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NUS-RMI Credit Research Initiative Technical Report Version: 2016 Update 1

RMI staff article
For any questions or comments on this article, please contact the CRI Team at
rmicri@nus.edu.sg

This document describes the implementation of the system which the Credit Research Initiative (CRI) at the Risk Management Institute (RMI) of the National University of Singapore (NUS) uses to produce probabilities of default (PD) and actuarial spread (AS). As of this version of the Technical Report, RMI-CRI covers over 60,000 exchange listed firms (including delisted ones) in 119 economies around the world (see Table A.1). Of them, over 30,000 firms have sufficient data to release daily updated PD and AS. The PD and AS for all firms are freely available to users who can provide evidence of their professional qualifications to ensure that they will not misuse the data. General users who do not request global access are restricted to a list of 3,000 firms. The individual company PD/AS data, along with aggregate PD/AS at the economy and sector level, can be accessed at http://rmicri.org.

The primary goal of this initiative is to drive research and development in the critical area of credit rating systems. As such, a transparent methodology is essential to this initiative. Having the details of the methodology available to everybody means that there is a base from which suggestions and improvements can be made. The objective of this Technical Report is to provide a full exposition of the CRI system. Readers of this document who have access to the necessary data and who have a sufficient level of technical expertise will be able to implement a similar system on their own. For a full exposition of the conceptual framework of the CRI, see Duan and Van Laere (2012).

The system used by the CRI will evolve as new innovations and enhancements are applied. The changes to the 2016 technical report and operational implementation of our model are: (1) The refined search method to enhance the credit event database; (2) A more refined classification of default and other exit events; (3) Replacement of stock index for Moroccan and Romanian companies;

(4) Replacement of 3-month interest rate for Indonesia and 1-year risk free rate for Denmark; (5) Revision to other liabilities fraction estimation in distance to default (DTD) computation; (6) A new section explaining the Corporate Vulnerability Index (CVI), a credit risk measure being calculated and released daily by the CRI. This version of the technical report provides an update on the operational implementation of the CRI and includes all changes to the system that had been implemented by May 2016. The latest version of the Technical Report and addenda to the latest version are available via the web portal and will include any changes to the system that have been implemented since the publication of this version.

In the remainder of this Technical Report, the PD model and its computational details will be explained in thorough details. As an application of the model, the computation of AS and CVI will be discussed in a much concise manner. Wherever no confusion is caused, "the model" refers to the PD model. The sections are organized as follows. Section I describes the quantitative model that is currently used to compute the PDs. The model was first described in Duan *et al.* (2012). The description includes calibration procedures, which are performed on a monthly basis, and individual firm's PD computations, which are performed on a daily basis.

Section II describes the input variables of the model as well as the data used to produce these inputs. This model uses both input variables that are common to all firms in an economy and input variables that are firm-specific. Another critical component in the estimation system is the default data, and this is also described in this section.

While Sec. I provides a broader description of the model, Sec. III describes the implementation details that are necessary for application, given real world issues of, for example, bad or missing data. The specific technical details needed to develop an operational system are also given, including details on the monthly calibration, daily computation of individual firm's PDs and aggregation of the individual firm's PDs. Distance-to default (DTD) in a Merton-type model is one of the firm-specific variables. The calculation for DTD is not the standard one, and has been modified to allow a meaningful computation of the DTD for financial firms. While most academic studies on default prediction exclude financial firms from consideration, it is important to include them given that the financial sector is a critical component in every economy. The calculation for DTD is detailed in this section.

Section IV shows an empirical analysis for those economies that are currently covered. While the analysis shows excellent results in several economies, there is room for improvement in a few others. This is because, at the CRI's current stage of development, the economies all use the variables used in the academic study of US firms in Duan *et al.* (2012). Future development within the CRI will deal with variable selection specific to different economies, and the performance is then expected to improve. Sections V and VI explain how the CVI and AS are formulated. A detailed theoretical background on AS can be found in Duan (2014). Section VII discusses future developments.

I. MODEL DESCRIPTION

The quantitative model that is currently being used by the CRI is a forward intensity model that was introduced in Duan *et al.* (2012). Certain aspects of the model are taken from Duan and Fulop (2013). This model allows PD forecasts to be made at a range of horizons. In the current CRI implementation of this model, PDs are forecasted from a horizon of one month up to a horizon of five years. At the RMI-CRI website, for every firm, the probability of that firm defaulting within one month, three months, six months, one year, two years, three years and five years is given. The ability to assess credit quality for different horizons is a useful tool for risk management, credit portfolio management, policy setting and regulatory purposes, since short- and long-term credit risk profiles can differ greatly depending on a firm's liquidity, debt structures and other factors.

The forward intensity model is a reduced form model in which the PD is computed as a function of different input variables. These can be firm-specific or common to all firms within an economy. The other category of the default prediction model is the structural model, whereby the corporate structure of a firm is modeled in order to assess the firm's PD.

A similar reduced form model by Duffie *et al.* (2007) relies on modeling the time series dynamics of the input variables in order to make PD forecasts for different horizons. However, there is little consensus on assumptions for the dynamics of variables such as accounting ratios, and the model output will be highly dependent on these assumptions. In addition, the time series dynamics will be of very high dimension. For example, with the two common variables and two firm-specific variables that Duffie *et al.* (2007) use, a sample of 10,000 firms gives a dimension of the state variables of 20,002.

Given the complexity in modeling the dynamics of variables such as accounting ratios, this model will be difficult to implement if different forecast horizons are required. The key innovation of the forward intensity model is that PD for different horizons can be consistently and efficiently computed based only on the value of the input variables at the time the prediction is made. Thus, the model specification becomes far more tractable.

Fully specifying a reduced form model includes the specification of the function that computes a PD from the input variables. This function is parameterized, and finding appropriate parameter values is called calibrating the model. The forward intensity model can be calibrated by maximizing a pseudo-likelihood function. The calibration is carried out by groups of economies and all firms within a group of economies will use the same parameter values along with each firm's variables in order to compute the firm's PD.

Section I.1 will describe the modeling framework, including the way PDs are computed based on a set of parameter values for the economy and a set of input variables for a firm. Section I.2 explains how the model can be calibrated. Section I.3 details the way parameters are estimated based on the Sequential Monte Carlo (SMC) technique.

I.1. Modeling Framework

While the model can be formulated in a continuous time framework, as done in Duan *et al.* (2012), an operational implementation requires discretization in time. Since the model is more easily understood in discrete time, the following exposition of the model will begin in a discrete time framework.

Variables for default prediction can have vastly different update frequencies. Financial statement data is updated only once a quarter or even once a year, while market data like stock prices are available at frequencies of seconds. A way of compromising between these two extremes is to have a fundamental time period Δt of one month in the modeling framework. As will be seen later, this does not preclude updating the PD forecasts on a daily basis. This is important since, for example, large daily changes in a firm's stock price can signal changes in credit quality even when there is no change in FS data.

Thus, for the purposes of calibration and subsequently for computing time series of PD, the input variables at the end of each month will be kept for each firm. The input variables associated with the ith firm at the end of the nth month (at time $t = n\Delta t$) is denoted by $X_i(n)$. This is a vector consisting of two parts: $X_i(n) = (W(n), U_i(n))$. Here, $W(n)$ is a vector of variables at the end of month n that is common to all firms in the economy and $U_i(n)$ is a vector of variables specific to firm i.

In the forward intensity model, a firm's default is signaled by a jump in a Poisson process. The probability of a jump in the Poisson process is determined by the intensity of the Poisson process. The forward intensity model draws an explicit dependence of intensities at time periods in the future (that is, forward intensities) to the values of input variables at the time of prediction. With forward intensities, PDs for any forecast horizon can be computed knowing only the values of the input variables at the time of prediction, without needing to simulate future values of the input variables.

There is a direct analogy in interest rate modeling. In spot rate models where dynamics on a short-term spot rate are specified, bond pricing requires expectations on realizations of the short rate. Alternatively, bond prices can be computed directly if the forward rate curve is known.

One issue in default prediction is that firms can exit public exchanges for reasons other than default, such as merge and acquisition (M&A) and OTC. In order to take these other exits into account, defaults and other exits are modeled as two independent Poisson processes, each with their own intensity. While defaults and exits classified as non-defaults are mutually exclusive by definition, the assumption of independent Poisson processes does not pose a problem since the probability of a simultaneous jump in the two Poisson processes is negligible. In the discrete time framework, the probability of simultaneous jumps in the same time interval is non-zero. As a modeling assumption, a simultaneous jump in the same time interval by both the default Poisson process and the non-default type exit Poisson process is considered as a default. In this way, there are three mutually exclusive possibilities during each time interval: survival, default and non-default exit. As with defaults, the forward intensity of the Poisson process for other exits is a function of the input variables. The parameters of this function can also be calibrated.

To further illustrate the discrete framework, the three possibilities for a firm at each time point are diagrammed. Either the firm survives for the next time period Δt, or it defaults within Δt, or it has a non-default exit within Δt. This setup is pictured in Fig. 1. Information about firm i is known up until time $t = m\Delta t$ and the figure illustrates possibilities in the future between $t = (n-1)\Delta t$ and $(n+1)\Delta t$. Here, m and n are integers with $m < n$.

The probabilities of each branch are, for example: $p_i(m, n)$ the conditional probability viewed from $t = m\Delta t$ that firm i will default before $(n+1)\Delta t$, conditioned on firm i surviving up until $n\Delta t$. Likewise, $\bar{p}_i(m, n)$ is the conditional probability viewed from $t = m\Delta t$ that firm i will have a non-default exit before $(n+1)\Delta t$, conditioned on firm i surviving up until $n\Delta t$. It is the modeler's objective to determine $p_i(m, n)$ and $\bar{p}_i(m, n)$, but for now it is assumed that these quantities are known. With the conditional default and other exit probabilities known, the corresponding conditional survival probability of firm i is $1 - p_i(m, n) - \bar{p}_i(m, n)$.

With this diagram in mind, the probability that a particular path will be followed is the product of the conditional probabilities along the path. For example, the probability at time $t = m\Delta t$ of firm i surviving until $(n-1)\Delta t$ and then defaulting between $(n-1)\Delta t$ and $n\Delta t$ is:

$$\text{Prob}_{t=m\Delta t}[\tau_i = n, \tau_i < \bar{\tau}_i] = p_i(m, n-1) \prod_{j=m}^{n-2} [1 - p_i(m, j) - \bar{p}_i(m, j)], \tag{1}$$

where τ_i is the default time for firm i measured in units of months, $\bar{\tau}_i$ is the other exit time measured in units of months, and the product is equal to 1 if there is no term in the product. The condition $\tau_i < \bar{\tau}_i$ is the requirement that the firm defaults before it has a non-default type of exit. Note that by measuring exits in units of months, if, for example, a default occurs at any time in the interval $[(n-1)\Delta t, n\Delta t]$, then $\tau_i = n$.

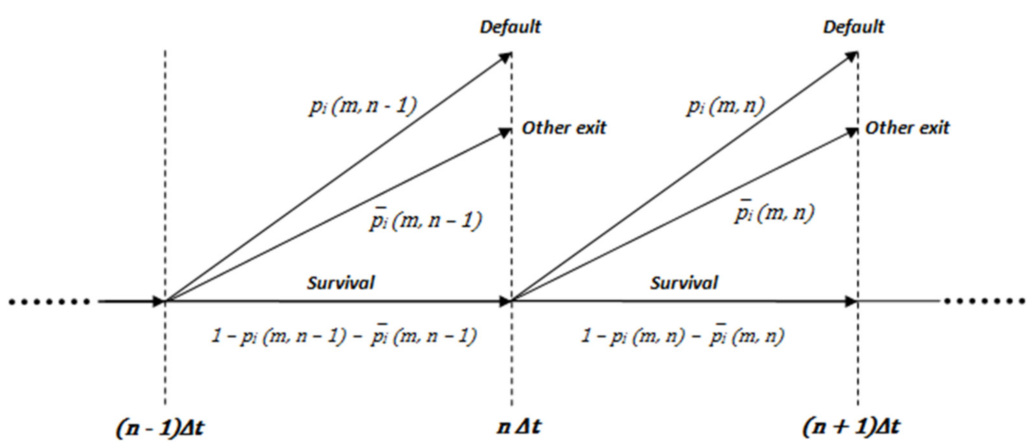


Figure 1. Default-other exit-survival tree for firm i, viewed from time $t = m\Delta t$.

Using Eq. (1), cumulative default probabilities can be computed. At $m\Delta t$ the probability of firm i defaulting at or before $n\Delta t$ and not having an other exit before $t = n\Delta t$ is obtained by taking the sum of all of the paths that lead to default at or before $n\Delta t$:

$$\text{Prob}_{t=m\Delta t}[m < \tau_i \leq n, \tau_i < \bar{\tau}_i] = \sum_{k=m}^{n-1} \left\{ p_i(m,k) \prod_{j=m}^{k-1} [1 - p_i(m,j) - \bar{p}_i(m,j)] \right\}. \quad (2)$$

While it is convenient to derive the probabilities given in Eqs. (1) and (2) in terms of the conditional probabilities, expressions for these in terms of the forward intensities need to be found, since the forward intensities will be functions of the input variable $X_i(m)$. The forward intensity for the default firm i that is observed at time $t = m\Delta t$ for the forward time interval from $t = n\Delta t$ to $(n+1)\Delta t$, is denoted by $h_i(m,n)$, where $m \leq n$. The corresponding forward intensity for a non-default exit is denoted by $\bar{h}_i(m,n)$. Because default is signaled by a jump in a Poisson process, its conditional probability is a simple function of its forward intensity:

$$p_i(m,n) = 1 - \exp[-\Delta t h_i(m,n)]. \quad (3)$$

Since joint jumps in the same time interval are assigned as defaults, the conditional other exit probability needs to take this into account:

$$\bar{p}_i(m,n) = \exp[-\Delta t h_i(m,n)] \times \{1 - \exp[-\Delta t \bar{h}_i(m,n)]\}. \quad (4)$$

The conditional survival probabilities in Eqs. (1) and (2) are computed as the conditional probability that the firm does not default in the period and the firm does not have a non-default exit either:

$$\text{Prob}_{t=m\Delta t}[\tau_i, \bar{\tau}_i > n+1 \mid \tau_i, \bar{\tau}_i > n] = \exp\{-\Delta t[h_i(m,n) + \bar{h}_i(m,n)]\}. \quad (5)$$

It remains to be specified the dependence of the forward intensities on the input variable $X_i(m)$. The forward intensities need to be positive so that the conditional probabilities are non-negative. A standard way to impose this constraint is to specify the forward intensities as exponentials of a linear combination of the input variables:

$$\begin{aligned} h_i(m,n) &= \exp[\beta(n-m) \cdot Y_i(m)], \\ \bar{h}_i(m,n) &= \exp[\bar{\beta}(n-m) \cdot Y_i(m)]. \end{aligned} \quad (6)$$

Here, β and $\bar{\beta}$ are coefficient vectors that are functions of the number of months between the observation date and the beginning of the forward period $(n-m)$, and $Y_i(m)$ is simply the vector $X_i(m)$ augmented by a preceding unit element: $Y_i(m) = (1, X_i(m))$. The unit element allows the linear combination in the argument of the exponentials in Eq. (6) to have a non-zero intercept.

In the current implementation of the forward intensity model in the CRI, the maximum forecast horizon is 60 months (5 years) and there are 12 input variables plus the intercept, so there are 60 sets of β and $\bar{\beta}$. While this is a large set of parameters, as will be seen in Secs. I.2 and I.3, the calibration is tractable because the default parameters can be calibrated separately from the other exit parameters, and the total number of parameters are greatly reduced after constraining the term-structure of the parameter estimates to be Nelson–Siegel functions.

Before expressing the probabilities in Eqs. (1) and (2) in terms of the forward intensities, a notation H is introduced for the forward intensities so that it becomes clear which parameters the forward intensity depends on:

$$H(\beta(n-m), X_i(m)) = \exp[\beta(n-m) \cdot Y_i(m)]. \quad (7)$$

This is the forward default intensity. The corresponding notation for other exit forward intensities is then just $H(\bar{\beta}(n-m), X_i(m))$. So, the probability in Eq. (1) is expressed in terms of the forward intensities, using Eq. (3) as the conditional default probability and Eq. (5) as the conditional survival probability:

$$\text{Prob}_{t=m\Delta t}[\tau_i = n, \tau_i < \bar{\tau}_i] = \{1 - \exp[-\Delta t \; H(\beta(n-1-m), X_i(m))]\}$$

$$\times \prod_{j=m}^{n-2} \exp\{-\Delta t\ [H(\beta(j-m), X_i(m)) + H(\bar{\beta}(j-m), X_i(m))]\}$$

$$= \{1 - \exp[-\Delta t\ H(\beta(n-m-1), X_i(m))]\} \times \exp\left\{-\Delta t \sum_{j=m}^{n-2} [H(\beta(j-m), X_i(m)) + H(\bar{\beta}(j-m), X_i(m))]\right\}. \quad (8)$$

This probability will be relevant in the next part during the calibration. The cumulative default probability given in Eq. (2) in terms of the forward intensities is then:

$$\text{Prob}_{t=m\Delta t}[m < \tau_i \leq n, \tau_i < \bar{\tau}_i] = \sum_{k=m}^{n-1} \left\{ \{1 - \exp[-\Delta t\ H(\beta(k-m), X_i(m))]\} \times \exp\left\{-\Delta t \sum_{j=m}^{k-1} [H(\beta(j-m), X_i(m)) + H(\bar{\beta}(j-m), X_i(m))]\right\}\right\}. \quad (9)$$

This formula is used to compute the main output of the CRI: an individual firm's PD within various time horizons. The β and $\bar{\beta}$ parameters are obtained when the firm's economy is calibrated, and using those together with the firm's input variables yields the firm's PD.

I.2. Pseudo-Likelihood Function

The empirical data set used for calibration can be described as follows. For the economy as a whole, there are N end of month observations, indexed as $n = 1, \ldots, N$. Of course, not all firms will have observations for each of the N months as they may start later than the start of the economy's data set or they may exit before the end of the economy's data set. There are a total of I firms in the economy, and they are indexed as $i = 1, \ldots, I$. As before, the input variables for the ith firm in the nth month is $X_i(n)$. The set of all observations for all firms is denoted by X.

In addition, the default times τ_i and non-default exit times $\bar{\tau}_i$ for the ith firm are known if the default or other exit occurs after time $t = \Delta t$ and at or before $t = N\Delta t$. The possible values for τ_i and $\bar{\tau}_i$ are integers between 2 and N, inclusive. If a firm exits before the month end, then the exit time is recorded as the first month end after the exit. If the firm does not exit before $t = N\Delta t$, then the convention can be used that both of these values are infinite. If the firm has a default type of exit within the data set, then $\bar{\tau}_i$ can be considered as infinite. If instead the firm has a non-default type of exit within the data set, then τ_i can be considered as infinite. The set of all default times and non-default exit times for all firms is denoted by τ and $\bar{\tau}$, respectively. The first month in which firm i has an observation is denoted by t_{0i}. Except for cases of missing data, these observations continue until the end of the data set if the firm never exits. If the firm does exit, the last needed input variable $X_i(n)$ is for $n = \min(\tau_i, \bar{\tau}_i) - 1$.

The calibration of the β and $\bar{\beta}$ parameters is done by maximizing a pseudo-likelihood function. The function to be maximized violates the standard assumptions of likelihood functions, but Appendix A in Duan *et al.* (2012) derives the large sample properties of the pseudo-likelihood function.

In formulating the pseudo-likelihood function, the assumption is made that the firms are conditionally independent from each other. In other words, correlations arise naturally from shared common factors $W(n)$ and any correlations between different firms' firm-specific variables. With this assumption, the pseudo-likelihood function for the horizon of ℓ months, a set of parameters β and $\bar{\beta}$ and the data set $(\tau, \bar{\tau}, X)$ is:

$$\mathcal{L}_\ell(\beta, \bar{\beta}; \tau, \bar{\tau}, X) = \prod_{m=1}^{N-1} \prod_{i=1}^{I} P_{\min(N-m,\ell)}(\beta, \bar{\beta}; \tau_i, \bar{\tau}_i, X_i(m)). \quad (10)$$

Here, $P_{\min(N-m,\ell)}(\beta, \bar{\beta}; \tau_i, \bar{\tau}_i, X_i(m))$ is a probability for the ith firm, with the nature of the probability depending on what happens to the firm during the period from month m to month $m + \min(N-m, \ell)$.

This is defined as:

$$
\begin{aligned}
&P_\ell(\beta, \bar{\beta}; \tau_i, \bar{\tau}_i, X_i(m)) \\
&= 1_{\{t_{0i} \le m, \min(\tau_i, \bar{\tau}_i) > m+\ell\}} \\
&\quad \times \exp\left\{ -\Delta t \sum_{j=0}^{\ell-1} [H(\beta(j), X_i(m)) + H(\bar{\beta}(j), X_i(m))] \right\} \\
&\quad + 1_{\{t_{0i} \le m, \tau_i \le \bar{\tau}_i, \tau_i \le m+\ell\}} \\
&\quad \times \{1 - \exp[-\Delta t\, H(\beta(\tau_i - m - 1), X_i(m))]\} \\
&\quad \times \exp\left\{ -\Delta t \sum_{j=0}^{\tau_i - m - 2} [H(\beta(j), X_i(m)) + H(\bar{\beta}(j), X_i(m))] \right\} \\
&\quad + 1_{\{t_{0i} \le m, \bar{\tau}_i \le \tau_i, \bar{\tau}_i \le m+\ell\}} \\
&\quad \times \{1 - \exp[-\Delta t\, H(\bar{\beta}(\bar{\tau}_i - m - 1), X_i(m))]\} \\
&\quad \times \exp[-\Delta t H(\beta(\tau_i - m - 1), X_i(m))] \\
&\quad \times \exp\left\{ -\Delta t \sum_{j=0}^{\bar{\tau}_i - m - 2} [H(\beta(j), X_i(m)) + H(\bar{\beta}(j), X_i(m))] \right\} \\
&\quad + 1_{\{t_{0i} > m\}} + 1_{\{\min(\tau_i, \bar{\tau}_i) \le m\}}.
\end{aligned} \tag{11}
$$

In words, if the ith firm survives from the observation time at month m for the full horizon ℓ until at least $m + \ell$, then the probability is the model-based survival probability for this period. This is the first term in Eq. (11). The second term handles the cases where the firm has a default within the horizon, in which case the probability is the model-based probability of the firm defaulting at the month that it ends up defaulting, as given in Eq. (8). The third term handles the cases where the firm has a non-default exit within the horizon, in which case the probability is the model-based probability of the firm having a non-default type exit at the month that the exit actually does occur. The expression for this probability uses the conditional non-default type exit probability given in Eq. (4). The final two terms handle the cases where the firm is not in the data set at month m — either the first observation for the firm is after m or the firm has already exited. A constant value is assigned in this case so that this firm will not affect the maximization at this time point.

