990), Laitinen and Laitinen (2000), Pompe and Bilderbeek (2005) and Hamza and Baghdadi (2008). Regarding the solvency ratio (cash flow/total debt), it did not appear to be significant in our model. In comparison with others studies (cf. supra), the prediction accuracy of the model can be considered satisfactory. Our results also suggest that the smaller and younger Belgian SMEs are more likely to go bankrupt. Therefore, we recommend to these firms to closely follow-up the evolution of the key analyzed ratios.

Although the results seem to be conclusive, it could be noted that the healthy sample was not paired with the bankrupt sample, which could increase the already good prediction rate. Further research could also focus on intra-sectorial analysis and the construction or the catering sectors could be studied because, according to the descriptive statistics, firms in both sectors are more likely to go bankrupt. Another research avenue could also take into account qualitative information such as managers' characteristics, the changes in governance or the style of management.

## Notes

1. In Belgium, firms with less than 100 employees are defined as SMEs.
2. We run several robustness tests by changing the division percentage of both groups. However, setting the observed group and the control group both at 50 per cent, or even 25 per cent of the initial sample for the observed group and 75 per cent for the control group, does not change our percentage of accurate prediction significantly. We can therefore consider our 70-30 per cent methodological choice as robust.

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**Corresponding author**
Loredana Cultrera can be contacted at: loredana.cultrera@umons.ac.be