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Why credit risk markets are predestined for exhibiting log-periodic power law structures

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HIGHLIGHTS

- The kernel logistic regression algorithm is discussed in detail.
- Nonlinear default indicator transformations are investigated.
- We present an equation which estimates large companies' probabilities of default.
- The discriminative power of accounting ratios is compared to those of market data.
- LPPL structures are established in the CDS spread trajectories of Cyprus and Ireland.

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ABSTRACT

Recent research has established the existence of log-periodic power law (LPPL) patterns in financial institutions' credit default swap (CDS) spreads. The main purpose of this paper is to clarify why credit risk markets are predestined for exhibiting LPPL structures. To this end, the credit risk prediction of two variants of logistic regression, i.e. polynomial logistic regression (PLR) and kernel logistic regression (KLR), are firstly compared to the standard logistic regression (SLR). In doing so, the question whether the performances of rating systems based on balance sheet ratios can be improved by nonlinear transformations of the explanatory variables is resolved. Building on the result that nonlinear balance sheet ratio transformations hardly improve the SLR's predictive power in our case, we secondly compare the classification performance of a multivariate SLR to the discriminative powers of probabilities of default derived from three different capital market data, namely bonds, CDSs, and stocks. Benefiting from the prompt inclusion of relevant information, the capital market data in general and CDSs in particular increasingly outperform the SLR while approaching the time of the credit event. Due to the higher classification performances, it seems plausible for creditors to align their investment decisions with capital market-based default indicators, i.e., to imitate the aggregate opinion of the market participants. Since imitation is considered to be the source of LPPL structures in financial time series, it is highly plausible to scan CDS spread developments for LPPL patterns. By establishing LPPL patterns in governmental CDS spread trajectories of some European crisis countries, the LPPL's application to credit risk markets is extended. This novel piece of evidence further strengthens the claim that credit risk markets are adequate breeding grounds for LPPL patterns.

1. Introduction

Estimating probabilities of default (PDs) is essential for banks in order to avoid adverse selection. Imagine that some banks have no adequate methods for estimating PDs (banks of type A). As a consequence, their loan decisions are merely dealing

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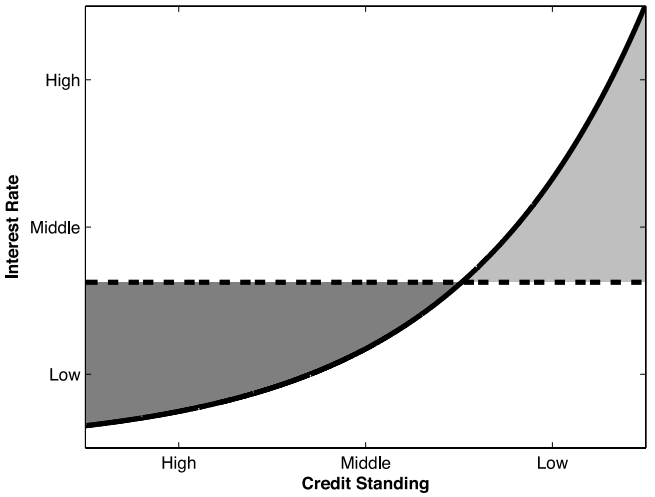

Fig. 1. *Importance of credit ratings.* Debtors of high credit standing drift towards banks of type B (solid line) which offer interest rates on an individual basis (dark grey area), whereas debtors of low credit quality are drawn to banks of type A (dashed line) which offer uniform interest rates irrespective of individual risks (light grey area).
Source: Based on Ref. [1].

with the question if loans at a uniform interest rate should be allocated. A risk-adequate pricing at the level of individual borrowers fails due to the lack of methods. However, a risk-adjusted rate on portfolio level is computed and included in the uniform interest rate in order to meet the default costs at least ex post. Uniform interest rates equally applying to all borrowers therefore imply that debtors of high credit quality provide financial support to debtors of low credit quality. Problems arise if other banks acquire the capability of risk-adequate pricing at the level of individual borrowers (banks of type B). Debtors of low credit quality drift towards banks of type A, whereas debtors of high credit quality are drawn to banks of type B. Substantial default cost implications for banks of type A result, implying the necessity of higher uniform interest rates. The process described above and illustrated in Fig. 1 repeats. Therefore, risk-adequate pricing at the level of individual debtors becomes an economic necessity, if some banks establish individual pricing systems and if the debtors know their credit standings [1–3]. Regulations, such as the Basel II capital accord, acted as catalysts during the introduction of internal rating approaches [4]. This Basel II capital accord aims at aligning the regulatory capital with the risks faced by banks, especially with respect to credit risk.

Thus, banks are caught between demand and availability of information on default risk. On the one hand, the PD of an obligor is not directly observable in reality. On the other hand, banks require those information at the time of loan decision in order to protect themselves against default costs [5]. To meet the demand for information, the PD is generally modelled as conditional probability, i.e., as the likelihood $p\left(y=1|\vec{x}\right)$ that a debtor who exhibits specific financial ratios $\vec{x}$ falls into default, denoted by $y=1$ [5]. Hence, the task of default prediction is twofold. First, default indicative financial ratios have to be selected, followed by the estimation of the PD from these ratios on the basis of adequate methods [5]. In previous financial literature, attention has been mostly dedicated to the second task, i.e. modelling the conditional PD by different classification algorithms. Physicists have recently contributed to the first task by applying the log-periodic power law (LPPL) to financial institutions' CDS spread trajectories [6]. More precisely, Wosnitza and Denz suggest the application of three LPPL parameters in order to capture the risk of "creditors' runs". The present paper aims at shedding some light on the question why credit risk markets are predestined for exhibiting LPPL structures. This overall question is addressed by answering three underlying research questions which are successively presented below.

The groundbreaking work by Altman defines the starting point of extracting default related information from financial ratios via statistical methods [7]. Reduced-form models assume an exogenous functional form for the relationship between PDs and risk factors [8]. In searching for more powerful rating models, recent studies mainly focused on comparing the forecasting abilities of different classification algorithms. The spectrum of investigated classification algorithms ranges from traditional statistical methods like multivariate discriminant analysis and logistic regression to more sophisticated artificial intelligence based algorithms like neural networks [9–11], support vector machines (SVMs) [10,12–15], and Gaussian process classifiers [16]. The general tenor of these papers is that machine learning techniques usually achieve better classification performances than traditional statistical methods. Nevertheless, the majority of these classification algorithms only differentiates between defaults and non-defaults. In contrast, the logistic regression is one of a few methods whose output can directly be interpreted as PD [17]. Partly as a result of this, the logistic regression has developed into a standard technique for estimating PDs [18]. Researchers often utilize logistic regression models as benchmarks in order to evaluate the classification performances of artificial intelligence methods. However, by limiting themselves to the standard logistic regression (SLR), these studies have not exploited the full potential of logistic regression [13,15]. Our paper presents the