The pseudo-likelihood function given in Eq. (10) can be numerically maximized to give estimates for the coefficients β and $\bar{\beta}$. Notice though that the sample observations for the pseudo-likelihood function are overlapping if the horizon is longer than one month. For example, when $\ell = 2$, default over the next two periods from month m is correlated to default over the next two periods from month $m + 1$ due to the common month in the two sample observations. However, in Appendix A of Duan *et al.* (2012), the maximum pseudo-likelihood estimator is shown to be consistent, in the sense that the estimators converge to the "true" parameter value in the large sample limit.

Notice though that each of the terms in Eq. (11) can be written as a product of terms containing only β and terms containing only $\bar{\beta}$. This will allow separate maximizations with respect to β and with respect to $\bar{\beta}$, that is, the defaults and other exits.

The β and $\bar{\beta}$ specific versions of Eq. (11) are:

$$
\begin{aligned}
&P_\ell^\beta(\beta; \tau_i, \bar{\tau}_i, X_i(m)) \\
&= 1_{\{t_{0i} \le m, \min(\tau_i, \bar{\tau}_i) > m+\ell\}} \exp\left\{ -\Delta t \sum_{j=0}^{\ell-1} H(\beta(j), X_i(m)) \right\} \\
&\quad + 1_{\{t_{0i} \le m, \tau_i \le \bar{\tau}_i, \tau_i \le m+\ell\}} \exp\left\{ -\Delta t \sum_{j=0}^{\tau_i - m - 2} H(\beta(j), X_i(m)) \right\} \\
&\quad \times \{1 - \exp[-\Delta t\, H(\beta(\tau_i - m - 1), X_i(m))]\} \\
&\quad + 1_{\{t_{0i} \le m, \bar{\tau}_i \le \tau_i, \bar{\tau}_i \le m+\ell\}} \exp\left\{ -\Delta t \sum_{j=0}^{\bar{\tau}_i - m - 2} H(\beta(j), X_i(m)) \right\} \\
&\quad \times \exp[-\Delta t\, H(\beta(\tau_i - m - 1), X_i(m))] \\
&\quad + 1_{\{t_{0i} > m\}} + 1_{\{\min(\tau_i, \bar{\tau}_i) \le m\}}, \\
&P_\ell^{\bar{\beta}}(\bar{\beta}; \tau_i, \bar{\tau}_i, X_i(m)) \\
&= 1_{\{t_{0i} \le m, \min(\tau_i, \bar{\tau}_i) > m+\ell\}} \exp\left\{ -\Delta t \sum_{j=0}^{\ell-1} H(\bar{\beta}(j), X_i(m)) \right\} \\
&\quad + 1_{\{t_{0i} \le m, \tau_i \le \bar{\tau}_i, \tau_i \le m+\ell\}} \exp\left\{ -\Delta t \sum_{j=0}^{\tau_i - m - 2} H(\bar{\beta}(j), X_i(m)) \right\} \\
&\quad + 1_{\{t_{0i} \le m, \bar{\tau}_i \le \tau_i, \bar{\tau}_i \le m+\ell\}} \exp\left\{ -\Delta t \sum_{j=0}^{\bar{\tau}_i - m - 2} H(\bar{\beta}(j), X_i(m)) \right\} \\
&\quad \times \{1 - \exp[-\Delta t\, H(\bar{\beta}(\bar{\tau}_i - m - 1), X_i(m))]\} \\
&\quad + 1_{\{t_{0i} > m\}} + 1_{\{\min(\tau_i, \bar{\tau}_i) \le m\}}.
\end{aligned} \tag{12}
$$

Then, the β and $\bar{\beta}$ specific versions of the pseudo-likelihood function are given by:

$$
\begin{aligned}
\mathcal{L}_\ell^\beta(\beta; \tau, \bar{\tau}, X) &= \prod_{m=1}^{N-\ell} \prod_{i=1}^{I} P_\ell^\beta(\beta; \tau_i, \bar{\tau}_i, X_i(m)), \\
\mathcal{L}_\ell^{\bar{\beta}}(\bar{\beta}; \tau, \bar{\tau}, X) &= \prod_{m=1}^{N-\ell} \prod_{i=1}^{I} P_\ell^{\bar{\beta}}(\bar{\beta}; \tau_i, \bar{\tau}_i, X_i(m)).
\end{aligned} \tag{13}
$$

With the definitions given in Eqs. (12) and (13), it can be seen that:

$$\mathcal{L}_\ell(\beta, \bar{\beta}; \tau, \bar{\tau}, X) = \mathcal{L}_\ell^{\beta}(\beta; \tau, \bar{\tau}, X)\mathcal{L}_\ell^{\bar{\beta}}(\bar{\beta}; \tau, \bar{\tau}, X). \tag{14}$$

Thus, $\mathcal{L}_\ell^{\beta}$ and $\mathcal{L}_\ell^{\bar{\beta}}$ can be separately maximized to find their respective parameters. Section I.3 will further explain how the optimum parameters can be estimated.

I.3. Parameter Estimation

Previously, the CRI system produced default predictions to a horizon of two years (CRI, 2012). An extension of the forecast horizon has been implemented as of the PD released on 1 April 2013. With this update, horizons of up to five years are now being computed. Technically speaking, horizons of arbitrary length can be calculated.

This extension to a five-year horizon is done by constraining the term-structure of the parameter estimates to be Nelson–Siegel (1987) (NS) functions of the forward-starting time. Horizon-specific parameters β, $\bar{\beta}$ can be obtained from the continuous NS function by using the forward prediction horizon as an input. The term-structures are further constrained so that the effect of risk factors on the forward intensity goes to zero as the horizon increases. This allows tractable and parsimonious extrapolations for horizons beyond five years.

The parameter estimation for the NS functions is based on a new numerical method (a pseudo-Bayesian SMC technique) developed in a working paper by Duan and Fulop (2013). The remainder of this section details the new parameter estimation. Section I.3.1 describes the parameterization of the parameters by NS functions, Sec. I.3.2 gives an overview of the SMC method that is used to estimate the NS functions, Sec. I.3.3 details the calculation of the confidence intervals for the parameter estimation, and Sec. I.3.4 describes how the parameters can be re-estimated given new data or updates of old data.

I.3.1. *Smoothed parameters*

Duan *et al.* (2012) formulate the forward intensity model in which the forward default intensity for a firm is a function of a number of covariates. The forward default intensities for different forward starting periods are computed using different sets of parameters.

In Duan *et al.* (2012), the sets of parameters are estimated separately for each forward starting time. Parameters at different forward starting times that are associated with each covariate can be approximated by a function of the forward starting time using NS type term structure functions. Duan *et al.* (2012) show that this approximation by NS functions does not negatively affect prediction performance. The CRI implementation follows Duan and Fulop (2013) to impose the functional restriction during the estimation as opposed to the method used in Duan *et al.* (2012) of fitting the curve after parameter estimates have been obtained. This is done for two reasons.

First, it will significantly reduce the number of parameters. For example, using 12 covariates for forward default intensities up to 60 months would require a joint estimation of $13 \times 60 = 780$ parameters. Here, 13 comes from adding an intercept to the intensity function with 12 covariates. If the coefficients corresponding to each covariate are represented by the NS function of four parameters, there will be at most $13 \times 4 = 52$ parameters. In fact, there will be fewer parameters as some of the NS parameters will be constrained to zero.

Second, the NS function will allow extrapolation. For example, the 13 NS functions estimated with predictions up to 60 months can be used for prediction, say, over 72 months.

The NS function with four free parameters is:

$$\begin{aligned} r(t; \varrho_0, \varrho_1, \varrho_2, d) &= \varrho_0 + \varrho_1 \frac{1-\exp(-t/d)}{t/d} \\ &\quad + \varrho_2 \left[\frac{1-\exp(-t/d)}{t/d} - \exp(-t/d)\right], \end{aligned} \tag{15}$$

where t is the forecast horizon (measured in years). In the CRI implementation, the horizon is 60 months (5 years) so that t ranges from 0 to $59/12$. Once the four NS parameters are estimated, individual horizon-specific parameters β, $\bar{\beta}$ are obtained from the NS function r using the forecast horizon as input to the NS function. In our current implementation with forecast horizons extending to 60 months (5 years), 120 sets of month specific β and $\bar{\beta}$ are obtained. For all covariates, the restriction $d > 0$ is imposed so that the functions converge to a value for large t. This formulation will be used for forward intensities for both defaults and other types of exit.

For the coefficients of all stochastic covariates, the long-run level ϱ_0 is restricted to zero, because the current value of a stochastic covariate should be uninformative of default or other exits when the forward starting time goes to infinity. In other words, the coefficient of such a stochastic covariate should approach zero when t goes to infinity.

The intercept of the forward intensity function is of course non-stochastic. Thus, ϱ_0 can have non-zero values for the intercept. With these restrictions on the NS parameters, take the example of 12 covariates, there will be a total of $12 \times 3 + 1 \times 4 = 40$ parameters.

In the CRI implementation, the NS function is further constrained to be non-positive for certain covariates: DTD level and trend, liquidity level and trend, and profitability level and trend. Refer to Sec. II for descriptions of these covariates.

I.3.2. *Parameter estimation by SMC*

Reliably estimating a system involving 40 parameters presents a numerical challenge. Moreover, the number of parameters can be greater than 40 if there are more than 12 covariates. The CRI implementation follows Duan and Fulop (2013) who use the SMC pseudo-Bayesian method for estimation and self-normalized statistics for inference.

Due to decomposability, the analysis can be performed separately on the forward default and other exit intensities. The data in the CRI implementation are refreshed with monthly frequency, and the sample likelihood used in estimation relies on default predictions running from 1 month to 60 months with a one month increment. Naturally, default prediction is subject to data availability. Towards the end of the period with available data, the prediction horizon naturally decreases and stops at one-month predictions.

The following exposition closely follows the appendix in Duan and Fulop (2013). It is important to note that the CRI implementation uses the model described in Duan and Fulop (2013), which does not contain any latent frailty or partial conditioning variable, and hence is technically much simpler in parameter estimation. For example, there is no nonlinear filtering problem.

According to the current modeling framework, where for a particular economy there are N end of the month observations, the input variables of the ith firm in the mth month is given by $X_i(m)$. Let θ denote a set of NS parameters and ℓ denote the forecast horizon ($\ell = 60$). Then the pseudo-likelihood function at step m, denoted by $\mathcal{L}_{m,\min(N-m,\ell)}(\theta)$, takes the form:

$$\mathcal{L}_{m,\min(N-m,\ell)}(\theta) = \prod_{i=1}^{I} P_{\min(N-m,\ell)}(\beta(\theta), \bar{\beta}(\theta); \tau_i, \bar{\tau}_i, X_i(m)), \quad (16)$$

where I is the number of firms, $\beta(\theta)$ and $\bar{\beta}(\theta)$ are the coefficient vectors from Eq. (6) generated from the NS functions with parameter θ. One may notice that $\mathcal{L}_{m,\min(N-m,\ell)}(\theta)$ is one of the terms in the outer-most product in Eq. (10).

Let $\pi(\theta)$ denote the prior. Following the notation from Sec. I.1, consider the following pseudo-posterior distribution at time n after one makes the ℓ-period prediction:

$$\gamma_n(\theta) \propto \prod_{m=1}^{n-1} \mathcal{L}_{m,\min(N-m,\ell)}(\theta)\pi(\theta), \quad \text{for } n = 2, \ldots, N. \quad (17)$$

One can apply the sequential batch-resampling routine of Chopin (2012) together with tempering steps as in Del Moral *et al.* (2006) to advance the system. For each n, this procedure yields a weighted sample of K particles, $(\theta^{(k,n)}, w^{(k,n)})$ for $k = 1, \ldots, K$, whose empirical distribution function will converge to $\gamma_n(\theta)$ as K increases. In the following paragraphs, the superscript k denotes the particle index. Note that in the CRI implementation, $K = 1{,}000$.

***Initialization*:** Draw an initial random sample from the prior: $(\theta^{(k,0)} \sim \pi(\theta),\ w^{(k,0)} = 1/K)$. Here, the only role of the prior $\pi(\theta)$, is to provide the initial particle cloud from which the algorithm can start. Of course, the support of $\pi(\theta)$ must contain the true parameter value θ_0. In the CRI implementation, normal/truncated normal priors are used. Truncation applies in order to impose the restriction $d > 0$. To obtain the means of the priors for the SMC method, a least square fit of the MLE parameter estimates to the NS function is conducted. The standard deviations of the priors are set to 5.

***Recursions and defining the tempering sequence*:** Assume there is a particle cloud $(\theta^{(k,n)}, w^{(k,n)})$ whose empirical distribution represents $\gamma_n(\theta)$. Then, a cloud representing $\gamma_{n+1}(\theta)$ will be reached by combining importance sampling and the Markov Chain Monte Carlo (MCMC) steps. Sometimes moving directly from $\gamma_n(\theta)$ to $\gamma_{n+1}(\theta)$ is too ambitious as the two distributions are too far from each other. This will be reflected in highly variable importance weights if one resorts to direct importance sampling. Hence, following Duan and Fulop (2013) which in turn followed Del Moral *et al.* (2006), a tempered bridge is built between the two densities and the particles are evolved through the resulting sequence of densities. In particular, assume that at time $n+1$, there are P_{n+1} intermediate densities:

$$\overline{\gamma}_{n+1,p}(\theta) \propto \gamma_n(\theta)\mathcal{L}^{\xi_p}_{n,\min(N-n,\ell)}(\theta), \quad \text{for } p = 1, \ldots, P_{n+1}. \tag{18}$$

This construction defines an appropriate bridge: $\xi_0 = 0$ so that $\overline{\gamma}_{n+1,0}(\theta) = \gamma_n(\theta)$, and $\xi_{P_{n+1}} = 1$ so that $\overline{\gamma}_{n+1,P_{n+1}}(\theta) = \gamma_{n+1}(\theta)$. For p between 0 and P_{n+1}, ξ_p is chosen from a grid of points to evenly distribute the weights, as decribed below. A particle cloud representing $\overline{\gamma}_{n+1,0}(\theta)$ can be initialized as $(\overline{\theta}^{(k,n+1,0)}, \overline{w}^{(k,n+1,0)}) = (\theta^{(k,n)}, w^{(k,n)})$. Then, for $p = 1, \ldots, P_{n+1}$ the sequence proceeds as follows:

- *Reweighting Step*: In order to arrive at a representation of $\overline{\gamma}_{n+1,p}(\theta)$, the particles representing $\overline{\gamma}_{n+1,p-1}(\theta)$ and the importance sampling principle can be used. This leads to:

$$\overline{\theta}^{(k,n+1,p)} = \overline{\theta}^{(k,n+1,p-1)}, \tag{19}$$

$$\begin{aligned}\overline{w}^{(k,n+1,p)} &= \overline{w}^{(k,n+1,p-1)} \\ &\quad\times \frac{\overline{\gamma}_{n+1,p}(\overline{\theta}^{(k,n+1,p)})}{\overline{\gamma}_{n+1,p-1}(\overline{\theta}^{(k,n+1,p)})} \\ &= \overline{w}^{(k,n+1,p-1)} \\ &\quad\times \mathcal{L}^{\xi_p-\xi_{p-1}}_{n,\min(N-n,\ell)}(\overline{\theta}^{(k,n+1,p)}).\end{aligned} \tag{20}$$

To avoid particle impoverishment in sequential importance sampling where most of the weight is concentrated in a small number of particles, a resample-move step is run, which is triggered whenever a measure of particle diversity — the efficient sample size (ESS) defined as

$$\text{ESS} = \frac{\left(\sum_{k=1}^{N} \overline{w}^{(k,n+1,p)}\right)^2}{\sum_{k=1}^{N}(\overline{w}^{(k,n+1,p)})^2}, \tag{21}$$

falls below some preset value B. Here, resampling directs the particle cloud towards more likely areas of the sampling space, while the move step enriches particle diversity.

In the CRI implementation, B is set to 50% of sample size, which is 500. Thus, if ESS < 500, the following resampling and move steps are performed.

- *Resampling Step*: The particles are resampled proportional to their weights. If $I^{(k,n+1,p)} \in (1, \ldots, K)$ are particle indices sampled proportional to $\overline{w}^{(k,n+1,p)}$, the equally weighted particles are obtained as

$$\overline{\theta}^{(k,n+1,p)} = \overline{\theta}^{(I^{(k,n+1,p)},n+1,p)}, \tag{22}$$

$$\overline{w}^{(k,n+1,p)} = \frac{1}{K}. \tag{23}$$

- *Move Step*: Each particle is passed through a Markov kernel $\mathcal{K}_{n+1,p}(\overline{\theta}^{(k,n+1,p)}, \cdot)$ that leaves $\overline{\gamma}_{n+1,p}(\theta)$ invariant, typically a Metropolis–Hastings kernel:

(1) Propose $\theta^{*(k)} \sim \mathcal{Q}_{n+1,p}(\,\cdot\,|\overline{\theta}^{(k,n+1,p)})$.
(2) Compute the acceptance weight α, where:

$$\alpha = \min\left(1, \frac{\overline{\gamma}_{n+1,p}(\theta^{*(k)})\mathcal{Q}_{n+1,p}(\overline{\theta}^{(k,n+1,p)}\,|\,\theta^{*(k)})}{\overline{\gamma}_{n+1,p}(\overline{\theta}^{(k,n+1,p)})\mathcal{Q}_{n+1,p}(\theta^{*(k)}\,|\,\overline{\theta}^{(k,n+1,p)})}\right). \tag{24}$$

(3) With probability α, set $\overline{\theta}^{(k,n+1,p)} = \theta^{*(k)}$, otherwise keep the old particle.

This step will enrich the support of the particle cloud while conserving its distribution. If the particle set is a poor representation of the target distribution, the move step can also help adjust the location of the support. Crucially, given the importance of the sampling setup, the proposal distribution $Q_{n+1,p}(\cdot \mid \overline{\theta}^{(k,n+1,p)})$ can be adapted using the existing particle cloud.

In the CRI implementation, block independent normal distribution proposals using the means and the standard deviations implied by the particle set are fitted to the particle cloud before the move. Three (or four) NS parameters corresponding to each covariate form one block. To ensure that the NS parameter d remains positive, any block with a non-positive value for d is discarded. To ensure the smoothness of the term structure of the forward intensity parameters, any block that does not produce an increasing or decreasing structure of the NS function for the first five months is also discarded. Once some block is discarded, the particle is regenerated until it meets the requirements. Note that the likelihood ratio in the Metropolis–Hastings algorithm is not affected by this because the truncated normal creates a common adjustment term in both numerator and denominator.

As mentioned previously, the coefficients for some covariates are also required to be non-positive over all forward starting times. This is achieved by checking whether the NS curve at a particular set of three (or four) parameters meets the condition. If not, the parameter set will be discarded.

To improve the support of the particle cloud, one can execute multiple such Metropolis–Hastings steps each time. In the CRI implementation, such Metropolis–Hastings steps are consecutively performed in each resampling-move step until the number of unique particles exceeds $K/2$.

When $p = P_{n+1}$ is reached, a representation of $\gamma_{n+1}(\theta)$ is:

$$(\theta^{(k,n+1)}, w^{(k,n+1)}) = (\overline{\theta}^{(k,n+1,P_{n+1})}, \overline{w}^{(k,n+1,P_{n+1})}). \tag{25}$$

Following Duan and Fulop (2013), the tempering sequence ξ_p is automatically set to ensure that the efficient sample size stays close to 500. This is done by a grid search, where the ESS is evaluated at a grid of candidate ξ_p and the one that produces the closest ESS to 500 is chosen.

After the recursion procedure (i.e., ξ_p reaches 1), additional moves using the means implied by the particle set but all standard deviations increased by a factor of 30% are further performed to enrich the support and adjust the location of the particle set. The number of such moves is set to 20 for the first time point and exponentially declines to 3 mid-way to the sample period and stays at 3 for the remainder. After that, if the number of unique particles is still below $K/2$, more moves using the means and the standard deviations implied by the particle set (without expansions) are consecutively performed until the particle set meets the requirement. (This case could only happen when ESS $\geq$ 500 for $\xi_p = 1$.)

I.3.3. *Statistical inference*

The full sample size has N time series data points but one can only make default prediction at $N-1$ time points; for example, at time point 2, the data is only available for making one-period default prediction at time point 1. Denote the pseudo-posterior mean of the parameter of the whole sample by $\hat{\theta}_N$. And for $n = 2, \ldots, N$,

$$\hat{\theta}_n = \frac{1}{\sum_{k=1}^{K} w^{(k,n)}} \sum_{k=1}^{K} w^{(k,n)} \theta^{(k,n)}. \tag{26}$$

Note that $(\overline{\theta}^{(k,n+1,0)}, \overline{\omega}^{(k,n+1,0)}) = (\theta^{(k,n)}, \omega^{(k,n)})$ is not a true posterior because the likelihood function in Eq. (17) is not a true likelihood function. Thus, it cannot directly provide valid Bayesian inference. But following Duan and Fulop (2013) — which is in turn based on Shao's self-normalized statistic (Shao, 2010) — inference can be performed using the t-like statistic. To test, for example, the hypothesis of the kth element of $\overline{\theta}^{(k,n+1,p)} = \overline{\theta}^{(I^{(k,n+1,p)},n+1,p)}$, denoted by $\overline{\omega}^{(k,n+1,p)} = \frac{1}{K}$, equal to a, one has:

$$t^* = \frac{\sqrt{N-1}(\hat{\theta}_N^{(k)} - a)}{\sqrt{\hat{\delta}_{k,N}}} \xrightarrow{d} \frac{W(1)}{[\int_0^1 (W(r) - rW(1))^2 dr]^{1/2}}, \quad (27)$$

where $W(r)$ is a Wiener process, $\hat{\delta}_{k,N}$ is the kth diagonal element of $\hat{C}_N$, and

$$\hat{C}_N = \frac{1}{(N-1)^2} \sum_{n=2}^{N} n^2 (\hat{\theta}_n - \hat{\theta}_N)(\hat{\theta}_n - \hat{\theta}_N)'. \quad (28)$$

The right-hand side random variable for t^* does not have a known distribution, but can be easily simulated. Kiefer *et al.* (2000) reported that the 95% quantile is 5.374 and the 97.5% quantile is 6.811. These values can also be used to set up confidence intervals.

I.3.4. *Periodic updating*

In reality, portfolio credit risk models need to be updated periodically as new data arrive and/or old data are revised. With one new month of data, this means that the final date index N is increased to $N+1$. A particular strength of Duan and Fulop (2013)'s methodology is that the estimation routine does not need to be re-initialized from the prior as the pseudo-posterior using data up to $N\Delta t$ will provide a much better proposal distribution.

Let the pseudo-posterior at time N (based on the old data set available at time N) be denoted by

$$\gamma_N^{(N)}(\theta) \propto \prod_{m=1}^{N-1} \mathcal{L}_{m,\min(N-m,\ell)}^{(N)}(\theta)\pi(\theta), \quad (29)$$

and the pseudo-posterior at time $N+1$ (based on the new data set available at time $N+1$) by

$$\gamma_{N+1}^{(N+1)}(\theta) \propto \prod_{m=1}^{N} \mathcal{L}_{m,\min((N+1)-m,\ell)}^{(N+1)}(\theta)\pi(\theta). \quad (30)$$

The superscript is introduced to differentiate the data set available at time N and $N+1$, respectively. It is important to note that $\mathcal{L}_{m,k}^{(N+1)}(\theta) \neq \mathcal{L}_{m,k}^{(N)}(\theta)$ can be caused by revisions to the old data set. More importantly, there is a generic difference between the pseudo-posterior distribution up to time N under the new data set and the corresponding quantity under the old data set specifically due to multiperiod prediction; that is, $\gamma_{N+1}^{(N)}(\theta) \neq \gamma_N^{(N)}(\theta)$ even without any data revisions to the period covered by the old data set. To put it concretely, using the new data set and at, say, one period before the last (i.e., time $N-1$), one can make default predictions up to two periods, whereas at the same time point, it was only possible to make one-period predictions under the old data set because there were no data beyond time N. Adjustments to the weights are thus necessary to reflect the change in data set before making any sequential updates.

There are several possible ways of advancing the system. The CRI implementation decomposes the move into two steps. First, we take care of data revision up to time N and then act as if we were making predictions with data only up to time N. Doing it this way is meant to maintain the same default prediction setting; that is, for example, only make one-period default prediction at time $N-1$ even though the new data set permits predictions up to two periods. Thus, we introduce

$$\gamma_N^{(N+1,N)}(\theta) \propto \prod_{m=1}^{N-1} \mathcal{L}_{m,\min(N-m,\ell)}^{(N+1)}(\theta)\pi(\theta) \quad (31)$$

to denote this pseudo-posterior when the superscript $(N+1, N)$ stands for the updated data set available at time $N+1$ but making default predictions as if the data were only available up to time N.

From the previous run up to time N, one already has a weighted set of particles $(\theta^{(k,N)}, w^{(k,N)})$ representing the pseudo-posterior distribution $\gamma_N^{(N)}(\theta)$. Next, perform a reweighting by

$$\theta^{*(k,N)} = \theta^{(k,N)}, \quad (32)$$

$$w^{*(k,N)} = w^{(k,N)} \times \frac{\gamma_N^{(N+1,N)}(\theta^{(k,N)})}{\gamma_N^{(N)}(\theta^{(k,N)})}. \quad (33)$$

Since the denominator is available from the previous run, one only needs to compute the numerator using the new data set up to time N. Then, the weighted set $(\theta^{*(k,N)}, w^{*(k,N)})$ represents the revised pseudo-posterior distribution at time N, i,e, $\gamma_N^{(N+1,N)}(\theta)$, specifically to account for data revisions. From this point onward, one can apply the same recursive procedure described in Sec. I.3.2, starting from Eq. (18), to complete the updating task.

Reweighting may substantially alter the ESS of the particle set due to a large volume of data changes. If the reweighting leads to a satisfactory ESS, i.e., ESS $\geq B$, advancing to $N+1$ continues as usual. Otherwise, the weighted sample will be discarded to prevent the support from degeneration. One can return to the particle set before reweighting and perform resampling to create an equally-weighted particle set. Then, make the Metropolis–Hastings moves by targeting $\gamma_N^{(N+1,N)}(\theta)$ using the Gaussian-type sampler described earlier and starting with the mean and variance implied by the resampled particle set. One should make these Metropolis–Hastings moves until the particle set reaches a desirable level of distinctiveness, and perhaps with a preset minimum number of moves to ensure that the resulting particle set is close enough to the target distribution. In the CRI implementation, the number of moves is set to be 20.

Furthermore, one can update all self-normalized statistics in the way as described earlier to reflect the additional one more pseudo-posterior means to the sequence.

The initial parameter estimation is carried out for all calibration groups using the data up to the end of January 2013. Relevant quantities (parameter estimates, the 1,000 parameter particles and corresponding weights and sample likelihoods) are saved for periodic updating for all future months. Additional implementation details on the calibration are given in Sec. III.

II. INPUT VARIABLES AND DATA

Section II.1describes the input variables used in the quantitative model. Currently, the same set of input variables is common to all of the economies under the CRI's coverage. Future enhancements to the CRI system will allow different input variables for different economies. The effect of each of the variables on the PD output will be discussed in the empirical analysis of Sec. IV.

Section II.2 gives the data sources and relevant details of the data sources. There are two categories of data sources: current and historical. Data sources used for current data need to be updated in a timely manner so that daily updates of PD forecasts are meaningful. They also need to be comprehensive in their current coverage of firms. Data sources that are comprehensive for current data may not necessarily have comprehensive historical coverage for different economies. Thus, other data sources are merged in order to obtain comprehensive coverage of historical and current data.

Section II.3 indicates the fields from the data sources that are used to construct the input variables. For some of the fields, proxies need to be used for a firm if the preferred field is not available for that firm.

Section II.4 discusses the definition and sources of defaults and of other exits used in the CRI.

II.1. Input Variables

Following the notation that was introduced in Sec. I, firm i's input variables at time $t = n\Delta t$ are represented by the vector $X_i(n) = (W(n), U_i(n))$ consisting of a vector $W(n)$ that is common to all firms in the same economy, and a firm-specific vector $U_i(n)$ which is observable from the date the firm's first FS is released, until the month end before the month in which the firm exits, if it does exit.

In Duan *et al.* (2012), different variables that are commonly used in the literature were tested as candidates for the elements of $W(n)$ and $U_i(n)$. The two common variables and 10 firm-specific variables, as described below, were selected as having the greatest predictive power for corporate defaults in the United States. In the current stage of development, this same set of 12 input variables is used for all economies. Future development will include variable selection for firms in different economies.

- Common variables

  The vector $W(n)$ contains two elements, which are:

  (1) Stock index return: the trailing one-year simple return on a major stock index of the economy;
  (2) Interest rate: a representative 3-month short-term interest rate.

- Firm-specific variables

  The 10 firm-specific input variables are transformations of measures of six different firm characteristics. The six firm characteristics are:

  (1) volatility-adjusted leverage;

(2) liquidity;
(3) profitability;
(4) relative size;
(5) market misvaluation/future growth opportunities; and
(6) idiosyncratic volatility.

Volatility-adjusted leverage is measured as the DTD in a Merton-type model. The calculation of DTD used by the CRI allows a meaningful DTD for financial firms, a critical sector that must be excluded from most DTD computations. This calculation is detailed in Sec. III.

Liquidity is measured as a ratio of cash and short-term investments to total assets. Profitability is measured as a ratio of net income to total assets. Relative size is measured as the logarithm of the ratio of market capitalization to the economy's median market capitalization.

Duan *et al.* (2012) transformed these first four characteristics into level and trend versions of the measures. For each of these characteristics, the level is computed as the one-year average of the measure, and the trend is computed as the current value of the measure minus the one-year average of the measure. The level and trend of a measure has seldom been used in the academic or industry literature for default prediction, and Duan *et al.* (2012) found that using the level and trend significantly improves the predictive power of the model for short-term horizons.

To understand the intuition behind using level and trend of a measure as opposed to using just the current value, consider the case of two firms with the same current value for all measures. If the level and trend transformations were not performed, only the current values would be used and the two firms would have identical PD. Suppose that for the first firm the DTD had reached its current level from a high level, and for the second firm the DTD had reached its current level from a lower level (see Fig. 2). The first firm's leverage is increasing (worsening) and the second firm's leverage is decreasing (improving). If there is a momentum effect in DTD, then firm 1 should have a higher PD than firm 2.

Duan *et al.* (2012) found evidence of the momentum effect in DTD, liquidity, profitability and size. For the other two firm characteristics, applying the level and trend transformation did not improve the predictive power of the model.

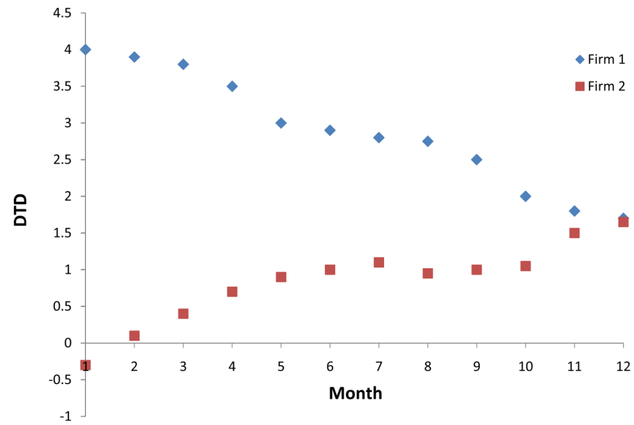


Figure 2. Two firms with all current values equal to each other, but DTD trending in the opposite direction.

One of the remaining two firm characteristics is the market mis-valuation/future growth opportunities characteristic, which is taken as the market-to-book asset ratio and measured as a ratio of market capitalization and total liabilities to total assets. One can see whether the market mis-valuation effect or the future growth opportunities effect dominates this measure by looking at whether the parameter for this variable is positive or negative. This will be further discussed in the empirical analysis of Sec. IV.

The last firm characteristic is the idiosyncratic volatility which is taken as SIGMA, following Shumway (2001). SIGMA is computed by regressing the daily returns of the firm's market capitalization against the daily returns of the economy's stock index, for the previous 250 days. SIGMA is defined to be the standard deviation of the residuals of this regression. Using daily returns is to ensure that SIGMA provides an accurate and timely measure of idiosyncratic risk of individual companies. Shumway (2001) reasons that SIGMA should be logically related to bankruptcy since firms with more variable cash flows and therefore more variable stock returns relative to a market index are likely to have a higher probability of bankruptcy.

Finally, the vector $U_i(n)$ contains 10 elements, consisting of:

(1) Level of DTD.
(2) Trend of DTD.

(3) Level of (cash + short-term investments)/total assets, abbreviated as CASH/TA.
(4) Trend of CASH/TA.
(5) Level of net income/total assets, abbreviated as NI/TA.
(6) Trend of NI/TA.
(7) Level of log (firm market capitalization/economy's median market capitalization), abbreviated as SIZE.
(8) Trend of SIZE.
(9) Current value of (market capitalization + total liabilities)/total asset, abbreviated as M/B.
(10) Current value of SIGMA.

The data fields that are needed to compute DTD and short-term investments are described in Sec. II.3. The remaining data fields required are straightforward and standard. The computation for DTD is explained in Sec. III.

II.2. Data Sources

There are two data sources that are used for the daily PD forecast updates: Thomson Reuters Datastream and the Bloomberg Data License Back Office Product. Many of the common factors such as short-term interest rates and macroeconomic data are retrieved from Datastream.

Firm-specific data comes from Bloomberg's Back Office Product which delivers daily update files by region via FTP after respective market closes. All relevant data is extracted from the FTP files and uploaded into the CRI database for storage. From this, the necessary fields are extracted and joined with previous months of data.

The Back Office Product includes daily market capitalization data based on closing share prices and also includes new FSes as companies release them. Firms will often have multiple versions of FSes within the same period, with different accounting standards, filing statuses (most recent, preliminary, original, reclassified or restated), currencies or consolidated/unconsolidated indicators. A major challenge lies in prioritizing these FSes to decide which data should be used. The priority rules are described in Sec. III.

The firm coverage of the Back Office Product is of sufficient quality that over 30,000 firms can be updated on a daily basis in the 119 economies under the CRI's coverage. While the current coverage is quite comprehensive, historical data from the Back Office Product can be sparse for certain economies. For this reason, various other databases are merged in order to fill out the historical data. The other databases used for historical data are: a database from the Taiwan Economics Journal (TEJ) for Taiwanese firms; a database provided by Korea University for South Korean firms; and data from Prowess for Indian firms.

With all of the databases merged together and for the 119 economies under the CRI's coverage, over 60,000 exchange listed firms are in the CRI database. The historical coverage of the firm data goes back to the early 1990s. In order to be included in our coverage, a company needs to have common equity traded on a stock exchange. Of these 119 economies, 78 economies have their own stock exchange (see Table A.2). For the other 38 economies under the CRI coverage, we cover companies domiciled in the economy that are quoted on a foreign exchange, either because those economies do not have a stock exchange or because data issues are preventing us from including the companies listed on the local exchange.

II.3. Constructing Input Variables

The chosen stock indices and short-term interest rates for the 78 economies with their own stock exchange under the CRI's current coverage are listed in Tables A.5 and A.6, respectively. All economies are listed by their three letter ISO code given in Table A.4.

Most of the firm-specific variables can be readily constructed from standard fields from firms' FSes in addition to daily market capitalization values. The only two exceptions are the DTD and the liquidity measure.

The calculation for DTD is explained in Sec. III. In the calculation, several variables are required. One variable is a proxy for a one-year risk-free interest rate, and the choices for each of the 78 economies are listed in Table A.7. Total assets, long-term borrowing and total liabilities are also required, but can be obtained from standard FS fields easily.

Total current liabilities are also required, and due to the relatively large numbers of firms that are missing this value, proxies have to be found. The preferred

Bloomberg field for this is BS_CUR_LIAB. If this is missing, then the sum of BS_ST_BORROW, BS_OTHER_ST_LIAB, BS_CUST_ACCPT_LIAB_CUSTDY_SEC (customers' acceptance and liabilities/custody securities) and BS_SEC_SOLD_REPO_AGRMNT is used. If one, two or three of these are missing, zero is inserted for those fields, but at least one of the four fields is required.

The liquidity measure requires different fields for financial and non-financial firms. For non-financial firms, the numerator of the ratio (cash + short-term investments) is taken as the sum of BS_CASH_NEAR_CASH_ITEM and BS_MKT_SEC_OTHER_ST_INVEST (marketable securities and other short-term investments). If BS_MKT_SEC_OTHER_ST_INVEST is missing, substitute zero (but BS_CASH_NEAR_CASH_ITEM is required).

It was found that this sum frequently overstated the liquidity for financial firms. In place of BS_MKT_SEC_OTHER_ST_INVEST, financial firms use the sum of ARD_SEC_PURC_UNDER_AGR_TO_RESELL (securities purchased under agreement to re-sell), ARD_ST_INVEST and BS_INTERBANK_ASSET. If one or two of these are missing, zero is inserted for those fields, but at least one field is required. The "ARD" prefix indicates that these are "as reported" numbers directly from the FSes. As such, for some firms these fields may need to be adjusted to the same units before adding them to other fields.

To summarize, the firm-specific variables include: DTD, Cash/TA, NI/TA, SIZE, M/B, and SIGMA, and the statistics grouped by economy are listed in Table A.8.

II.4. Data for Corporate Events

The CRI database contains 5822 default events and 44641 other exits events from 1990 to the present. The default events come from numerous sources, including Bloomberg, Compustat, CRSP, Moodys reports, TEJ, exchange websites and news sources. Moreover, in order to enhance default coverage, from December 2015, the CRI team has started to use "defaults" reported by major credit rating agencies as an additional data source.

The default events that are recognized by the CRI can be classified under one of the following events:

(1) Bankruptcy filing, receivership, administration, liquidation or any other legal impasse to the timely settlement of interest and/or principal payments;
(2) A missed or delayed payment of interest and/or principal, excluding delayed payments made within a grace period;
(3) Debt restructuring/distressed exchange, in which debt holders are offered a new security or package of securities that result in a diminished financial obligation (e.g., a conversion of debt to equity, debt with lower coupon or par amount, debt with lower seniority, debt with longer maturity).

The more precise sub-categories of default corporate actions are listed in Table A.9.

Delisting due to other reasons such as failure to meet listing requirements, inactive stock prices or M&A are counted as "other exits" and are not considered as default. Especially, if a firm has stale stock price for more than a year but has no record on experiencing any credit events, we will assume that it has been suspended and exited from its stock exchange. If two credit events of the same type happen in a row or a default event happens followed by another event of either type, we only keep the first event assuming that the series of events arise from the same source of financial distress. However, if firms are delisted from an exchange and then experience a default event within 365 calendar days of the delisting, we will only keep the default event, and any information between the two dates won't be used. Technical defaults such as covenant violations are not included in our definition of default. The exit events that are not considered as defaults in the CRI system are listed in Table A.10.

In addition to the aforementioned events, there are still cases that require special attention and will be assessed on a case-by-case basis, e.g., subsidiary default. As a general rule, the CRI does not consider related party-default (e.g., subsidiary bankruptcy) as a default event. However, when a non-operating holding parent company relies heavily on its subsidiary, bankruptcy by the subsidiary will cause a considerable economic impact on the parent company. Such cases will be reviewed and final classifications will be made.

Complete statistics of the total number of firms, number of defaults and number of other exits in each of the 78 economies from 1994 to 2015 are listed in Table A.11.

III. IMPLEMENTATION DETAILS

Section I described the modeling framework underlying the current implementation of the CRI system. It focused on theory rather than the details encountered in an operational implementation. The present section describes how the CRI system handles more specific issues.

Section III.1 describes implementation details related to data, mainly dealing with data cleaning and missing data. Section III.2 describes the specific computation of DTD used by the CRI system that leads to meaningful DTD for financial firms. Section III.3 explains how the calibration previously described in Sec. I.2 can be implemented. Section III.4 gives the implementation details relevant to the daily output. This includes an explanation of the various modifications needed to compute daily PDs so that the daily PDs are consistent with the usual month end PD, and a description of the computation of the aggregate PDs provided by the CRI.

III.1. Data Treatment for Calibration

Fitting data to monthly frequency: Historical end of month data for every firm in an economy is required to calibrate the model. For daily data such as market capitalization, interest rates and stock index values, the last day of the month for which there is valid data is used.

Up to October 2012 calibration, FS variables data were used, starting from the period end of the statement lagged by 3 months. This is to ensure that predictions are made based on information that was available at the time the prediction was made. However, this treatment can be over-conservative, and many companies actually release their FSes quicker than 3 months. Therefore, we implement a new logic and we start using the values in an FS as soon as its latest revision was put into the CRI database, unless the FS' release was delayed for more than 3 months. If there was no revision to an FS, the originally released FS is used. Whenever the latest revision is available more than 3 months after the period end, we revert to the previous logic. We start including the FS before the latest revision is actually available as a compromise, to avoid situations like later minor revisions of the FS holding back more up-to-date information. It should be noted that the new approach was only applied for FS input into the CRI database after February 2011, as the revision dates were not accurately recorded before this date. The CRI considers FS variables to be valid for one year without restriction, after they were first used.

Priority of FSes with the same period end: As described in Sec. II.2, data provided in Bloomberg's Back Office Product can include numerous versions of FSes within the same period. If there are multiple FSes with the same period end, priority rules must be followed in order to determine which to use. The formulation and implementation of these rules are major challenges and areas of continuing development.

The first rule is to prioritize by consolidated/unconsolidated status. This rule applies to all economies, however, special treatment is imposed on firms in the "diversified financial services" sector in South Korea and Taiwan. In this sector of the two economies, firms issue unconsolidated FSes more frequently than consolidated ones. As a result, this prioritization rule can lead to cases where the FSes chosen switch between unconsolidated and consolidated ones on a regular basis. In South Korea and Taiwan, where corporate structures are biased toward large holding companies, this switching may substantially distort the DTD calculation for these holding companies. Therefore, as of October 2013 calibration, in the case of South Korea, and November 2013 calibration, in the case of Taiwan, if a company has released at least one consolidated FS over the last 12 months, all unconsolidated FS will be ignored.

If, after the first prioritization rule has been applied, there are still multiple FSes, the second rule is applied. This is prioritization by fiscal period. In most economies, annual statements are required to be audited, whereas other fiscal periods are not necessarily audited. The order of priority from highest to lowest is, therefore: annual, semi-annual, quarterly, cumulative, and finally other fiscal periods. We have observed that the capital structure breakdown reported by Australian domiciled-banks differs between annual and semi-annual reports, leading to DTD calculations that are not meaningful. Because of this, as of October 2013 calibration, we only use data from annual FSes for Australian banks.

The third prioritization rule is based on filing status. The "Most Recent" statement is used before the "Original" statement, which is used before the "Preliminary" statement.

The final prioritization rule is based on the accounting standard. As more and more countries adopt the International Financial Reporting Standards (IFRS) as their mandatory accounting standard, FSes that are reported using IFRS are given higher priority than they were before. The revised rule is implemented from the 2014 October calibration and is described as follows. For the countries with mandatory IFRS adoption, FSes under IFRS are now given the highest priority after their respective mandatory adoption dates. Before the mandatory adoption dates and for countries without mandatory IFRS adoption, FSes under the Generally Accepted Accounting Principles (GAAP) have the highest priority. If an FS does not indicate its accounting standard, it will not be used.

Having all the prioritization descriptors in place, we rank all the FSes available in the database from the highest priority to the lowest. If there are FSes where all the financial information needed in our model is present, the FS with the highest ranking will be chosen. If instead there is no such FS, we will pick the values variable by variable. For example, the total liability is taken from the highest ranked FS with this information available, while the total asset can be from another FS, which ranks the highest among those bearing this information and having the same FS period end. This treatment is to get as much information as possible and to accommodate the fact that Bloomberg occasionally only revises the variables that have changed values, leaving the other fields NaN.

One variable that requires special attention is the net income. Net income is a flow variable and needs to be adjusted based on the fiscal period of the FS. More specifically we transform the net income into a monthly net income by dividing the net income by the number of months that the FS covers. For example, the monthly net income can be computed from the annual net income divided by 12, the semi-annual net income divided by 6 and the quarterly net income divided by 3. When the monthly net income can be obtained from different sources simultaneously, the quarterly net income will have the highest priority (followed by the cumulative quarterly, semiannual, annual, and others) because it covers a more recent period of time.

Treatment of stale market capitalization prices: The market capitalization of a firm is required in a few input variables: DTD, SIZE, M/B and SIGMA. For most firms, the market capitalization is available from Bloomberg on a daily basis.

A check on the trading volume of shares is used to remove stale prices. Specifically, if there are more than two consecutive days of identical market capitalization prices, subsequent identical prices are removed only if the trading volume is equal to zero. This is to avoid, for example, cases where the shares of a company are under a trading suspension but the market capitalization data is incorrectly carried forward.

An exception is for Indian companies, where it is common for some companies to have market capitalizations reported only once a month with several consecutive months having identical prices and positive trading volume. These prices are very likely not to be accurate reflections of the firms' value. So, the trading volume is not checked for Indian firms and market capitalizations are excluded after more than two repeated prices.

For some firms, the market capitalization data is not available for some periods. To fill in the blanks, we use the outstanding shares obtained from the previous available market capitalization divided by the price on that day as a proxy. If the market capitalization data is missing for more than a year, we use the share price multiplied by the shares outstanding listed in the balance sheet and then multiplied again by the adjustment factor that Bloomberg provides to account for splits, dividends, etc. If there is still market capitalization missing in the data, then shares outstanding from other data sources including Compustat and Korean University Database are used.

Currency conversion: Currency conversions are required if the market capitalization or any of the FS variables are reported in a currency different than the currency of the economy. If a currency conversion is required, the foreign exchange rate used is the one reported at the relevant market close. For firms traded in most of the Asian economies and Asia-Pacific, the Tokyo closing rate is used; for firms traded in Europe and Middle East, the London closing rate is used; and for firms traded in North and Latin America, the New York closing rate is used. For market capitalizations, the FX rate used is for the date that the market capitalization is reported. For FS variables, the FX rate used is for the date of the period end of the statement.

Treatment for mergers and acquisitions (*M&A*): M&A events are common occurrences in the economic world. For our purpose, we define the M&A events as the cases where a firm ("acquirer") acquires partial or full ownership of another firm ("target"). Once an M&A deal is completed, the market capitalization of the acquirer changes immediately, reflecting the restructure of the acquirer. However, its FSes do not usually immediately reflect the new situation due to the fact that they are only released on a periodic basis. As a result, the DTD and market-to-book ratio, which are important inputs for the PD computation, will be distorted due to a mismatch in the market capitalization and the FS variables. In order to ensure the accuracy and reliability of our PD estimates, some special treatments are taken for PD calculations to companies whose financials are presumably significantly affected by the M&A events. The treatments are only applied to the acquirers.

The treatment starts with the screening of the important M&A deals. Only the important M&A deals are treated, assuming that the unimportant ones would not significantly affect a firm's corporate structure. An M&A deal is considered important if it satisfies the following three criteria:

(1) Upon the deal's completion, the acquirer owns 20% or more of the target company.
(2) The size of the deal is material to the acquirer. This is measured in terms of total assets. If α is the percentage of the target that is being acquired, the size is considered material if the product of α and the total assets of the target is greater than or equal to 20% of the total assets of the acquirer.
(3) The change in market capitalization is material, with the largest absolute daily market capitalization return, within 20 days of the M&A completion day, larger than or equal to 5%.

One thing to note in implementation is that some targets stopped producing financial statements years before the M&A events. As a result, they may not have a valid value of total asset (needed for testing criterion 2) on the deal completion date. In this case, we use their last available value within two years before the deal completion as a substitute. If the last available value is beyond the 2-year range, we think that the data is not informative enough to reflect the financial situation upon deal completion and thus skip this particular case.

In order to mitigate the mismatching problem between the market capitalization and FS variables, we make the simplest and most conservative treatments, which are in line with the fundamental accounting standards. The treatment period will begin on the deal completion date and end when the first financial statement that reflects the post-M&A situation becomes available, which varies across economies and can range from 3 months to a few years. After identifying the important M&A deals, which must have had an ownership level of equal or more than 20%, we treat them in two different ways:

(1) If the acquirer owns 20–50% (excluding 50%) of the target upon deal completion, the "Equity Method" is used to treat the financial statement variables. Under the "Equity Method", the total asset of the acquirer will increase by a proportion, which is the percentage of ownership acquired in this deal, of the targets equity. Its net income will increase by the same proportion of the target's net income. In contrast, other financial statement variables will stay the same.
(2) If the acquirer owns 50–100% (including 50%) of the target upon deal completion, the "Acquisition Method" is used to adjust the financial statement variables. By using this method, we assume that the financial manager of the acquirer consolidates the financial statements of both entities. As a consequence, the financial statement variables, including total liability, total asset, and cash and marketable securities, take the simple sum of the values from both entities. The net income will still increase by a proportion (the percentage of ownership acquired in this deal) of the targets net income,

simply because it is the profit attributed to the shareholders.

After constructing the hypothetical financial statement data in the above mentioned way, we use them to compute the DTD and the historical monthly PDs wherever applicable. Note that we do not let the hypothetical values enter the model's calibration process. With enough data points in the database to robustly calibrate the model parameters at the economy or region level, we can afford to disregard a small portion of data for the M&A period during which we believe them to be mismatched. After getting the model parameters, however, we not only use the hypothetical values to re-calibrate the firm-specific DTD parameters and re-calculate the DTD values, we also use them to adjust other variables with financial information. This is to guarantee that the PDs during the treatment period are properly calculated.

Treatment for missing values and outliers: Missing values and outliers are dealt with by a three-step procedure. In the first step, the 10 firm-specific input variables are computed for all firms and all months. In this step, the extreme values will be calculated and the missing values will be determined. In the second step, outliers are eliminated by winsorization. In the final step, missing values are replaced under certain conditions. Note that the macroeconomic variables do not go through this process.

The first step is to compute the input variables and to determine which are missing. As mentioned previously, FS variables are carried forward for one year after the date that they are first used. The date that they are first used is generally three months after the period end of the statement. If no FS is available for the company within this year, then the FS variable will be missing. For market capitalization, if there is no valid market capitalization value within the calendar month, then the value is set to be missing.

For illiquid stocks, if there has been no valid market capitalization value for a firm within the last 90 calendar days, then the market capitalization is deemed to not properly reflect the value of the firm. The firm is considered to have exited with a non-default event. Once the firm starts trading again and a new FS is released, the firm can enter back into the calibration. With regard to historical PDs, the PDs can be reported again once there are enough valid variables.

With regard to the level variables, their values in the current and the last 11 months are averaged to compute the level. A minimum of six observations in the 12-month range are required to calculate the level variables. If fewer than six observations exist in this case, the level variables will bear missing values. However, this condition is not enforced during the initial 6 months after the firm releases the first financial statement.

To compute the trend variables, the level is subtracted from the current month value. If the current month value is missing, the trend variable is set to be the last valid value during the previous one year.

The value of M/B is set to be missing if any of the following values are missing: market capitalization, total liabilities or total assets of the firm. For the computation of SIGMA, at least 50 valid returns over the last 250 days of possible returns are required for the regression. If there are less than 50 valid returns, SIGMA is set to be missing.

In this way, the 8-trend and level variables as well as M/B and SIGMA are computed and identified as missing or present. Winsorization can then be performed as a second step to eliminate outliers. The volume of outliers is too large to be able to determine whether each one is valid or not, so winsorization applies a floor and a cap on each of the variables. The historical 0.1‰ and 99.9‰ for all firms in the economy are recorded for each of the 10 variables. Any values that exceed these levels are set to equal these boundary values.

With a winsorization level of 0.1‰ and 99.9‰, the boundary values still may not be reasonable. For example, NI/TA levels of nearly -25, meaning an annual net income -25 times larger than the total assets of a firm, has been observed at this stage. In these cases, a more aggressive winsorization level is applied, until the boundary values are reasonable. Thus, the winsorization level is economy- and variable-specific, and will depend on the data quality for that economy and variable. Winsorization levels different from the default of 0.1‰ and 99.9‰ are indicated in Table A.8.

A third and final step can be taken to deal with missing values. If during a particular month, no variable is missing for a particular firm, the PD can then be computed. If 6 or more of these 10 variables are missing, there is deemed to be too many missing observations and no replacement shall be made.

If between 1 and 5 variables are missing out of the 10, the first step is to trace back for at most 12 months to use previous values of these variables instead. If this does not succeed in replacing all of the variables, a replacement by sector medians is done. A firm's sector during a certain month is classified as either financial or non-financial, which is based on its Bloomberg industry sector code during that month. As of January 2015, the sector median replacement is no longer implemented in the calibration process but still in the PD computation. One special case is that the sector replacement is not done if it results in a relative change in the historical PD of 10% or more when the initial PD was at or above 100 bps, or an absolute change in the historical PD of 10 bps or more when the initial PD was below 100 bps.

One thing to note is that in the initial phase of a company — six months or even longer after its IPO — the data availability and quality are relatively low due to, for example, the delay in the issuance of FSes or illiquid trading. As observed in our data, replacing the missing values during this period with a sector median sometimes results in extreme spikes and falls in the company's PD. These extreme values are not easily detected, because in the beginning of a company's history, there are not many previous PD values to compare to as can be done later in the company's history. In order to avoid this, as of the 2015 January calibration, we set the rule to start treating the missing values only from the month when both the DTD level and trend are available and finite. By doing so, we make the PDs in the beginning of a company's history more reflective of its true credit quality.

Inclusion/exclusion of companies for calibration: Firms are included within an economy for calibration when the primary listing of the firm is on an exchange in the economy. This ensures that all firms within the economy are subject to the same disclosure and accounting rules. There are a relatively small number of firms that are listed in multiple economies. For example, Bank of China Ltd is listed both in Hong Kong Stock Exchange and China's Shanghai Stock Exchange. Based on Bloomberg's classification of its primary listing, Bank of China Ltd is assigned to the calibration group of Asia-Pacific rather than China.

In the US, firms traded on the OTC markets or the Pink Sheets are not considered as exchange listed so are not included in calibration or in the reporting of PD forecasts. Many of these firms are small or start-up firms. Including this large group of companies would skew the calibration and the aggregate results. The TSX Venture Exchange in Canada also contains only small and start-up firms, so firms listed here are also excluded.

Other exclusions include Taiwan's Taipei Exchange, Vietnam's Hanoi UPCoM, Switzerland's OTC-X BEKB, Brazil's Soma and Romania's RASDAQ. To identify the smaller markets outside of the US and Canada is challenging due to data availability. However, continuing work is being done in the CRI system to exclude firms that are not listed on major exchanges within a country.

III.2. Distance-to-Default Computation

The DTD computation used in the CRI system is not a standard one. Standard computations exclude financial firms, which is of course a critical part of any economy. Thus, the standard DTD computation must be extended to give meaningful estimates for financial firms as well. Duan and Wang (2012) have provided a review of different DTD calculations with several examples for financial and non-financial firms.

The description of the specialized DTD computation starts with a brief description of the Merton (1974) model. Merton's model makes the simplifying assumption that firms are financed by equity and a single zero-coupon bond with maturity date T and principal L. The asset value of the firm V_t follows a geometric Brownian motion:

$$dV_t = \mu V_t dt + \sigma V_t dB_t, \tag{34}$$

where, B_t is the standard Brownian motion, μ is the drift of the asset value in the physical measure, and σ is the volatility of the asset value. Following the Merton (1974) model, the probability of the company's default at time T evaluated at time t is $\Pr_t(V_T \leq L)$, from Eq. (34), we can derive $\Pr_t(V_T \leq L) = N(-\text{DTD}_t)$, where DTD at time t is defined as:

$$\text{DTD}_t = \frac{\log\left(\frac{V_t}{L}\right) + \left(\mu - \frac{\sigma^2}{2}\right)(T-t)}{\sigma\sqrt{T-t}}. \tag{35}$$

The standard KMV assumptions given in Crosbie and Bohn (2003) are to set the time to maturity $T-t$ at a value of one year, and the principal of the zero-coupon bond L to a value equal to the firm's current liabilities plus one half of its long-term debt. Here, the current liabilities and long-term debt are taken from the firm's FSes. If the firm is missing the current liabilities field, then various substitutes for this field can be used, as described in Sec. II.3.

This is a poor assumption of the debt level for financial firms, since they typically have large liabilities, such as deposit accounts, that are neither classified as current liabilities nor long-term debt. Thus, using these standard assumptions means ignoring a large part of the debt of financial firms.

To properly account for the debt of financial firms, Duan (2010) included a fraction δ of a firm's other liabilities. The other liabilities are defined as the firm's total liabilities minus both the short and long-term debt. The debt level L then becomes the current liabilities plus half of the long-term debt plus the fraction δ multiplied by the other liabilities, so that the debt level is a function of δ. The standard KMV assumptions are then a special case where $\delta = 0$.

The fraction δ can be optimized along with μ and σ in the transformed-data maximum likelihood estimation method developed in Duan (1994, 2000). As asset value is unobservable, it has to be implied from market equity value. Noted that equity holders receive the excess value of the firm above the principal of the zero-coupon bond and have limited liability, so the equity value at maturity is: $\max(V_T - L, 0)$. This is just a call option payoff on the asset value with a strike value of L. Thus, the Black–Scholes option pricing formula can be used to calculate the equity value at times t before T,

$$E_t = V_t N(d_+) - e^{-r(T-t)} L N(d_-), \tag{36}$$

where r is the risk-free rate, $N(\cdot)$ is the standard normal cumulative distribution function, and

$$d_\pm = \frac{\log\left(\frac{V_t}{L}\right) + \left(r \pm \frac{\sigma^2}{2}\right)(T-t)}{\sigma\sqrt{T-t}}. \tag{37}$$

Then, we can express the likelihood function of the observed equity values by viewing the equity values as the transformed data from pricing formula in Eq. (36). It should be noted that the transformation involves the unknown asset volatility. By standard transformation theory, the likelihood of observed equity values must equal the product of the likelihood of the asset values (implied by equity values) and the Jacobian of the inverse transformation (from the equity value back to the asset value). Moreover, following Duan *et al.* (2012), the firm's market value of assets is standardized by its book value A_t, so that the scaling effect from a major investment or financing by the firm will not distort the time series from which the parameter values are estimated. Thus, the log-likelihood function based on equity prices is:

$$\begin{aligned}\mathcal{L}(\mu, \sigma, \delta) = {} & -\frac{n-1}{2}\log(2\pi) - \frac{1}{2}\sum_{t=2}^{n}\log(\sigma^2 h_t) \\ & - \sum_{t=2}^{n}\log\left(\frac{\hat{V}_t(\sigma,\delta)}{A_t}\right) \\ & - \sum_{t=2}^{n}\log[N(\hat{d}_+(\hat{V}_t(\sigma,\delta),\sigma,\delta))] \\ & - \frac{1}{2\sigma^2}\sum_{t=2}^{n}\frac{1}{h_t}\left[\log\left(\frac{\hat{V}_t(\sigma,\delta)}{A_t}\right.\right. \\ & \left.\left.\times \frac{A_{t-1}}{\hat{V}_{t-1}(\sigma,\delta)}\right) - \left(\mu - \frac{\sigma^2}{2}\right)h_t\right]^2,\end{aligned} \tag{38}$$

where n is the number of days with observations of the equity value in the sample, $\hat{V}_t$ is the implied asset value found by solving Eq. (36), $\hat{d}_+$ is computed with Eq. (37) using the implied asset value, and h_t is the number of trading days as a fraction of the year between observations $t-1$ and t. Notice that the implied asset value and $\hat{d}_+$ are dependent on δ by virtue of the dependence of L on δ.

Implementation of DTD computation: The DTD at the end of each month is needed for every firm in order to calibrate the forward intensity model. A moving window, consisting of the last one year of data before each month end is used to compute the month end DTD. Daily market capitalization data based on closing prices is used for the equity value in the implied asset value computation of Eq. (36). If there are fewer than 50 days of valid observations for the DTD input variables (market capitalization, FS variables and interest rate), the DTD value is set to be missing. An observation is valid if there is positive trading volume that day. If the trading volume is not available, the observation is assumed to be valid if the value for the market capitalization changes often enough. The precise criterion is as follows: if the market capitalization does not change for three days or more in a row, the first day is taken as a valid observation and the remaining days with the same value are set to be missing.

A straightforward idea for the DTD computation is to first estimate the three variables μ, σ and δ via maximizing the log-likelihood function (38) over $\sigma \geq 0$ and $0 \leq \delta \leq 1$, and then to calculate the DTD from Eq. (35). Let $(\hat{\mu}, \hat{\sigma}, \hat{\delta})$ be an optimal solution to the maximization problem. By direct calculation, it is not hard to see that

$$\hat{\mu} = \frac{\hat{\sigma}^2}{2} + \frac{1}{\sum_{t=2}^{n} h_t} \log\left(\frac{\hat{V}_n(\hat{\sigma}, \hat{\delta})}{A_n} \times \frac{A_1}{\hat{V}_1(\hat{\sigma}, \hat{\delta})}\right). \tag{39}$$

In view of this, maximizing the three-dimensional function $\mathcal{L}(\mu, \sigma, \delta)$ can be equivalently reduced to maximizing the two-dimensional function $\tilde{\mathcal{L}}(\sigma, \delta)$ taking the form

$$\begin{aligned}\tilde{\mathcal{L}}(\sigma, \delta) = &-\frac{n-1}{2}\log(2\pi) - \frac{1}{2}\sum_{t=2}^{n}\log(\sigma^2 h_t) \\ &-\sum_{t=2}^{n}\log\left(\frac{\hat{V}_t(\sigma, \delta)}{A_t}\right) \\ &-\sum_{t=2}^{n}\log N(d_+) \\ &-\frac{1}{2\sigma^2}\left\{\sum_{t=2}^{n}\frac{1}{h_t} \times \left[\log\left(\frac{\hat{V}_t(\sigma, \delta)}{A_t} \times \frac{A_{t-1}}{\hat{V}_{t-1}(\sigma, \delta)}\right)\right]^2 - \frac{1}{\sum_{t=2}^{n} h_t} \times \left[\log\left(\frac{\hat{V}_n(\hat{\sigma}, \hat{\delta})}{A_n} \times \frac{A_1}{\hat{V}_1(\hat{\sigma}, \hat{\delta})}\right)\right]^2\right\}.\end{aligned} \tag{40}$$

However, with quarterly FSes there will never be more than three changes in the corporate structure (defined in this model by L and A_t) throughout the year, leading to possibly unstable estimates of δ. This problem is mitigated by performing a two stage optimization for σ and δ.

In the first stage, the maximization of $\tilde{\mathcal{L}}(\sigma, \delta)$ for each firm is performed over both σ and δ. For each firm, at the first month in which DTD can be computed, the maximization is constrained in $\sigma \geq 0$ and $0 \leq \delta \leq 1$. Thereafter, at month n, the maximization is still constrained in $\sigma \geq 0$ while δ is constrained in the interval $[\max(0, \hat{\delta}_{n-1} - 0.05), \min(1, \hat{\delta}_{n-1} + 0.05)]$, where $\hat{\delta}_{n-1}$ is the estimate of δ made in the previous month. In other words, a 10% band around the previous estimate of δ (where that band is floored with 0 and capped with 1) is applied so that the estimates do not fluctuate too much from month to month.

However, for many firms, the estimate of δ would frequently lie on the boundary of the constraining interval, meaning that the estimates of δ were not stable. Therefore, a second stage is implemented to impose greater stability. Within the same calibration group, all firms in the same sector (Bloomberg 10-industry sectors classification) are assumed to share the same estimate of δ, chosen to be the average of all its individual estimates. However, for some small economies, especially in their early years, the average of δ is still observed to be not stable due to some sector or even the whole calibration group has only few individual estimates of δ. To well handle such cases, a threshold rule at each time of estimation is applied under the following conditions: (a) If a sector has fewer than 10 individual estimates, the shared estimate of δ will be set to the average of whole calibration group instead of the sector average; (b) furthermore, if the whole calibration group still has fewer than 10 individual estimates, the shared estimate of δ is deemed not available. Accordingly, with δ being fixed to be the sector average on the calibration group level, the original maximization of $\tilde{\mathcal{L}}(\sigma, \delta)$ is reduced to a one-dimensional maximization in σ for each firm.

Since the first stage is done to obtain a stable sector-average estimate of δ, the criteria used to include a firm-month is more strict. In the first stage, a two-year window of FS variables, market capitalization and interest rate is used instead of one year, and a minimum of 250 days of valid observations of the DTD input variables are required instead of 50. If a firm has less than 250 days of valid observations within the last two years of a particular month end, δ will not be estimated for that firm and that month end.

It was found that after applying the two-stage procedure described above, the estimate of μ was frequently unstable and could lower the explanatory power of DTD. For example, suppose a firm has a large drop in its implied asset value in January 2011, so that the estimated μ is negative for the DTD calculation at the end of December 2011. If there is little change in the company in January 2012, then the drop in implied asset value in January 2011 is no longer within the observation window for the DTD calculation at the end of January 2012. There will be a large increase in the estimated μ, resulting in a substantial improvement of the DTD just because of the moving observation window. To avoid this problem, we now set μ to be equal to $\sigma^2/2$. So in calculating DTD, the second term in the numerator of Eq. (35) is eliminated.

In summary, the DTD for each firm is computed using the sector average within a calibration group for δ in that month, and the estimate of σ based on the last year of data for the firm.

Carrying out this two-stage procedure would take about 70 h of computation time on a single PC, given the millions of firm months that are required. However, each of the stages is parallelizable. In the first stage, the DTD can be computed independently between firms. In the second stage, once the sector averages of the δ have been computed for each month, the DTD can again be computed independently between firms. In the current CRI system, by using the NUS' high performance computing facility, the DTD computational time has been greatly reduced thanks to the application of parallel computing.

III.3. Calibration

Implementation: As shown in Sec. I, the calibration of the forward intensity model involves multiple maximum pseudo-likelihood estimations, where the pseudo-likelihood functions are given in Eq. (13). The maximizations are on the logarithm of these expressions, and the default parameters' maximization is performed independently from the non-default exit parameters. Parameter estimates for the entire horizon up to five years for the default and non-default exits can be obtained directly from the NS function.

A few input variables have an unambiguous effect on a firm's probability of default. Increments of both the level and trend of DTD, CASH/TA, and NI/TA should indicate that a firm is becoming more creditworthy and should lead to a decreasing PD. For large and relatively clean data sets such as the US, an unconstrained optimization leads to parameter values which mostly have the expected sign. For each of the DTD level and trend, CASH/TA level and trend, and NI/TA level, the default parameters at all horizons are negative. A negative default parameter at a horizon means that if the variable increases, the forward intensity will decrease (based on Eq. (6)), so that the conditional default probability at that horizon will decrease.

Grouping for economies: There are not enough defaults in some small economies and calibrations of these individual economies are not statistically meaningful. In order to ensure that there are enough defaults for calibration, the 78 economies are categorized into groups according to similarities in their stage of development and their geographic locations. Within these groups, the economies are combined and calibrated together.

As of January 2015, Canada and the US remain in the North America calibration group, and the developed economies of Asia-Pacific (Australia, Hong Kong, Japan, Singapore, South Korea, Taiwan and New Zealand) form another calibration group. China and

India, the two major emerging economies of Asia Pacific are each calibrated as individual groups. All the European countries covered by the CRI are in a single calibration group, which now includes Bosnia and Herzegovina, Serbia and Montenegro. The other emerging economies of Asia Pacific, Latin America, Middle-East and Africa form the “emerging markets” calibration group, which now includes Bangladesh, Oman, Jamaica and Tunisia. Detailed grouping can be found in Table A.4.

All economies in the same calibration group share the same coefficients for all variables except for the 3-month interest rate variable. The 3-month interest rate variable is entered as the current value minus the historical month-end mean in order to reflect the contemporary change relative to the historical average. Its coefficient is allowed to vary, because different economies with different currencies have different dependencies on their interest rates, the levels of which can also differ significantly across economies.

We allow for a unique coefficient on the interest rate variable for each economy. However, certain treatments and exceptions apply due to various reasons. For New Zealand, it does not have enough default events to identify a separate coefficient. In this case, the actual interest rates are replaced with zeros throughout the whole time series. This is to disable the effect of interest rate in the particular calibration, but it will not induce bias based on the nature of the demeaned interests. For the eurozone economies, all of them use the demeaned Germany’s 3-month Bubill rate after the respective dates they joined the eurozone. This aims to reflect more of the monetary rather than the sovereign credit conditions in those economies. Before joining the eurozone, the interest rate variable is set to be 0 for each of those economies except Germany, because none of them has enough default events before that date. Among the non-eurozone economies, Denmark, Norway, Sweden and UK have their own respective coefficients on the interest rate variable, but Iceland, Switzerland along with all the others share the same one. In the Emerging Markets group, only Indonesia, Malaysia, the Philippines and Thailand have their own economy-specific coefficients on the interest rate variable. The Latin American subgroup has a universal coefficient for all the member economies, and all the others in the Emerging Markets group share their coefficient.

One thing to note is that in addition to the unique coefficient on the interest rate variable, Indonesia also has its own coefficient for the relative size level as of October 2013.

Relative size: For the calibration data set, the median market cap of firms in an economy for each month end includes the market cap from the last trading day of each firm in the month. If a firm does not trade in a particular month, the firms market cap is not included in the median. For certain economies, many firms are illiquid and the median market cap experiences large variations due to the change in composition of firms rather than the market value of the firms. Another problem is data quality at the beginning of the historical sample: if a data provider starts including the market cap for a large number of firms in one month compared to the previous, there can be a large jump in the median market cap.

To avoid this problem, we use a combination of the economy’s stock index and the economy’s median market cap as the divisor in the Relative Size variable:

(1) We choose a recent month where there is a more complete set of firms in the economy that have trading activity, and calculate the ratio of the economy’s median market cap to stock index value at the end of the month.
(2) For each month, the divisor for the Relative Size variable of firms in the economy is taken as the month end stock index multiplied by that ratio.

III.4. Daily Output

Individual firms’ *PD*: In computing the pseudo-log-likelihood functions in Eq. (13), only the end of month data is needed. The data needs to be extended to daily values in order to produce daily PDs.

For the level variables, the last 12 end-of-month observations (before averaging) are combined with the current value. The current value is scaled by a fraction equal to the current day of the month divided by the number of calendar days in the month. The earliest monthly value is scaled by one minus this fraction. The sum is then divided by the number of valid monthly observations, with the current value and the earliest monthly value jointly having the weight of one observation if either or both are not missing. Not performing this scaling can lead to an artificial jump in PD at the beginning of the month. When performing the scaling, the change in level is more gradual throughout the month.

SIGMA is computed by regressing the daily returns of the firm's market capitalization against the daily returns of the economy's stock index for the previous 250 days.

Aggregating PDs: The CRI provides term structures of the probability distributions for the number of defaults as well as the expected number of defaults for different groups of firms. The companies are grouped by economy (using each firm's country of domicile), by sector (using the firm's Bloomberg industrial sector code) and sectors within economies.

To compute the probability distribution of the number of defaults, we use an algorithm which was originally reported in Anderson *et al.* (2003). It assumes conditional independence and uses a fast recursive scheme to compute the necessary probability distribution. With the individual firms' PDs, the expected number of defaults is trivial to compute and is simply the sum of the individual PDs within each group. Note that while this algorithm is currently used to produce the probability distribution of the number of defaults within an economy or sector, it can easily be generalized to compute loss distributions for a portfolio manager, in which case the portfolio's exposure to each firm should be aggregated.

As of 8th July 2014, the display of the aggregate PDs on the RMI-CRI website started to adopt the simple median of the individual PDs within each group. This change will mitigate the effect from extreme outliers and synchronize with the aggregate display of the newly launched AS. It should be noted that the aggregate PDs using mean values are still accessible through the data downloading section on the website.

Inclusion of firms in aggregation: As explained in Sec. III.1, firms are included in an economy for calibration if the firms' primary listing is on an exchange in that economy. This is to ensure that all firms in an economy are subject to the same disclosure and accounting requirements. In contrast, a firm is included in an economy's aggregate results if the firm is domiciled in that economy. This is because users typically associate firms with their economy of domicile rather than the economy where their primary listing is, if they are different. For example, the Bank of China has its primary listing in Hong Kong, but its economy of domicile is China so the Bank of China is included in the aggregation forecasts for China, and is included under China when searching for the individual PDs.

Treatment of companies after a default event: When a company experiences a default event, the CRI system discontinues the PD calculation for that company. However, if the company resumes operations after some time, it will be treated as a new company, and we continue to generate PD. The new company's PDs are not affected by the FS or market cap data prior to the event. So, the PDs calculated are independent of the PDs that were generated before the default event. On our website, the PDs are however displayed on a single graph for the convenience of our users.

IV. EMPIRICAL ANALYSIS

This section presents an empirical analysis of the CRI outputs for the 78 economies with their own exchange that are currently being covered. In Sec. IV.1, an overview is given of the default parameter estimates. Section IV.2 explains and provides the accuracy ratios for the different countries under the CRI coverage.

IV.1. Parameter Estimates

With 60 months of forecast horizons, 13 variables and six different groups of economies, tables of the parameter estimates occupy over 20 pages and are not included in this Technical Report. In Figs. B.1 and B.2, the parameter estimates are from calibrations performed in January 2016 using data up until the end of December 2015. As an example, plots of the default parameters for the US are given in Figs. B.1 and B.2 in Appendix B. In this part, a brief overview is given of the general traits and patterns seen in the default parameter estimations of the economies covered by the CRI.

Recall that if a default parameter for a variable at a particular horizon is estimated to be positive (negative) from the maximum pseudo-likelihood estimate, then an increasing value in the associated variable will lead to an increasing (decreasing) value of the forward intensity at that horizon, which in turn means an increasing (decreasing) value for the conditional default probability at that horizon.

For the stock index one-year trailing return variable, most groups have default parameters that are slightly negative in the shorter horizons and then become positive in the longer horizons. When the equity market performs well, this is only a short-term positive for firms and in the longer term, firms are actually more likely to default. This seemingly counterintuitive result could be due to correlation between the market index and other firm-specific variables. For example, Duffie *et al.* (2009) suggested that a firm's DTD can overstate its creditworthiness after a strong bull market. If this is the case, then the stock index return serves as a correction to the DTD levels at these points in time.

As expected we observe a different relationship between the short-term interest rate and default across economies. This observation possibly indicates different lead-lag relationships between credit conditions and the raising and cutting of short-term interest rates.

DTD is a measure of the volatility-adjusted leverage of a firm. Low or negative DTD indicates high leverage and high DTD indicates low leverage. Therefore, PD would be expected to increase with decreasing DTD. Indeed, the DTD level has negative default parameters across calibration groups.

The ratio of the sum of cash and short-term investments to total assets (CASH/TA) measures liquidity of a firm. This indicates the availability of a firm's funds and its ability to make interest and principal payments. For almost all economies, the default parameters for CASH/TA level in shorter horizons are significantly negative. The magnitude of the default parameters typically decreases for longer horizons, indicating that CASH/TA level is a better indicator of a firm's ability to make payments in the short-term than the long-term.

The ratio of net income to total assets (NI/TA) measures profitability of a firm. The relationship between PD and NI/TA is as expected: the default parameters for NI/TA level is negative for all economies and all horizons.

The logarithm of the market capitalization of a firm over the median market capitalization of firms within the economy (SIZE) does not have a consistent effect on PD across different economies. For example, in the US the default parameters for SIZE level are positive for almost all horizons, suggesting that the complexity of larger firms outweighs the potential benefits, such as diversified business lines and funding sources. On the other hand, in China the default parameters for SIZE level are negative across almost all horizons. These differences may reflect differences in the business environments in the respective economies.

The default parameters associated with DTD Trend, CASH/TA Trend, SIZE Trend and NI/TA Trend are negative across almost all economies and horizons. The trend variables reflect momentum. The momentum effect is a short-term effect, and evidence of this is seen in the lower magnitude of the default parameters at longer horizons than at shorter horizons. The exception is the NI/TA Trend, which for some calibration groups has a higher magnitude at longer horizons.

The ratio of the sum of market capitalization and total liabilities to total assets (M/B) can either indicate the market mis-valuation effect or the future growth effect. This default parameter is negative for the US in the shorter term, indicating that higher M/B implies lower PD, and the future growth effect dominates during this period. On the other hand, in China and in the Developed Asia-Pacific calibration group, the default parameter for M/B is positive, indicating that for these economies, the market misvaluation effect dominates.

Shumway (2001) argued that a high level of the idiosyncratic volatility (SIGMA) indicates highly variable stock returns relative to the market index, which is equivalent to highly variable cash flows. Empirically, the sign on SIGMA is different across countries and across prediction horizons.

IV.2. Prediction Accuracy

In-sample testing: Various tests are carried out to test the prediction accuracy of the RMI-CRI PD forecasts. These tests are conducted in-sample.

A single calibration is conducted for the in-sample tests, using data to the end of the data sample. As an example, one-year PD forecasts are made for 31 December, 2000 by using the data at or before 31 December, 2000 and the parameters from the calibration. These PD forecasts can be compared to actual defaults that occurred at any time in 2001.

Accuracy ratio: The accuracy ratio (AR) is one of the most popular and meaningful tests of the discriminatory power of a rating system (BCBS, 2005). The AR and the equivalent Area Under the Receiver Operating Characteristic (AUROC) are described in Duan and Shrestha (2011). In short, if defaulting firms had been assigned among the highest PD of all firms before they defaulted, then the model has discriminated well between safe and distressed firms. This leads to higher values of AR and AUROC. The range of possible AR values is in [0, 1], where 0 is a completely random rating system and 1 is a perfect rating system. The range of possible AUROC values is in [0.5, 1]. AUROC and AR values are related by: $\text{AR} = 2 \times \text{AUROC} - 1$.

The AR and AUROC values for different horizons are available in Table B.1 of this technical report. Only economies with more than 20 defaults entering into the AR and AUROC computation are listed.

The AUROC values have been provided only for the purpose of comparison, if other rating systems report their results in terms of AUROC. The discussion will focus only on AR. The model is able to achieve strong AR results mostly greater than 0.80 at the one and six-month horizons for developed economies. There is a drop in AR at one and two-year horizons, but the AR are still mostly acceptable.

The AR in some emerging market economies such as China, India, Indonesia, and the Philippines are noticeably weaker than the results in the developed economies. This can be due to a number of issues. The quality of data is worse in emerging markets, in terms of availability and data errors. This may be due to lower reporting and auditing standards. Also, variable selection is likely to play a more important role in emerging markets. The variables were selected based on the predictive power in the US. Performing variable selections specific to the calibration group are expected to improve predictive accuracy, especially in emerging market economies. Finally, there could be structural differences in how defaults and bankruptcies occur in emerging market economies. If the judicial system is weak and there are no repercussions for default, firms may be less reluctant to default.

Aggregate defaults: The time series of aggregate predicted number of defaults and actual number of defaults in each calibration group are also available in Figs. B.3–B.8. For China and India in particular, these figures show that there is room for improvement in the predictive power of the model.

V. CORPORATE VULNERABILITY INDEX

In July 2012, the CRI launched the Corporate Vulnerability Index (CVI), which is a new suite of indices to produce bottom-up measures of credit risk in economies, regions and portfolios of special interest. The suite of CVIs is available in three distinctive types:

(1) Value-weighted CVI (CVI_{vw}): RMI-CRI PDs are aggregated with each firm weighted by its market-capitalization so that the size of each firm is taken into account.
(2) Equally-weighted CVI (CVI_{ew}): RMI-CRI PDs are aggregated with each firm equally weighted. This captures the prevalence of credit risk by focusing on the number of firms at risk.
(3) Tail CVI (CVI_{tail}): In taking the fifth percentile of the highest RMI-CRI PDs, the most vulnerable firms in a group are measured.

The CVIs are a set of indicators that gauge economic and financial environments in a new dimension. They are best viewed as stress indicators that reflect heightened credit risks in the corporate sector from three different angles.

Index Construction The primary inputs to the CVI are RMI-CRI 1-year PDs for individual exchange listed firms.

- Value-weighted CVI (CVI_{vw}): CVI_{vw} is an aggregation of individual PDs weighted by each firm's market-capitalization. In other words, at time t, given an interested group or portfolio G,

$$\mathrm{CVI}_{\mathrm{vw}}(t) = \sum_{i=1}^{I} \omega_{it} p_i(t, 12),$$

where $p_i(t, 12)$ is firm i's default probability within 12 months viewed from t, $i \in \{1, 2, \ldots, I\}$. Also, the weight for firm i at time t is ω_{it}, and $\omega_{it} = \frac{\mathrm{MC}_{it}}{\sum_{i=1}^{I} \mathrm{MC}_{it}}$, in which, MC_{it} is firm i's market-capitalization at time t. If a firm does not trade on a particular day, the market-capitalization from the previous valid day (within 20 trading days) is used. The market-capitalization weighting is applied to all economies and groups of economies, but is not applied to portfolios such as the S&P 500 index. The S&P 500 index is a float-adjusted index where the shares available to investors are used instead of the total shares outstanding, and our weighting scheme of $\mathrm{CVI}_{\mathrm{vw}}(\mathrm{SPP})$ is consistent with the S&P 500 index.

- Equally-weighted CVI ($\mathrm{CVI}_{\mathrm{ew}}$): The equally-weighted CVI is computed by aggregating each firm's PD with equal weights applied to each firm. In other words,

$$\mathrm{CVI}_{\mathrm{ew}} = \frac{1}{I} \sum_{i=1}^{I} p_i(t, 12).$$

- Tail CVI ($\mathrm{CVI}_{\mathrm{tail}}$): The tail CVI provides a measure of the relatively more distressed firms in a group. It is the highest fifth percentile of PDs. The tail CVI can also be interpreted as the conditional median of the 10% tail, which is a more robust measure of "tail average" than the conditional mean of the 10% tail.

Inclusion of Firms: A firm's PD is computed with the model parameters from its primary exchange. The construction of CVI, however, is based on the firm's country of domicile. In regions like the eurozone, some of the public holidays do not coincide. In this case, the aggregation is computed by using PDs from the previous trading day for firms that are listed in countries that have a public holiday, and PDs from the current trading day for firms that are listed in countries that do not have a public holiday. And firms are included in the eurozone CVI only if their countries of domicile are part of the eurozone at time t. For CVI of the S&P 500 portfolio, the constituents typically coincide with the constituents of the S&P 500 index for each point in time, and missing any PD value for a company in the S&P 500 is filled in with the most recently available PD.

VI. ACTUARIAL SPREAD

In July 2014, the CRI launched a new credit risk measure, the AS, which are the counterparts of market credit default swap (CDS) with contract horizons ranging from 1 year to 5 years but valued based on RMI-CRI's PDs in the forward horizons. Since then, the computation and publication of the AS have been implemented on a daily basis in addition to those of the PDs. Much like the par spread in a standard credit default swap (CDS) contract, the AS leverages the term structure of the physical PDs of the CRI and is essentially the premium rate that purely reflects the actuarial present value of a default protection. It provides a new metric of credit risk that the financial practitioners are more familiar with.

The construction of the AS relies on the features of a standard CDS contract. To fulfill a CDS contract, the protection buyer pays premiums on a regular basis to the seller until the contract matures or the reference entity defaults. In exchange, the protection buyer receives at the default time a contingent lump sum payment, the amount of which is based on the recovery rate on the reference instrument. Such a CDS contract terminates on its maturity date if there is no default up to its maturity; otherwise, it ceases on a default day, if any. Note that, if a default occurs during a payment period, the premium for the protection from the first accrual day to the default day is also assumed to be paid by the CDS buyer on the default day. Considering no effect from the market liquidity and using the physical PDs that the CRI generates, the AS is calculated in a way that the expected present value of the contingent claim upon default is equal to the expected present value of the series of premiums up until the stop of a CDS contract. To familiarize the details of its theoretical formulation, please refer to Duan (2014). As opposed to the continuous model introduced in Duan (2014), this technical report provides a discrete representation of the model for implementation purpose. For easy comparison, it adopts the same notations in the journal article as much as it possibly can.

A typical CDS contract adopts one day as the fundamental period of time. For this, we abbreviate the interval $((d-1)\cdot\Delta t, d\cdot\Delta t]$ in a forward time axis by the term day $d \in \mathbb{N}$ where $\Delta t = 1/365$ reflects the 365 day count convention. Consider t as the trading day of a CDS contract terminating on the day $T > t$. If the reference entity defaults at on a random day τ where $t+1 \leq \tau \leq T$, he will in return get a lump sum payment, which is 1 minus the recovery rate R_τ, from a unit-notional CDS and cease to make the scheduled payment beyond the default point. We assume the premiums are scheduled to be paid on the days $t_1, t_2, \ldots, t_k$ with $t_k = T$, where each payment period is roughly three months. Note that a payment day t_{i-1} is also the first day of the coming accrual period, which ends on the day before next payment day, denoted and defined by $t_i' = t_i - 1$. However, a trading day t may also occur after a payment day, say t_{i-1}, and we denote the exact start date of its remaining accrual period by $t_{i-1} \vee (t+1) = \max\{t_{i-1}, t+1\}$ for a general purpose.

Another actual/360 day count convention is usually adopted to define the length in year of an accrual period, for which we denote $A(s,q)$ the period length in year from the day s to the day $q > s$ (both inclusive). For example, if a quarterly accrual period from t_{i-1} to t_i' (both inclusive) has 91 days, then $A(t_{i-1}, t_i') = 91/360$ is applicable.

Compared to the risk-neutral probability measure used in the CDS pricing, the AS is essentially its counterpart based on a physical probability measure P. We denote it by $S_t^{(a)}(T-t)$ with its days to maturity $(T-t)$. Following the assumption that there is no arbitrage for CDS buyer and seller, the AS is defined to satisfy the equation:

$$
\begin{aligned}
&E_t^p\left[(1-R_\tau)D_t(\tau-t)\cdot 1_{\{t<\tau\leq t_k'\}}\right] \\
&\quad = S_t^{(a)}(T-t)\sum_{i=1}^{k}\Big\{A(t_{i-1}\vee(t+1), t_i') \\
&\qquad \times E_t^p\left[D_t(t_i-t)\cdot 1_{\{t_i'<\tau\}}\right] \\
&\qquad + E_t^p\Big[A(t_{i-1}\vee(t+1), \tau) \\
&\qquad \times D_t(\tau-t)\cdot 1_{\{t_{i-1}'<\tau\leq t_i'\}}\Big]\Big\},
\end{aligned}
$$

where E_t^P is an expectation operator with respect to the physical probability measure P, τ refers to the random default day, $D_t(\tau-t)$ is the random money market discount factor starting from the day t to another day τ and k is the number of the CDS premium payments.

The real-time LIBOR rates up to one year and Swap rates beyond are generally available from the market. With the combination, one can bootstrap the implied LIBOR rates beyond one year. As the AS is calculated based on days, a linear interpolation is further performed to obtain the implied LIBOR rates up to each forward day (in continuously compounded annualized form), which then serve the role of the discount factor $D_t(\cdot)$. Let $r_t(s,q)$ be the day-t risk-free annualized forward discount rate between the day $t+s$ and the day $t+q$ (both inclusive) with $q \geq s \geq 1$. In particular, $r_t(1,q)$ refers to the day-t risk-free spot discount rate covering the days $t+1, \ldots, t+q$. The standard term structure theory implies that

$$r_t(1,q) = -\frac{1}{q}\ln(E_t^P[D_t(q)]).$$

Further we let $r_t(q,q) = r_t(1,q)\cdot q - r_t(1,q-1)\cdot(q-1)$ for $q \geq 2$, which refers to the day-t instantaneous forward rate for the day $t+q$. As will be seen later, defining $r_t(s,q)$ this way is to make it consistent with the definition of the forward default/other exit intensity in terms of the day count convention. With the RMI-CRI PDs serving as the physical probability measure P and the use of a standard recovery rate of $\bar{R}_t = 40\%$, the AS is rewritten as

$$
\begin{aligned}
&S_t^{(a)}(T-t) \\
&\quad = \frac{(1-\bar{R}_t)\cdot E_t^p\left[e^{-r_t(1,\tau-t)(\tau-t)/365}\cdot 1_{\{t<\tau\leq t_k'\}}\right]}{\begin{aligned}\textstyle\sum_{i=1}^{k}\Big\{&A(t_{i-1}\vee(t+1), t_i') \\ &\times e^{-r_t(1,t_i-t)(t_i-t)/365}\cdot E_t^p\left[1_{\{t_i'<\tau\}}\right] \\ &+ E_t^p\,[A(t_{i-1}\vee(t+1),\tau) \\ &\times e^{-r_t(1,\tau-t)(\tau-t)/365}\cdot 1_{\{t_{i-1}'<\tau\leq t_i'\}}\Big\}\end{aligned}},
\end{aligned}
\tag{41}
$$

where the actual/365 day count convention is used for the discount factor and integration.

To obtain the physical probability of defaults and their term structures, we apply CRI's forward intensity model. Define $f_t(u)$ to be the day-t forward default intensity over the day $t+u$, which will be used to calculate the probability of default of a firm conditioning on its survival up to the day $t+(u-1)$. The forward intensity for other exits, or $h_t(u)$, can be similarly defined. These two intensities are expressed as exponential linear functions of 13 covariates, including an intercept term, two macroeconomic variables and 10 firm-specific variables, in the form of

$$f_t(u) = \exp\{\alpha_0(u) + \alpha_1(u)x_{1,t} + \cdots + \alpha_{12}(u)x_{12,t}\}$$

and

$$h_t(u) = \exp\{\beta_0(u) + \beta_1(u)x_{1,t} + \cdots + \beta_{12}(u)x_{12,t}\}.$$

The coefficients $\alpha_i(u)$ and $\beta_i(u)$ are functions of forward starting time, which are further modelled by NS term structure functions, such as

$$\begin{aligned}\alpha_i(u;\varrho_{i,0},\varrho_{i,1},\varrho_{i,2},d_i) &= \varrho_{i,0} + \varrho_{i,1}\frac{1-\exp(-u\Delta t/d_i)}{u\Delta t/d_i} \\ &\quad + \varrho_{i,2}\left[\frac{1-\exp(-u\Delta t/d_i)}{u\Delta t/d_i} - \exp(-u\Delta t/d_i)\right], \qquad (42)\end{aligned}$$

for $i = 0, 1, 2, \ldots, 12$. Recall that, except for the intercept terms $\alpha_0(u)$ and $\beta_0(u)$, the other covariates are stochastic and their long-term levels are restricted to zeros; namely, $\varrho_{i,0} = 0$ for $i = 1, 2, \ldots, 12$. With $f_t(u)$ and $h_t(u)$ in place, we are ready to define $\psi_t(s,q) = \frac{\sum_{u=s}^{q}[f_t(u)+h_t(u)]}{q-(s-1)}$, for $q \geq s \geq 1$, which is a standardized forward termination intensity covering the days $t+s, \ldots, t+q$.

One important feature of the CDS is that when the reference entity ceases to exist due to reasons other than default, such as mergers and acquisitions, the CDS protection is typically shifted to the merged or acquiring entity. Naturally, we should take into account the fact that the successor entity will then face subsequent default or other exits. There indeed are a number of ways to model the relationship between the termination probability of the reference entity and the successor entity (see Duan, 2014). In CRI's implementation, we further assume that the successor has the forward default and other exit intensities identical to those of the original reference entity.

Let $P_t(s, q; r_t(1,u), s \leq u \leq q)$ denote the day-t discounted forward probability of the reference entity of the CDS being terminated, including successions, over the days $t+s, \ldots, t+q$. Under the assumptions above (Duan, 2014) has derived its analytical solution, which can be re-written in the discrete form below

$$\begin{aligned}&P_t(s, q; r_t(1,v), s \leq v \leq q) \\ &\quad = \sum_{v=s}^{q} e^{-\sum_{u=s}^{v}[r_t(u,u)+f_t(u)]\Delta t} f_t(v)\Delta t. \qquad (43)\end{aligned}$$

By temporarily setting the forward interest rate to 0 in Eq. (43), the first term of denominator in Eq. (41) can be presented in the form of

$$\begin{aligned}E_t^P(1_{\{t_i'<\tau\}}) &= 1 - P_t(1, t_i'-t; r_t(1,u) \\ &= 0 \quad \text{for } 1 \leq u \leq t_i'-t). \qquad (44)\end{aligned}$$

The solutions to the two remaining two terms of Eq. (41) can be expressed as

$$\begin{aligned}&E_t^p\left[e^{-r_t(1,\tau-t)(\tau-t)/365}\cdot 1_{\{t<\tau\leq t_k'\}}\right] \\ &\quad = \sum_{q=1}^{t_k'-t} e^{-[r_t(1,q)+\psi_t(1,q)]\cdot(q/365)} \cdot f_t(q)\cdot\Delta t \\ &\quad\quad + \sum_{q=1}^{t_k'-t} e^{-[r_t(1,q)+\psi_t(1,q)]\cdot(q/365)} \\ &\quad\quad \times h_t(q)\cdot P_t(q, t_k'-t; r_t(1,v), q \leq v \leq t_k'-t) \\ &\quad\quad \times \Delta t\end{aligned}$$

and

$$\begin{aligned}&E_t^p\left[A(t_{i-1}\vee(t+1),\tau)\right] \\ &\quad\quad \times e^{-r_t(1,\tau-t)(\tau-t)/365}\cdot 1_{\{t_{i-1}'<\tau\leq t_i'\}} \\ &\quad = \sum_{q=t_{i-1}\vee(t+1)}^{t_i'} A(t_{i-1}\vee(t+1),q) \\ &\quad\quad \times e^{-[r_t(1,q-t)+\psi_t(1,q-t)]\cdot(q-t)/365}\cdot f_t(q-t)\cdot\Delta t \\ &\quad\quad + \sum_{q=t_{i-1}\vee(t+1)}^{t_i'} A(t_{i-1}\vee(t+1),q)\end{aligned}$$

$$\times e^{-[r_t(1,q-t)+\psi_t(1,q-t)]\cdot(q-t)/365}\cdot h_t(q-t)$$
$$\times P_t(q-t, t_i'-t; r_t(1,v), q-t \leq v \leq t_i'-t)$$
$$\times \Delta t.$$

With the formulas mentioned above, we compute the AS, or $S_t^{(a)}(T-t)$, and provide it to the public on a daily basis.

VII. ONGOING DEVELOPMENTS

The CRI can be developed along a number of directions. We now comment on obvious ones that in our view are likely to bring meaningful and measurable benefits. Besides modifications to the current modeling framework of the forward intensity, a change in modeling platform will be undertaken if another model proves more promising in terms of accuracy and robustness of results. For this type of development, we also rely on the collective efforts by the worldwide credit research community to challenge and improve the existing modeling platform.

Within the current modeling framework, future developments involve, for example, the CRI plans to implement DTD estimations by a novel density-tempered expanding-data sequential Monte Carlo method. Another example is variable selection where more experiments are needed to identify common risk factors and company-specific attributes that are more indicative of defaults in emerging markets. Also, we are designing a more comprehensive treatment scheme to handle missing data.

Finally, a series of new applications and tools using the RMI-CRI PDs as an input are currently being developed. More specifically, the CRI is actively working with users and exploring different possibilities of taking advantage of the world class research infrastructure at the institute to propagate real world applications in credit rating and testing. The CRI has developed a tool for stress testing the financial stability for economies around the world. The CRI has also developed a methodology to address default correlations within a portfolio. The CRI remains committed to making its vast resources available for academic research.

Acknowledgement

The RMI CRI is premised on the concept of credit ratings as a "public good". Being a non-profit undertaking allows a high level of transparency and collaboration that other commercial credit rating systems cannot replicate. The research and support infrastructure is in place and researchers from around the world are invited to contribute to this initiative. Any methodological improvements that researchers develop will be incorporated into the CRI system. In essence, the initiative operates as a "selective wikipedia" where many can contribute but implementation control is retained.

If you have feedback on this technical report or wish to work with us in this endeavor, please contact us at rmicri@globalcreditreview.com.

APPENDIX A. DATA

Table A.1. All countries under the CRI coverage.

Region	Economy
Asia Pacific (Developed) (7)	Australia, Hong Kong, Japan, New Zealand, Singapore, South Korea, Taiwan.
Asia Pacific (Emerging) (15)	Bangladesh, Cambodia, China, India, Indonesia, Kazakhstan, Macau, Malaysia, Mongolia, Pakistan, Papua New Guinea, Philippines, Sri Lanka, Thailand, Vietnam.
North America (4)	Bermuda, Canada, Greenland, United States.
Western Europe (28)	Austria, Belgium, Cyprus, Denmark, Faeroe Islands, Finland, France, Germany, Gibraltar, Greece, Guernsey, Iceland, Ireland, Italy, Isle of Man, Jersey, Liechtenstein, Luxembourg, Malta, Monaco, Netherlands, Norway, Portugal, Reunion, Spain, Sweden, Switzerland, United Kingdom.
Eastern Europe (19)	Azerbaijan, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Macedonia, Montenegro, Poland, Romania, Russian Federation, Serbia, Slovakia, Slovenia, Turkey, Ukraine.
Latin America and Caribbean (18)	Argentina, Bahamas, Belize, Brazil, British Virgin Islands, Cayman Islands, Chile, Colombia, Curacao, Dominican Republic, Falkland Islands, Jamaica, Mexico, Peru, Panama, Puerto Rico, U.S. Virgin Islands, Venezuela.
Middle East and Africa (28)	Angola, Bahrain, Cameroon, Egypt, Gabon, Ghana, Iraq, Israel, Jordan, Kuwait, Madagascar, Mauritius, Morocco, Mozambique, Namibia, Nigeria, Niger Republic, Oman, Qatar, Saudi Arabia, Sierra Leone, South Africa, Sudan, Tanzania, Togo, Tunisia, United Arab Emirates, Zambia.

Table A.2. The 78 countries under the CRI coverage for which we cover companies listed on the exchange.

Region	Economy
Asia Pacific (Developed) (7)	Australia, Hong Kong, Japan, New Zealand, Singapore, South Korea, Taiwan.
Asia Pacific (Emerging) (11)	Bangladesh, China, India, Indonesia, Kazakhstan, Malaysia, Pakistan, Philippines, Sri Lanka, Thailand, Vietnam.
North America (2)	Canada, United States.
Western Europe (20)	Austria, Belgium, Cyprus, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Malta, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, United Kingdom.
Eastern Europe (18)	Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Macedonia, Montenegro, Poland, Romania, Russian Federation, Serbia, Slovakia, Slovenia, Turkey, Ukraine.
Latin America and Caribbean (8)	Argentina, Brazil, Colombia, Chile, Jamaica, Mexico, Peru, Venezuela.
Middle East and Africa (12)	Bahrain, Egypt, Israel, Jordan, Kuwait, Morocco, Nigeria, Oman, Saudi Arabia, South Africa, Tunisia, United Arab Emirates.

Table A.3. The 41 countries under the CRI coverage for which we cover companies domiciled in the economy but listed on a foreign exchange included in Table A.2.

Angola	Gibraltar	Niger Republic
Azerbaijan	Greenland	Panama
Bahamas	Guernsey	Papua New Guinea
Belize	Iraq	Puerto Rico
Bermuda	Isle of Man	Qatar
British Virgin Islands	Jersey	Republic of Ghana
Cambodia	Liechtenstein	Republic of Zambia
Cameroon	Macau	Sierra Leone
Cayman Islands	Madagascar	Sudan
Curacao	Mauritius	Tanzania
Dominican Republic	Monaco	Togolese Republic
Faeroe Island	Mongolia	United States Virgin Islands
Falkland Islands	Mozambique	Reunion
Gabon	Namibia	

Note: The gray boxes indicate that these economies also have their own local stock exchange.

Table A.4. The ISO codes of 78 economies covered by the CRI and the corresponding calibration groups and stock exchanges.

ISO code	Economy	Calibration group	Stock exchange
ARE	United Arab Emirates	Emerging	Abu Dhabi Securities Exchange Dubai Financial Market National Association of Securities Dealers Automated Quotations Dubai
ARG	Argentina	Emerging	Buenos Aires Stock Exchange
AUS	Australia	Developed Asia-Pacific	Australian Securities Exchange National Stock Exchange of Australia SIM Venture Securities Exchange
AUT	Austria	Europe	Vienna Stock Exchange
BEL	Belgium	Europe	Brussels Stock Exchange
BGD	Bangladesh	Emerging	Dhaka Stock Exchange
BGR	Bulgaria	Europe	Bulgarian Stock Exchange
BHR	Bahrain	Emerging	Bahrain Stock Exchange
BIH	Bosnia and Herzegovina	Europe	Banja Luka Stock Exchange Sarajevo Stock Exchange
BRA	Brazil	Emerging	BM&FBOVESPA
CAN	Canada	North America	Canadian Securities Exchange Toronto Stock Exchange
CHE	Switzerland	Europe	Berne Stock Exchange Six Swiss Exchange
CHL	Chile	Emerging	Santiago Stock Exchange Santiago Electronic Stock Exchange
CHN	China	China	Shanghai Stock Exchange Shenzhen Stock Exchange
COL	Colombia	Emerging	Colombia Stock Exchange

(*Continued*)

Table A.4. (*Continued*)

ISO code	Economy	Calibration group	Stock exchange
CYP	Cyprus	Europe	Cyprus Stock Exchange
CZE	Czech Republic	Europe	Prague Stock Exchange
DEU	Germany	Europe	Berlin Stock Exchange
			BOAG Borsen AG
			Dusseldorf Stock Exchange
			Frankfurt Stock Exchange
			Munich Stock Exchange
			Stuttgart Stock Exchange
DNK	Denmark	Europe	Copenhagen Stock Exchange
			First North Denmark
EGY	Egypt	Emerging	Egyptian Exchange
			Nile Stock Exchange
ESP	Spain	Europe	Barcelona Stock Exchange
			Bilbao Stock Exchange
			Madrid Stock Exchange
			Valencia Stock Exchange
EST	Estonia	Europe	Tallinn Stock Exchange
FIN	Finland	Europe	Helsinki Stock Exchange
			NASDAQ OMX NORDIC
FRA	France	Europe	Paris Stock Exchange
GBR	United Kingdom	Europe	Icap Securities and Derivatives Exchange
			London International Financial Futures and Options Exchange
			London Stock Exchange
			Professional Liability Underwriting Society Market Group
GRC	Greece	Europe	Alternative Market of Athens Exchange
			Athens Stock Exchange
HKG	Hong Kong	Developed Asia-Pacific	Hong Kong Exchanges and Clearing Limited
HRV	Croatia	Europe	Zagreb Stock Exchange
HUN	Hungary	Europe	Budapest Stock Exchange
IDN	Indonesia	Emerging	Indonesian Stock Exchange
IND	India	India	Bombay Stock Exchange
			MCX Stock Exchange Limited
			National Stock Exchange of India Limited
IRL	Ireland	Europe	Irish Stock Exchange
ISL	Iceland	Europe	Iceland Stock Exchange
			Reykjavik Stock Exchange
ISR	Israel	Europe	Tel Aviv Stock Exchange
ITA	Italy	Europe	Borsa Italiana S.p.A
			Hi-Multilateral Trading Facilities Sim S.p.A
JAM	Jamaica	Emerging	Jamaica Stock Exchange
JOR	Jordan	Emerging	Amman Stock Exchange
JPN	Japan	Developed Asia-Pacific	Fukuoka Stock Exchange
			JASDAQ Securities Exchange
			Nagoya Stock Exchange
			Osaka Securities Exchange
			Sapporo Stock Exchange
			Tokyo Stock Exchange
KAZ	Kazakhstan	Emerging	Kazakhstan Stock Exchange JSC
KOR	South Korea	Developed Asia-Pacific	Korea New Exchange
			Korea Stock Exchange
			Korean Securities Dealers Automated Quotations
KWT	Kuwait	Emerging	Kuwait Stock Exchange
LKA	Sri Lanka	Emerging	Colombo Stock Exchange

(*Continued*)

Table A.4. (*Continued*)

ISO Code	Economy	Calibration group	Stock exchange
LTU	Lithuania	Europe	OMX Vilnius Stock Exchange
LUX	Luxembourg	Europe	Luxembourg Stock Exchange
LVA	Latvia	Europe	OMX Riga Stock Exchange
MAR	Morocco	Emerging	Casablanca Stock Exchange
MEX	Mexico	Emerging	Mexican Stock Exchange
MKD	Macedonia	Europe	Macedonian Stock Exchange Inc.
MLT	Malta	Europe	Malta Stock Exchange
MNE	Montenegro	Europe	Montenegro Stock Exchange
MYS	Malaysia	Emerging	Kuala Lumpur Stock Exchange
NGA	Nigeria	Emerging	Nigerian Stock Exchange
NLD	Netherlands	Europe	Euronext Amsterdam Stock Exchange
NOR	Norway	Europe	Oslo Stock Exchange
NZL	New Zealand	Developed Asia-Pacific	New Zealand Exchange
OMN	Oman	Emerging	Muscat Securities Market
PAK	Pakistan	Emerging	Karachi Stock Exchange Pakistan Stock Exchange
PER	Peru	Emerging	Lima Stock Exchange
PHL	Philippines	Emerging	Philippine Stock Exchange
POL	Poland	Europe	Warsaw Stock Exchange
PRT	Portugal	Europe	Euronext Lisbon Stock Exchange Opex Stock Exchange
ROM	Romania	Europe	Bucharest Stock Exchange Sibiu Stock Exchange
RUS	Russian Federation	Europe	Moscow Exchange Moscow Interbank Currency Exchange Russian Trading System
SAU	Saudi Arabia	Emerging	Saudi Stock Exchange
SGP	Singapore	Developed Asia-Pacific	Singapore Exchange
SRB	Serbia	Europe	Belgrade Stock Exchange
SVK	Slovakia	Europe	Bratislava Stock Exchange
SVN	Slovenia	Europe	Ljubljana Stock Exchange
SWE	Sweden	Europe	AktieTorget Stock Exchange First North Stockholm Nordic Growth Market Stockholm Stock Exchange
THA	Thailand	Emerging	Stock Exchange of Thailand
TUN	Tunisia	Emerging	Tunis Stock Exchange
TUR	Turkey	Europe	Istanbul Stock Exchange
TWN	Taiwan	Developed Asia-Pacific	Taiwan Stock Exchange
UKR	Ukraine	Europe	First Stock Trading System Russian Trading System Ukraine
USA	United States	North America	NASDAQ Capital Market NASDAQ Global Market NASDAQ Global Select Market New York Stock Exchange NYSE Arca NYSE MKT LLC
VEN	Venezuela	Emerging	Caracas Stock Exchange
VNM	Vietnam	Emerging	Hanoi Stock Exchange Ho Chi Minh City Stock Exchange
ZAF	South Africa	Emerging	Johannesburg Stock Exchange

Note: The stock exchanges covered by the CRI database are collected from Bloomberg system and labeled as primary exchange.

Table A.5. The stock indices used for each economy in computing the first common variable.

Country	Stock index	Period used*
ARE	FTSE NASDAQ DUB UAE 20	06/28/2006–Present
ARG	Buenos Aires Stock Exchange Merval Index	
AUS	All Ordinaries Index	
AUT	Austrian Traded ATX Index	
BEL	Belgian Stk Mkt Ret Index	
BGD	DSEX Index	01/28/2013–Present
	Dhaka Stock Exchange General I	–1/27/2013
BGR	Bulgaria Stock Exchange Sofix Index	10/24/2000–Present
BHR	BB All Share Index	07/08/2004–Present
BIH	SASE Free Market 10 Index	12/31/2004–Present
BRA	Brazil Bovespa Stock Index	
CAN	S&PTSX Composite Index	
CHE	SPI Swiss Performance Index	
CHL	Santiago Stock Exchange IPSA Index	
CHN	Shanghai SE Composite Index	12/19/1990–Present
COL	FTSE All World Series Colombia Local	01/01/1999–Present
CYP	Cyprus Stock Exchange General Index	09/03/2004–Present
	Cyprus Stock Exchange General	04/02/1996–09/02/2004
CZE	Prague Stock Exchange Index	04/05/1994–Present
DEU	CDAX Performance Index	
DNK	OMX Copenhagen 20 Index	
EGY	EGX 100 Index	05/01/2006–Present
ESP	IBEX 35 Index	
EST	OMX Tallinn OMXT	06/03/1996–Present
FIN	OMX Helsinki Index	
FRA	CAC 40 Index	
GBR	FTSE 100 Index	
GRC	Athex Composite Share Price Index	
HKG	Hang Seng Index	
HRV	Croatia Zagreb CROBEX	06/14/2002–Present
HUN	Budapest Stock Exchange Index	01/02/1991–Present
IDN	Jakarta Composite Index	
IND	BSE Sensex 30 Index	
IRL	ISEQ Overall Index	
ISL	OMX Iceland All-Share PR	12/31/1992–Present
ISR	Tel Aviv 100 Index	12/31/1991–Present
ITA	Italy Stock Market BCI Comit Globale	
JAM	Jamaica Stock Exchange Market Index	
JOR	MSCI Jordan Index	
JPN	Nikkei 500	
KAZ	Kazakhstan Stock Exchange Index KASE	07/12/2000–Present
KOR	KOSPI Index	
KWT	Kuwait SE Weighted Index	01/02/2012–Present
	Kuwait Global General Index	–1/01/2012
LKA	Sri Lanka Colombo Stock Exchange All-Share Index	
LTU	OMX Vilnius OMXV	01/04/2000–Present
LUX	Luxembourg Stock Exchange Luxx Index	01/04/1999–Present
	Luxembourg Stock Exchange 13 'Dead'	01/02/1998–01/03/1999
LVA	OMX Riga OMXR	01/03/2000–Present
MAR	MASI Free Float All Shares Index	03/31/1995–Present
	CFG 25 CFG 25	12/31/1993–03/30/1995
MEX	Mexico Bolsa Index	01/19/1994–Present
MKD	Macedonian Stock Exchange MBI 10	12/30/2004–Present
MLT	Malta Stock Exchange	12/27/1995–Present

(*Continued*)

Table A.5. (*Continued*)

Country	Stock index	Period used*
MNE	Montenegro Stock Exchange Index	01/04/2015–Present
	Montenegro Stock Exchange 20	03/03/2003–03/31/2015
MYS	FTSE Bursa Malaysia KLCI	
NGA	Nigeria Stock Exchange All Share	01/30/1998–Present
NLD	AEX-Index	
NOR	OBX Price Index	
NZL	NZX All Index	03/30/1992–Present
OMN	MSM30 Index	03/31/1992–Present
PAK	Karachi All Share Index	03/11/1998–Present
PER	S&PBVL Peru General Index TR PEN	01/05/2015–Present
	Bolsa de Valores de Lima General Sector Index	01/02/1990–04/30/2015
PHL	Philippine Stock Exchange Index	
POL	WSE WIG Index	04/16/1991–Present
PRT	PSI General Index	
ROM	BET Index	09/22/1997–Present
RUS	MICEX Index	09/22/1997–Present
SAU	Tadawul All Share Index	01/31/1994–Present
SGP	Straits Times Index	10/01/2008–Present
	Straits Times Old Index	01/04/1985–01/09/2008
SRB	BELEXline Index	10/01/2004–Present
SVK	Slovak Share Index	09/14/1993–Present
SVN	HSBC Slovenia Dollar	12/29/1995–Present
SWE	OMX Stockholm All-Share	
THA	Stock Exchange Of Thai Index	
TUN	Tunis SE TUNINDEX	04/30/1999–Present
TUR	Istanbul Stock Exchange National 100 Index	
TWN	Taiwan Stock Exchange Weighted Index	
UKR	Ukraine PFTS Index	01/12/1998–Present
USA	S&P 500 Index	
VEN	Caracas Stock Exchange Stock Market Index	12/30/1993–Present
VNM	Ho Chi Minh Stock Index	07/28/2000–Present
ZAF	MSCI South Africa Index	12/31/1992–Present

Note: *A blank Period Used column indicates that there is only a single interest rate that is used throughout the whole period.

Table A.6. The interest rates used for each economy as the second common variable.

Country	Short-term interest rate	Period used*
ARE	UAE Ibor 3 Month	05/15/2000–Present
ARG	Argentina Deposit Tate 90 Day	04/01/1991–Present
AUS	Australia Dealer Bill 90 Day	
AUT	Germany 3 Month Bubill	01/01/1999–Present
	—	–12/31/1998
BEL	Germany 3 Month Bubill	01/01/1999–Present
	—	–12/31/1998
BGD	Bangladesh 3 Month Bill Auction Cut Off Yield	
BGR	Bulgaria Interbank 3 Month	02/17/2003–Present
BHR	Bahrain Ibor 3 Month	12/14/2006–Present
BIH	—	
BRA	Andima Brazil Govt Bond Fixed Rate 3 Months	04/03/2000–Present
	Brazil CDB (Up To 30 Days)	10/10/1994–04/02/2000

(*Continued*)

Table A.6. (*Continued*)

Country	Short-term interest rate	Period used*
CAN	Canada Treasury Bill 3 Month	01/02/1990–Present
CHE	Swiss Interbank 3m (ZRC:SNB)	
CHL	Chile TAB UF Interbank Rate 90 Days	11/02/1992–Present
CHN	China Time Deposit Rate, 3 Month	05/17/1993–Present
COL	Colombia CD Rate 90-Day	
CYP	Germany 3 Month Bubill	01/01/2008–Present
	—	–12/31/2007
CZE	Czech Republic Interbank 3 Month	04/22/1992–Present
DEU	Germany 3 Month Bubill	05/25/1993–Present
	Germany Interbank 3 Month	01/02/1986–05/24/1993
DNK	Denmark Interbank 3 Month	
EGY	Egypt 91 Day T-Bill	07/06/2004–Present
ESP	Germany 3 Month Bubill	01/01/2015–Present
	—	–12/31/2014
EST	Germany 3 Month Bubill	01/01/2011–Present
	—	–12/31/2010
FIN	Germany 3 Month Bubill	01/01/1999–Present
	—	–12/31/1998
FRA	Germany 3 Month Bubill	01/01/1999–Present
	—	–12/31/1998
GBR	UK Treasury Bill Tender 3 Month	01/04/1995–Present
GRC	Germany 3 Month Bubill	01/01/1999–Present
	—	–12/31/1998
HKG	Hong Kong Exchange Fund Bill 3 Month	06/10/1991–Present
HRV	Croatia Zibor Rate 3 Month	06/02/1997–Present
HUN	Hungary Interbank 3 Month	09/07/1995–Present
IDN	Indonesia Interbank 3 Months	07/10/2003–Present
	Indonesia SBI/DISC 90 Day 'dead'	–07/09/2003
IND	India Treasury Bill 3 Month	05/20/2013–Present
	India T-Bill Secondary 91 Day	01/15/1993–05/19/2013
IRL	Germany 3 Month Bubill	01/01/1999–Present
	—	–12/31/1998
ISL	Iceland Interbank 3-Month	08/04/1998–Present
	Iceland 90-Day Cb Notes	08/03/1998
ISR	Israel T-Bill Secondary 3 Month	05/30/1995–Present
ITA	Germany 3 Month Bubill	01/01/1999–Present
	—	–12/31/1998
JAM	Jamaica 3 Months Repo Rate	07/17/2008–Present
JOR	Jordanian Dinar Interbank Offered Rate 3 Months	09/20/2006–Present
	Jordan Re-discount rate	03/12/2001–09/19/2006
JPN	Japan Treasury Discount Bills 3 Month	07/10/1992–Present
	Japan Government Bond Interest Rate — 1 Year	–07/09/1992
KAZ	Kazakhstan KIBOR/KIBID 90 Days Interbank	09/29/2001–Present
KOR	Korea Commercial Paper 91d	06/14/1993–Present
KWT	Kuwait Interbank 3 Month	
LKA	Sri Lanka Treasury Bill 3 Month	
LTU	Germany 3 Month Bubill	01/01/1999–Present
	—	–12/31/1998
LUX	Germany 3 Month Bubill	01/01/1999–Present
	—	–12/31/1998
LVA	Germany 3 Month Bubill	01/01/2008–Present
	—	–12/31/2007

(*Continued*)

Table A.6. (*Continued*)

Country	Short-term interest rate	Period used*
MAR	Morocco Deposit Rate 3 Month	06/06/2003–Present
MEX	Mexico Cetes 2nd Mkt. 90 Day	06/26/1996–Present
	Mexico CETES 91 Day Avg.Ret.At Auc.	–06/25/1996
MKD	Macedonia Skibor 3 Months	07/02/2007–Present
MLT	Germany 3 Month Bubill	01/01/2009–Present
	—	–12/31/2008
MNE	—	
MYS	Malaysia Deposit 3 Month	
NGA	Nigeria Interbank Offered Rate 3 Month	01/30/2004–Present
NLD	Germany 3 Month Bubill	01/01/2007–Present
	—	–12/31/2006
NOR	Norway Govt Treasury Bills 3 Month	06/27/1995–Present
	Norway Interbank 3 Month (Effective)	–06/26/1995
NZL	—	
OMN	OMR 3 Month Deposit	07/16/2002–Present
PAK	PKR 3 Month Repo	10/29/1999–Present
PER	Peru Savings Rate	07/01/1991–Present
PHL	Philippine Treasury Bill 91d	
POL	Poland Interbank 3 Month (EOD)	06/04/1993–Present
PRT	Germany 3 Month Bubill	01/01/1999–Present
	—	–12/31/1998
ROM	Romanian Interbank 3 Month	08/01/1995–Present
RUS	MosPime 3 Months Rate	04/18/2005–Present
	Russia Moscow Interbank Non Co	08/14/2000–04/17/2005
	Russia Interbank 31 To 90 Day	09/01/1994–08/13/2000
SAU	Saudi Interbank 3 Month	
SGP	Monetary Authority of Singapore Benchmark Govt Bill Yield 3 Month	09/20/2013–Present
	Singapore T-Bill 3 Month	–09/19/2013
SRB	National Bank of Serbia Belibor 3M Rate (Interbank Rate)	01/28/2005–Present
SVK	Germany 3 Month Bubill	01/01/2001–Present
	—	–12/31/2000
SVN	Germany 3 Month Bubill	01/01/2014–Present
	—	–12/31/2013
SWE	Sweden T Bill 3 Month	05/25/1993–Present
	Sweden Treasury Bill 90 Day	–05/24/1993
THA	Thailand Bibor Fixings 3 Month	05/30/2002–Present
	Thailand Repo 3 Month (BOT) 'Dead'	03/11/1994–05/29/2002
TUN	Tu Policy Rates: TMM (Avg.)	12/15/1994–Present
TUR	Turkish Interbank 3 Month	08/01/2002–Present
TWN	Taiwan Money Market 90 Day	
UKR	Ukraine Interbank 3 Months	03/01/2001–Present
USA	US Generic Govt 3 Month Yield	
VEN	Venezuela 90 Day Deposit Rate	01/10/1997–Present
	Venezuela Overnight	11/28/1994–01/09/1997
VNM	Vietnam Interbank 3 Month	12/11/1998–Present
ZAF	SA T-Bill 91 Days (Tender Rates)	

Note: *A blank Period Used column indicates that there is only a single interest rate that is used throughout the whole period.

Table A.7. The interest rates used for each economy in the DTD calculation.

Country	Interest rate name	Period used*
ARE	UAE IBOR 1 Year	05/15/2000–Present
ARG	Argentina Deposit 90 Day (PA.)	04/01/1991–Present
AUS	Australia Govt Bonds Generic Mid Yield 1 Year	
AUT	German Government Bonds 1 Year BKO	01/01/1999–Present
	Austria VIBOR 12 Month	06/10/1991–12/31/1998
BEL	German Government Bonds 1 Year BKO	01/01/1999–Present
	Belgium Treasury Bill 1 Year	04/02/1991–12/31/1998
BGD	Bangladesh 12 Month Bill Auction Cut Off Yield	
BGR	Bulgaria Interbank 3 Month	02/17/2003–Present
BHR	Bahrain IBOR 1 Year	12/14/2006–Present
BIH	BP Real Interest Rate (%) NADJ	06/30/1998–Present
BRA	Andima Brazil Govt Bond Fixed Rate 1 Year	03/04/2000–Present
	Brazil CDB (Up To 30 Days)	10/10/1994–04/02/2000
CAN	Canada Treasury Bill 1 Year	01/02/1990–Present
CHE	Swiss Interbank 1 Year (ZRC:SNB)	
CHL	Chile Tab UF Interbank Rates 360 Days	01/08/1996–Present
	Chile Tab UF Interbank Rate 90 Days	11/02/1992–07/31/1996
CHN	China Household Savings Deposits 1 Year Rate	01/02/1992–Present
COL	Colombia Government Generic Bond 1 Year Yield	01/03/2001–Present
	Colombia CD Rate 360-Day	07/12/1993–02/28/2001
CYP	German Government Bonds 1 Year BKO	01/01/2008–Present
	Cyprus, Treasury Bill Rate — 13 Week	01/15/1993–12/31/2007
CZE	Czech Republic Interbank 3 Month	04/22/1992–Present
DEU	German Government Bonds 1 Year BKO	10/01/1995–Present
	Germany Interbank 12 Month	11/02/1990–01/09/1995
DNK	Denmark Government Bonds 1 Year Note Generic Bid Yield	06/19/2008–Present
	Denmark Euro-Krone 1 Year (FT/ICAP/TR)	06/14/1985–06/18/2008
EGY	Egypt 364 Day T-Bill	07/06/2004–Present
ESP	German Government Bonds 1 Year BKO	01/01/1999–Present
	Spain 12 Month Treasury Bill Yield	12/29/1995–12/31/1998
	Spain Interbank 12 Month	12/19/1991–11/29/1992
EST	German Government Bonds 1 Year BKO	01/01/2011–Present
	Estonia, Interest Rates, Prices, Production, and LABOUR, Interest Rates, Deposit Rate	02/15/1993–12/31/2010
FIN	German Government Bonds 1 Year BKO	01/01/1999–Present
	Finland Interbank Close 12 Month	04/02/1992–12/31/1998
FRA	German Government Bonds 1 Year BKO	01/01/1999–Present
	France Treasury Bill 12 Months	–12/31/1998
GBR	UK Govt Bonds 1 Year Note Gene	09/12/2001–Present
	UK Govt. Liab. Nom. Spot Curve 12 Month	–09/11/2001
GRC	German Government Bonds 1 Year BKO	01/01/2001–Present
	Greece Treasury Bill 1 Year	01/02/1990–12/31/2000
HKG	HKMA Hong Kong Exchange Fund Bills 12 Month	10/28/1991–Present
HRV	Croatia ZIBOR Rate 3 Month	06/02/1997–Present
HUN	Hungary Central Bank Base Rate	10/15/1990–Present
IDN	INDONESIA SBI 90 DAY	07/10/2003–Present
	INDONESIA SBI/DISC 90 DAY'DEAD'	01/01/1985–07/09/2003
IND	India Treasury Bill 1 Year	05/20/2013–Present
	INDIA T-BILL SECONDARY 1 YEAR	01/01/1993–05/19/2013
IRL	German Government Bonds 1 Year BKO	01/01/1999–Present
	Dublin Interbank Offered Rates	04/10/1991–12/31/1998

(*Continued*)

Table A.7. (*Continued*)

Country	Interest rate name	Period used*
ISL	Iceland Interbank 12-Month	02/01/2000–Present
	Iceland Interbank 3-Month	08/04/1998–01/31/2000
	Iceland 90-Day CD Notes	–08/03/1998
ISR	Israel T-Bill Secondary 1 Year	11/15/1994–Present
ITA	German Government Bonds 1 Year BKO	01/01/1999–Present
	Italy Bots Treasury Bill 12 Month Gross Yields	12/29/1995–12/31/1998
	Italy T-Bill Auct. Gross 12 Month	–09/04/1994
JAM	Jamaica 12 Months Repo Rate	07/17/2008–Present
JOR	Jordan Re-Discount Rate	03/12/2001–Present
JPN	Japan Treasury Bills 12 Month	12/14/1999–Present
KAZ	Kazakhstan KIBOR/KIBID 90 Days Interbank	09/29/2001–Present
KOR	Korea Monetary Stab. Bonds 1 Year	01/03/1992–Present
KWT	Kuwait Interbank 1 Year	
LKA	Sri Lanka Fixed Deposit 1 Year	
LTU	German Government Bonds 1 Year BKO	01/01/2015–Present
	Vilnius Interbank 12 Month	03/29/2000–12/31/2014
LUX	German Government Bonds 1 Year BKO	01/01/1999–Present
	Long Term Government Bond Yields — Maastricht Definition (Avg.)	–12/31/1998
LVA	German Government Bonds 1 Year BKO	01/01/2014–Present
	Treasury Bill Rate 1 Year	04/03/1996–12/31/2013
MAR	Morocco Deposit Rate 1 Year	06/06/2003–Present
MEX	Mexico Cetes 2nd Mkt. 360 Day	06/26/1996–Present
	Mexico Cetes 91 Day Avg.Ret.At Auc.	–06/25/1996
MKD	Macedonia SKIBOR 3 Months	07/02/2007–Present
MLT	German Government Bonds 1 Year BKO	01/01/2008–Present
	Long Term Government Bond Yields — Maastricht Definition (Avg.)	01/15/1985–12/31/2007
MNE	Treasury Bill Rate — 182-Day (EP)	07/16/2004–Present
MYS	Bank Negara Malaysia 1 Year Govt Securities Indicative YTM	06/21/2005–Present
	Malaysia Deposit 1 Year	–06/20/2005
NGA	Nigeria Interbank Offered Rate 12 Month	09/29/2011–Present
	Nigeria Interbank Offered Rate 3 Month	01/30/2004–09/28/2011
NLD	German Government Bonds 1 Year BKO	01/01/1999–Present
	Netherland Interbank 1 Year	–12/31/1998
NOR	Norway Govt Treasury Bills 12 Month	07/01/1997–Present
	Norway Interbank 1 Year	–06/30/1997
NZL	New Zealand Dollar Deposit 1 Year	
OMN	OMR 12 Month Deposit	07/16/2002–Present
PAK	PKR 12 Month Repo	10/29/2004–Present
PER	Peru Savings Rate	07/01/1991–Present
PHL	Philippine Treasury Bill 364d	
POL	Poland Interbank 1 Year (EOD)	10/11/1995–Present
PRT	German Government Bonds 1 Year BKO	01/01/1999–Present
ROM	Romanian Interbank 12 Month	08/01/1995–Present
RUS	Mospime 3 Months Rate	04/18/2005–Present
	Russia Moscow Interbank Non Co	08/14/2000–04/17/2005
	Russia Interbank 31 To 90 Day	09/01/1994–08/13/2000
SAU	Saudi Interbank 1 Year	
SGP	Monetary Authority of Singapore Benchmark Govt Bill Yield 3 Month	09/20/2013–Present
	Singapore T-Bill 3 Month	–09/19/2013
SRB	Serbia Treasury Bill Auction Results 12 Months Average Accepted Yield	08/26/2009–Present
SVK	German Government Bonds 1 Year BKO	01/01/2009–Present
	Slovak Rep. Interbank 1 Year	08/09/1994–12/31/2008

(*Continued*)

Table A.7. (*Continued*)

Country	Interest rate name	Period used*
SVN	German Government Bonds 1 Year BKO	01/01/2007–Present
	Slovenia Treasury Bill 3 Month'dead'	10/29/1998–12/31/2006
SWE	Sweden T Bill 3 Month	05/25/1993–Present
	Sweden Treasury Bill 90 Day	–05/24/1993
THA	Thailand Govt Bond 1 Year Note	07/08/2000–Present
	Thailand Deposit 12 Month (KT)	01/02/1991–08/06/2000
TUN	TU BCT Key Interest Rate	12/15/1994–Present
TUR	Turkish Interbank 12 Month	08/01/2002–Present
TWN	Taiwan Deposit 12 Month	
UKR	Ukraine Interbank 3 Months	03/01/2001–Present
USA	US Treasury Constant Maturities 1 Year	
VEN	Venezuela Savings Deposit Rate	03/01/2000–Present
	Venezuela Overnight	11/28/1994–01/02/2000
VNM	Vietnam Interbank 3 Month	12/11/1998–Present
ZAF	South African Prime Overdraft 1 Year Rate	

Note: *A blank Period Used column indicates that there is only a single interest rate that is used throughout the whole period.

Table A.8. Summary statistics of input variables (based on data from January 1990 to January 2016).

	Min	25%	Median	75%	Max	Mean	StdDev	No. of observations
				DTD Level				
ARE	−0.80	1.77	2.72	3.91	17.43	3.14	2.00	6542
ARG	−1.75	1.27	2.59	3.90	24.69	2.88	2.43	13144
AUT	−2.68	1.93	3.24	5.22	26.04	4.07	3.98	21347
AUS	−1.29	1.72	2.89	4.34	20.40	3.29	2.30	300287
BIH	−1.54	1.41	2.57	4.82	26.04	3.61	3.58	3722
BGD	−1.71	1.97	3.14	4.86	21.63	3.60	2.23	9712
BEL	−2.68	2.51	4.49	7.06	26.04	5.20	3.99	30413
BGR	−1.77	1.02	2.04	3.46	26.04	2.65	2.69	10132
BHR	−0.20	1.58	2.67	4.76	18.28	3.70	3.21	1348
BRA	−1.82	0.64	2.00	3.91	24.69	2.61	2.89	50487
CAN	−1.12	1.82	3.22	5.06	24.54	3.73	2.73	234492
CHE	−2.68	2.64	4.24	6.29	26.04	4.73	3.05	53083
CHL	−1.82	3.32	5.19	7.17	24.69	5.70	3.70	26288
CHN	0.00	3.15	4.28	5.86	16.40	4.74	2.29	317006
COL	−1.35	2.23	4.14	6.44	19.98	4.62	3.23	5516
CYP	−1.19	0.84	1.55	2.59	23.81	2.11	2.35	15119
CZE	−2.68	1.24	2.45	4.03	20.27	2.85	2.40	5527
DEU	−2.68	1.60	2.96	4.67	26.04	3.43	2.80	187611
DNK	−2.68	1.78	3.17	4.93	26.04	3.74	3.19	42713
EST	−0.30	2.43	3.86	6.37	13.88	4.55	2.81	1080
EGY	−1.82	1.87	2.99	4.43	24.69	3.38	2.26	18529
ESP	−2.68	1.96	3.48	5.21	26.04	3.95	3.24	34477
FIN	−2.68	2.33	3.57	5.19	16.52	3.89	2.39	30060
FRA	−2.68	1.84	3.16	4.88	26.04	3.65	2.85	167406
GBR	−2.68	2.09	3.55	5.53	26.04	4.11	2.93	367108
GRC	−2.68	1.24	2.29	3.66	23.59	2.61	2.17	58275

(*Continued*)

Table A.8. (*Continued*)

	Min	25%	Median	75%	Max	Mean	StdDev	No. of observations
				DTD Level				
HKG	−1.29	1.60	2.66	4.16	20.40	3.18	2.39	239148
HRV	−2.68	1.03	2.28	3.98	22.30	2.80	2.56	11167
HUN	−1.45	1.41	2.66	4.26	26.04	3.09	2.54	7537
IDN	−1.82	0.78	1.86	3.28	24.69	2.31	2.38	63552
IRL	−1.43	1.84	3.26	4.94	26.04	3.61	2.59	8643
ISR	−2.68	1.27	2.46	3.92	26.04	2.89	2.56	80239
IND	−2.70	0.81	1.79	3.07	23.08	2.27	2.43	499559
ISL	−1.48	1.77	3.05	4.77	20.01	3.59	2.70	3919
ITA	−2.68	1.58	2.89	4.52	26.04	3.27	2.60	63959
JAM	−0.77	1.32	2.67	3.59	15.40	2.77	2.12	2278
JOR	−0.99	2.56	3.69	5.44	23.78	4.28	2.55	23652
JPN	−1.29	2.12	3.22	4.70	20.40	3.67	2.32	875990
KOR	−1.29	1.37	2.36	3.66	20.40	2.77	2.29	322101
KWT	−0.44	2.28	3.31	4.69	24.69	3.79	2.32	23883
KAZ	−1.60	0.49	1.58	3.45	24.69	2.82	4.40	774
LKA	−1.82	1.58	2.63	4.05	19.20	3.07	2.28	22377
LTU	−1.30	1.51	3.26	5.52	20.91	3.86	3.36	4819
LUX	−0.56	3.23	5.06	8.75	26.04	6.77	5.20	2823
LVA	−1.45	1.13	2.24	3.95	26.04	2.88	2.56	2827
MAR	−0.68	2.63	3.82	5.37	21.62	4.16	2.42	8725
MNE	−0.28	1.52	2.32	3.01	9.75	2.61	1.70	1072
MKD	−1.09	1.26	1.98	3.04	17.84	2.95	3.20	2210
MLT	−0.65	2.38	3.72	5.45	14.99	4.54	3.37	1100
MEX	−1.82	2.09	3.95	6.24	24.69	4.53	3.48	18905
MYS	−1.82	1.62	2.91	4.77	24.69	3.63	3.03	204881
NGA	−1.78	1.07	2.31	3.68	24.69	3.04	3.68	15821
NLD	−2.68	2.41	3.99	5.91	26.04	4.43	3.02	37841
NOR	−2.68	1.23	2.43	3.98	20.50	2.74	2.18	43904
NZL	−1.23	2.75	4.97	7.39	20.40	5.39	3.46	18673
OMN	−0.05	3.31	4.70	7.24	23.82	5.77	3.73	2879
PER	−1.82	1.79	3.24	4.92	22.71	3.76	2.92	10149
PHL	−1.82	1.22	2.49	4.20	24.69	3.00	2.62	39799
PAK	−1.82	0.50	2.00	3.72	13.99	2.32	2.39	27740
POL	−2.68	1.36	2.44	3.66	26.04	2.73	2.14	67761
PRT	−2.68	0.99	2.31	4.06	20.20	2.78	2.51	13289
ROM	−2.68	0.80	1.77	3.02	26.04	2.14	2.06	13712
SRB	−2.68	0.50	1.94	3.29	22.90	2.28	2.78	2886
RUS	−2.28	0.71	1.93	3.53	26.04	2.33	2.29	19869
SAU	−1.52	3.96	5.82	8.44	24.69	6.63	3.79	18130
SWE	−2.68	1.68	3.09	4.80	26.04	3.52	2.68	86547
SGP	−1.29	1.52	2.70	4.45	20.40	3.29	2.56	128770
SVN	−2.47	1.65	3.27	5.39	16.87	3.75	3.13	5808
SVK	−0.68	0.92	2.21	3.70	26.04	4.30	6.68	841
THA	−1.71	1.79	3.05	4.73	24.69	3.53	2.66	104772
TUN	−1.69	2.03	3.45	5.67	17.78	4.09	2.93	7221
TUR	−1.66	1.69	2.95	4.76	26.04	3.70	3.28	48884
TWN	−1.24	2.90	4.11	5.70	20.40	4.59	2.67	157833
UKR	−2.04	0.56	1.49	2.72	21.66	1.82	2.25	3902
USA	−1.12	1.84	3.16	4.94	24.54	3.69	2.72	1553284
VEN	−1.82	0.58	1.56	3.28	17.11	2.46	3.41	3014
VNM	−1.34	1.10	1.93	3.08	20.52	2.32	1.85	44476
ZAF	−1.82	1.17	2.71	4.78	24.69	3.37	3.21	77667

(*Continued*)

Table A.8. (*Continued*)

	Min	25%	Median	75%	Max	Mean	StdDev	No. of observations
				DTD Trend				
ARE	−7.61	−0.46	−0.03	0.32	6.02	−0.08	0.84	6542
ARG	−7.63	−0.50	−0.01	0.43	7.36	−0.03	1.04	13144
AUT	−8.26	−0.57	−0.02	0.45	7.67	−0.13	1.55	21347
AUS	−5.88	−0.51	−0.04	0.40	5.71	−0.06	1.01	300287
BIH	−8.26	−0.53	−0.09	0.22	7.67	−0.15	1.26	3722
BGD	−5.20	−0.24	0.06	0.40	5.82	0.11	0.78	9712
BEL	−8.26	−0.63	−0.01	0.62	7.67	−0.02	1.55	30413
BGR	−8.26	−0.45	0.00	0.39	7.67	−0.04	1.10	10132
BHR	−7.63	−0.39	0.00	0.28	4.39	−0.12	0.93	1348
BRA	−7.63	−0.46	−0.02	0.38	7.36	−0.04	1.06	50487
CAN	−6.45	−0.57	−0.03	0.46	5.55	−0.07	1.14	234492
CHE	−8.26	−0.63	0.01	0.65	7.67	0.01	1.32	53083
CHL	−7.63	−0.70	0.00	0.63	7.36	−0.03	1.58	26288
CHN	−5.85	−0.63	−0.04	0.48	5.34	−0.10	1.08	317006
COL	−7.63	−0.61	−0.00	0.63	7.36	−0.01	1.51	5516
CYP	−8.26	−0.36	−0.07	0.19	7.67	−0.12	0.79	15119
CZE	−7.78	−0.40	0.00	0.39	5.78	−0.02	0.93	5527
DEU	−8.26	−0.51	−0.02	0.45	7.67	−0.03	1.13	187611
DNK	−8.26	−0.52	0.00	0.48	7.67	−0.02	1.27	42713
EST	−4.30	−0.22	0.13	0.73	7.31	0.24	1.16	1080
EGY	−7.63	−0.49	−0.02	0.47	7.36	−0.02	1.00	18529
ESP	−8.26	−0.53	0.00	0.55	7.67	0.00	1.31	34477
FIN	−8.26	−0.47	0.03	0.55	7.67	0.03	1.07	30060
FRA	−8.26	−0.50	0.00	0.48	7.67	−0.02	1.13	167406
GBR	−8.26	−0.61	−0.02	0.50	7.67	−0.08	1.32	367108
GRC	−8.26	−0.51	−0.08	0.32	7.67	−0.10	0.93	58275
HKG	−5.88	−0.51	−0.01	0.44	5.71	−0.04	1.00	239148
HRV	−6.40	−0.53	−0.05	0.30	7.67	−0.10	0.98	11167
HUN	−8.26	−0.42	0.00	0.42	7.67	−0.05	0.96	7537
IDN	−7.63	−0.37	0.00	0.36	7.36	−0.02	0.88	63552
IRL	−8.26	−0.52	0.01	0.53	7.67	−0.04	1.17	8643
ISR	−8.26	−0.46	0.00	0.46	7.67	−0.02	1.10	80239
IND	−7.89	−0.37	−0.01	0.36	5.91	−0.01	0.90	499559
ISL	−8.26	−0.75	−0.06	0.47	6.70	−0.19	1.46	3919
ITA	−8.26	−0.55	−0.01	0.49	7.67	−0.04	1.13	63959
JAM	−7.51	−0.37	0.00	0.41	5.28	0.04	0.92	2278
JOR	−7.63	−0.48	−0.00	0.43	7.36	−0.04	1.10	23652
JPN	−5.88	−0.46	0.00	0.47	5.71	0.01	0.91	875990
KOR	−5.88	−0.44	0.00	0.43	5.71	−0.01	0.94	322101
KWT	−7.63	−0.48	−0.01	0.42	7.36	−0.05	1.07	23883
KAZ	−7.63	−0.61	−0.05	0.36	7.36	−0.23	1.41	774
LKA	−7.63	−0.34	0.04	0.48	7.36	0.09	0.95	22377
LTU	−8.26	−0.62	−0.00	0.61	7.67	−0.01	1.39	4819
LUX	−8.26	−0.65	0.04	0.61	7.67	−0.06	1.64	2823
LVA	−8.26	−0.44	0.00	0.39	6.67	−0.06	1.08	2827
MAR	−7.63	−0.54	−0.05	0.39	7.36	−0.08	1.05	8725
MNE	−3.61	−0.31	0.03	0.29	4.94	0.03	0.74	1072
MKD	−6.14	−0.34	−0.01	0.41	6.55	0.05	0.93	2210
MLT	−8.26	−0.50	0.00	0.68	7.67	0.07	1.39	1100
MEX	−7.63	−0.50	0.03	0.62	7.36	0.04	1.23	18905
MYS	−7.63	−0.49	−0.01	0.44	7.36	−0.04	1.10	204881
NGA	−7.63	−0.50	−0.01	0.44	7.36	−0.01	1.58	15821
NLD	−8.26	−0.65	−0.02	0.58	7.67	−0.04	1.24	37841

(*Continued*)

Table A.8. (*Continued*)

	Min	25%	Median	75%	Max	Mean	StdDev	No. of observations
				DTD Trend				
NOR	−8.26	−0.48	−0.01	0.41	7.67	−0.05	0.96	43904
NZL	−5.88	−0.65	0.00	0.65	5.71	−0.01	1.48	18673
OMN	−7.63	−0.70	0.00	0.68	7.36	−0.03	1.63	2879
PER	−7.63	−0.51	−0.01	0.54	7.36	0.01	1.33	10149
PHL	−7.63	−0.41	0.00	0.41	7.36	−0.00	1.05	39799
PAK	−6.81	−0.26	0.04	0.39	7.36	0.06	0.76	27740
POL	−8.26	−0.47	−0.02	0.39	7.67	−0.06	0.93	67761
PRT	−8.26	−0.49	−0.04	0.38	7.67	−0.05	0.99	13289
ROM	−8.26	−0.32	0.00	0.30	7.67	0.01	0.83	13712
SRB	−8.26	−0.40	−0.03	0.20	4.71	−0.13	0.88	2886
RUS	−8.26	−0.54	−0.03	0.38	7.67	−0.13	1.09	19869
SAU	−7.63	−1.01	0.00	0.90	7.36	−0.08	1.85	18130
SWE	−8.26	−0.48	−0.00	0.47	7.67	−0.01	1.06	86547
SGP	−5.88	−0.48	−0.02	0.41	5.71	−0.04	1.01	128770
SVN	−5.13	−0.57	−0.04	0.35	7.67	−0.11	1.09	5808
SVK	−8.26	−0.23	0.02	0.34	7.67	−0.12	2.23	841
THA	−7.63	−0.53	−0.00	0.49	7.36	−0.02	1.08	104772
TUN	−7.63	−0.55	−0.05	0.49	7.36	−0.04	1.21	7221
TUR	−8.26	−0.60	0.01	0.59	7.67	0.01	1.36	48884
TWN	−5.88	−0.60	−0.00	0.58	5.71	−0.01	1.11	157833
UKR	−5.71	−0.59	−0.07	0.32	7.67	−0.17	1.01	3902
USA	−6.45	−0.50	0.00	0.48	5.55	−0.02	1.02	1553284
VEN	−6.72	−0.38	−0.02	0.37	7.36	−0.01	1.13	3014
VNM	−7.63	−0.34	0.00	0.34	7.36	−0.00	0.70	44476
ZAF	−7.63	−0.49	−0.02	0.40	7.36	−0.07	1.19	77667
				CASH/TA Level				
ARE	0.00	0.07	0.14	0.22	0.94	0.16	0.13	8775
ARG	0.00	0.02	0.05	0.11	0.69	0.08	0.07	14771
AUT	0.00	0.03	0.07	0.15	0.99	0.11	0.13	23775
AUS	0.00	0.04	0.13	0.35	0.98	0.23	0.25	333186
BIH	0.00	0.01	0.02	0.07	0.78	0.07	0.12	6430
BGD	0.00	0.01	0.08	0.21	0.82	0.14	0.17	16258
BEL	0.00	0.03	0.07	0.17	0.99	0.14	0.17	34471
BGR	0.00	0.01	0.03	0.09	0.60	0.07	0.09	11738
BHR	0.00	0.09	0.17	0.25	0.91	0.19	0.13	3586
BRA	0.00	0.03	0.08	0.17	0.94	0.12	0.13	59756
CAN	0.00	0.02	0.07	0.22	0.99	0.16	0.21	250218
CHE	0.00	0.05	0.10	0.20	0.99	0.16	0.16	60821
CHL	0.00	0.01	0.03	0.08	0.94	0.06	0.09	33861
CHN	0.00	0.08	0.15	0.25	0.88	0.19	0.15	332099
COL	0.00	0.03	0.06	0.09	0.76	0.08	0.08	7138
CYP	0.00	0.01	0.05	0.15	0.93	0.10	0.14	17256
CZE	0.00	0.02	0.05	0.11	0.99	0.09	0.12	6880
DEU	0.00	0.03	0.08	0.20	0.99	0.15	0.18	201038
DNK	0.00	0.03	0.08	0.18	0.99	0.14	0.16	49095
EST	0.00	0.03	0.05	0.12	0.53	0.09	0.09	2917
EGY	0.00	0.04	0.10	0.21	0.94	0.14	0.14	20970
ESP	0.00	0.02	0.05	0.11	0.99	0.09	0.11	41964
FIN	0.00	0.04	0.08	0.16	0.96	0.12	0.14	32670
FRA	0.00	0.04	0.09	0.17	0.99	0.13	0.15	179839
GBR	0.00	0.03	0.09	0.22	0.99	0.17	0.21	419063
GRC	0.00	0.02	0.05	0.13	0.83	0.10	0.11	61092

(*Continued*)

Table A.8. (*Continued*)

	Min	25%	Median	75%	Max	Mean	StdDev	No. of observations
				CASH/TA Level				
HKG	0.00	0.07	0.14	0.27	0.98	0.19	0.17	251693
HRV	0.00	0.01	0.02	0.05	0.51	0.05	0.08	14902
HUN	0.00	0.02	0.05	0.12	0.74	0.09	0.10	8467
IDN	0.00	0.03	0.08	0.17	0.91	0.12	0.12	74092
IRL	0.00	0.05	0.09	0.22	0.97	0.16	0.17	10139
ISR	0.00	0.03	0.10	0.23	0.99	0.18	0.22	85387
IND	0.00	0.01	0.03	0.07	0.84	0.06	0.10	691080
ISL	0.00	0.02	0.04	0.08	0.53	0.06	0.06	4984
ITA	0.00	0.03	0.07	0.14	0.99	0.10	0.12	68519
JAM	0.00	0.05	0.12	0.26	0.94	0.19	0.21	5722
JOR	0.00	0.01	0.05	0.17	0.94	0.12	0.16	29956
JPN	0.00	0.08	0.14	0.23	0.98	0.17	0.14	899627
KOR	0.00	0.04	0.09	0.18	0.98	0.14	0.14	330349
KWT	0.00	0.03	0.07	0.20	0.94	0.15	0.18	26928
KAZ	0.00	0.07	0.13	0.17	0.41	0.13	0.08	1202
LKA	0.00	0.02	0.05	0.10	0.94	0.09	0.12	24348
LTU	0.00	0.01	0.03	0.07	0.51	0.06	0.08	5136
LUX	0.00	0.05	0.11	0.16	0.97	0.14	0.14	3561
LVA	0.00	0.01	0.04	0.11	0.45	0.07	0.09	3745
MAR	0.00	0.01	0.05	0.12	0.78	0.08	0.10	12451
MNE	0.00	0.00	0.01	0.08	0.45	0.06	0.09	2385
MKD	0.00	0.02	0.06	0.19	0.59	0.12	0.13	3000
MLT	0.00	0.03	0.08	0.17	0.50	0.13	0.13	1775
MEX	0.00	0.03	0.06	0.12	0.77	0.08	0.08	23167
MYS	0.00	0.03	0.07	0.17	0.94	0.12	0.13	211850
NGA	0.00	0.02	0.07	0.19	0.73	0.13	0.14	18330
NLD	0.00	0.02	0.05	0.12	0.99	0.10	0.13	40784
NOR	0.00	0.04	0.09	0.19	0.99	0.15	0.18	49405
NZL	0.00	0.01	0.03	0.11	0.98	0.10	0.18	21082
OMN	0.00	0.03	0.07	0.16	0.94	0.12	0.14	15310
PER	0.00	0.01	0.04	0.13	0.71	0.09	0.11	13611
PHL	0.00	0.02	0.09	0.19	0.94	0.14	0.16	45595
PAK	0.00	0.01	0.05	0.14	0.90	0.10	0.12	35789
POL	0.00	0.02	0.06	0.14	0.99	0.11	0.13	71354
PRT	0.00	0.01	0.03	0.07	0.54	0.06	0.08	15567
ROM	0.00	0.01	0.03	0.10	0.73	0.08	0.11	16649
SRB	0.00	0.03	0.12	0.26	0.91	0.17	0.17	10319
RUS	0.00	0.02	0.06	0.15	0.99	0.11	0.13	26824
SAU	0.00	0.04	0.09	0.19	0.94	0.16	0.19	18846
SWE	0.00	0.04	0.09	0.21	0.99	0.16	0.19	92327
SGP	0.00	0.06	0.13	0.24	0.98	0.17	0.15	135350
SVN	0.00	0.01	0.03	0.08	0.41	0.06	0.07	7991
SVK	0.00	0.02	0.04	0.09	0.62	0.08	0.10	1865
THA	0.00	0.02	0.06	0.14	0.94	0.10	0.12	110178
TUN	0.00	0.03	0.07	0.13	0.71	0.10	0.12	8069
TUR	0.00	0.02	0.06	0.15	0.99	0.11	0.14	71777
TWN	0.00	0.05	0.11	0.21	0.89	0.15	0.13	161150
UKR	0.00	0.01	0.02	0.07	0.88	0.07	0.12	6419
USA	0.00	0.03	0.08	0.25	0.99	0.18	0.22	1631744
VEN	0.00	0.04	0.07	0.19	0.94	0.12	0.11	4253
VNM	0.00	0.03	0.08	0.18	0.94	0.14	0.15	47440
ZAF	0.00	0.03	0.08	0.16	0.94	0.12	0.14	87831

(*Continued*)

Table A.8. (*Continued*)

	Min	25%	Median	75%	Max	Mean	StdDev	No. of observations
				CASH/TA Trend				
ARE	−0.36	−0.02	−0.00	0.01	0.40	−0.01	0.05	8775
ARG	−0.36	−0.01	0.00	0.01	0.40	0.00	0.04	14771
AUT	−0.47	−0.01	0.00	0.00	0.48	−0.00	0.04	23775
AUS	−0.43	−0.03	−0.00	0.01	0.46	−0.01	0.09	333186
BIH	−0.47	−0.00	0.00	0.00	0.47	−0.00	0.04	6430
BGD	−0.36	−0.01	0.00	0.00	0.40	−0.00	0.05	16258
BEL	−0.47	−0.01	0.00	0.01	0.48	−0.00	0.04	34471
BGR	−0.31	−0.00	0.00	0.00	0.48	−0.00	0.04	11738
BHR	−0.36	−0.02	0.00	0.01	0.40	−0.00	0.06	3586
BRA	−0.36	−0.01	0.00	0.01	0.40	−0.00	0.05	59756
CAN	−0.44	−0.02	−0.00	0.01	0.43	−0.00	0.07	250218
CHE	−0.47	−0.01	0.00	0.01	0.48	−0.00	0.04	60821
CHL	−0.36	−0.01	−0.00	0.01	0.40	0.00	0.04	33861
CHN	−0.30	−0.03	−0.00	0.01	0.31	−0.01	0.05	332099
COL	−0.36	−0.01	0.00	0.01	0.40	0.00	0.05	7138
CYP	−0.47	−0.01	0.00	0.00	0.48	−0.00	0.04	17256
CZE	−0.33	−0.00	0.00	0.01	0.48	0.00	0.04	6880
DEU	−0.47	−0.01	0.00	0.01	0.48	−0.00	0.06	201038
DNK	−0.47	−0.01	−0.00	0.01	0.48	−0.00	0.05	49095
EST	−0.25	−0.01	0.00	0.01	0.17	−0.00	0.03	2917
EGY	−0.36	−0.02	0.00	0.01	0.40	−0.00	0.05	20970
ESP	−0.47	−0.01	0.00	0.01	0.48	−0.00	0.04	41964
FIN	−0.47	−0.01	−0.00	0.01	0.48	−0.00	0.05	32670
FRA	−0.47	−0.01	0.00	0.01	0.48	−0.00	0.04	179839
GBR	−0.47	−0.02	0.00	0.01	0.48	−0.00	0.07	419063
GRC	−0.47	−0.01	−0.00	0.01	0.48	−0.00	0.04	61092
HKG	−0.43	−0.02	−0.00	0.01	0.46	−0.00	0.07	251693
HRV	−0.20	−0.01	−0.00	0.00	0.44	0.00	0.03	14902
HUN	−0.47	−0.01	−0.00	0.01	0.48	−0.00	0.05	8467
IDN	−0.36	−0.01	−0.00	0.01	0.40	−0.00	0.04	74092
IRL	−0.47	−0.01	0.00	0.01	0.48	−0.00	0.05	10139
ISR	−0.47	−0.02	−0.00	0.01	0.48	−0.00	0.08	85387
IND	−0.35	−0.00	0.00	0.00	0.36	−0.00	0.04	691080
ISL	−0.30	−0.01	0.00	0.00	0.23	−0.00	0.03	4984
ITA	−0.47	−0.01	−0.00	0.01	0.48	−0.00	0.04	68519
JAM	−0.36	−0.01	0.00	0.01	0.40	0.00	0.05	5722
JOR	−0.36	−0.01	0.00	0.00	0.40	−0.00	0.05	29956
JPN	−0.43	−0.01	0.00	0.01	0.46	−0.00	0.04	899627
KOR	−0.43	−0.02	−0.00	0.01	0.46	−0.00	0.06	330349
KWT	−0.36	−0.01	−0.00	0.01	0.40	−0.00	0.05	26928
KAZ	−0.18	−0.02	0.00	0.01	0.40	−0.00	0.05	1202
LKA	−0.36	−0.01	−0.00	0.01	0.40	0.00	0.05	24348
LTU	−0.20	−0.01	−0.00	0.00	0.32	−0.00	0.03	5136
LUX	−0.24	−0.01	0.00	0.00	0.26	0.00	0.03	3561
LVA	−0.21	−0.01	0.00	0.01	0.32	0.00	0.04	3745
MAR	−0.36	−0.01	0.00	0.01	0.40	−0.00	0.04	12451
MNE	−0.23	−0.00	0.00	0.00	0.24	0.00	0.03	2385
MKD	−0.21	−0.00	0.00	0.00	0.31	0.00	0.04	3000
MLT	−0.32	−0.01	0.00	0.00	0.21	−0.00	0.03	1775
MEX	−0.32	−0.01	−0.00	0.01	0.40	−0.00	0.03	23167
MYS	−0.36	−0.01	0.00	0.01	0.40	−0.00	0.05	211850
NGA	−0.36	−0.01	0.00	0.01	0.40	−0.00	0.06	18330
NLD	−0.47	−0.01	0.00	0.01	0.48	−0.00	0.04	40784

(*Continued*)

Table A.8. (*Continued*)

	Min	25%	Median	75%	Max	Mean	StdDev	No. of observations
				CASH/TA Trend				
NOR	−0.47	−0.02	−0.00	0.01	0.48	−0.00	0.06	49405
NZL	−0.43	−0.01	0.00	0.00	0.46	−0.00	0.06	21082
OMN	−0.36	−0.01	0.00	0.01	0.40	−0.00	0.05	15310
PER	−0.32	−0.01	0.00	0.01	0.39	−0.00	0.04	13611
PHL	−0.36	−0.01	0.00	0.01	0.40	−0.00	0.06	45595
PAK	−0.36	−0.01	0.00	0.00	0.40	−0.00	0.04	35789
POL	−0.47	−0.01	0.00	0.00	0.48	−0.00	0.05	71354
PRT	−0.40	−0.01	0.00	0.00	0.48	−0.00	0.03	15567
ROM	−0.47	−0.00	0.00	0.00	0.48	−0.00	0.04	16649
SRB	−0.47	−0.00	0.00	0.00	0.48	−0.00	0.06	10319
RUS	−0.47	−0.01	0.00	0.01	0.48	0.00	0.06	26824
SAU	−0.36	−0.02	−0.00	0.01	0.40	−0.00	0.06	18846
SWE	−0.47	−0.02	−0.00	0.01	0.48	−0.00	0.06	92327
SGP	−0.43	−0.02	0.00	0.01	0.46	−0.00	0.06	135350
SVN	−0.30	−0.00	0.00	0.00	0.28	−0.00	0.03	7991
SVK	−0.13	−0.01	0.00	0.00	0.15	−0.00	0.02	1865
THA	−0.36	−0.01	−0.00	0.01	0.40	−0.00	0.05	110178
TUN	−0.22	−0.01	0.00	0.01	0.24	−0.00	0.03	8069
TUR	−0.47	−0.01	−0.00	0.01	0.48	−0.00	0.06	71777
TWN	−0.43	−0.02	0.00	0.02	0.46	0.00	0.04	161150
UKR	−0.23	−0.00	0.00	0.00	0.33	0.00	0.03	6419
USA	−0.44	−0.02	−0.00	0.01	0.43	−0.00	0.06	1631744
VEN	−0.18	−0.01	0.00	0.00	0.31	−0.00	0.03	4253
VNM	−0.36	−0.02	−0.00	0.01	0.40	−0.00	0.05	47440
ZAF	−0.36	−0.01	0.00	0.01	0.40	−0.00	0.05	87831
				NI/TA Level				
ARE	−0.04	0.00	0.00	0.01	0.03	0.00	0.01	8847
ARG	−0.04	−0.00	0.00	0.01	0.03	0.00	0.01	14826
AUT	−0.64	0.00	0.00	0.00	0.18	−0.00	0.03	24143
AUS	−0.54	−0.02	−0.00	0.00	0.11	−0.02	0.06	334198
BIH	−0.07	−0.00	0.00	0.00	0.11	0.00	0.01	6899
BGD	−0.04	0.00	0.00	0.01	0.03	0.00	0.01	16733
BEL	−0.35	0.00	0.00	0.01	0.18	0.00	0.01	34677
BGR	−0.19	−0.00	0.00	0.01	0.18	0.00	0.02	13355
BHR	−0.04	0.00	0.00	0.01	0.03	0.01	0.01	3623
BRA	−0.04	−0.00	0.00	0.01	0.03	0.00	0.01	59820
CAN	−0.72	−0.01	0.00	0.00	0.21	−0.01	0.06	251066
CHE	−0.72	0.00	0.00	0.01	0.18	0.00	0.02	61108
CHL	−0.04	0.00	0.00	0.01	0.03	0.00	0.01	33958
CHN	−0.12	0.00	0.00	0.01	0.14	0.00	0.01	332212
COL	−0.04	0.00	0.00	0.01	0.03	0.00	0.01	7250
CYP	−0.72	−0.00	0.00	0.00	0.18	−0.00	0.03	17858
CZE	−0.29	0.00	0.00	0.00	0.04	0.00	0.01	6946
DEU	−0.72	−0.00	0.00	0.00	0.18	−0.00	0.03	203741
DNK	−0.72	−0.00	0.00	0.00	0.18	−0.00	0.04	49811
EST	−0.09	−0.00	0.00	0.01	0.05	0.00	0.01	2941
EGY	−0.04	0.00	0.00	0.01	0.03	0.01	0.01	21183
ESP	−0.72	0.00	0.00	0.00	0.18	0.00	0.03	42064
FIN	−0.44	0.00	0.00	0.01	0.18	0.00	0.01	32772
FRA	−0.72	0.00	0.00	0.00	0.18	0.00	0.02	181414
GBR	−0.72	−0.01	0.00	0.01	0.18	−0.01	0.05	422041
GRC	−0.72	−0.00	0.00	0.01	0.18	0.00	0.02	61460

(*Continued*)

Table A.8. (*Continued*)

	Min	25%	Median	75%	Max	Mean	StdDev	No. of observations
				NI/TA Level				
HKG	−0.54	−0.00	0.00	0.01	0.11	−0.00	0.03	251784
HRV	−0.16	−0.00	0.00	0.00	0.18	0.00	0.01	15402
HUN	−0.21	−0.00	0.00	0.01	0.04	0.00	0.01	8487
IDN	−0.04	0.00	0.00	0.01	0.03	0.00	0.01	74219
IRL	−0.72	−0.00	0.00	0.01	0.18	−0.00	0.03	10223
ISR	−0.72	−0.00	0.00	0.00	0.18	−0.01	0.07	85540
IND	−0.04	0.00	0.00	0.01	0.03	0.00	0.01	697780
ISL	−0.31	0.00	0.00	0.01	0.18	0.00	0.01	5066
ITA	−0.49	−0.00	0.00	0.00	0.18	0.00	0.01	68844
JAM	−0.04	0.00	0.00	0.01	0.03	0.01	0.01	6200
JOR	−0.04	−0.00	0.00	0.00	0.03	0.00	0.01	30559
JPN	−0.54	0.00	0.00	0.00	0.11	0.00	0.01	899831
KOR	−0.54	−0.00	0.00	0.01	0.11	−0.00	0.02	334075
KWT	−0.04	0.00	0.00	0.01	0.03	0.00	0.01	27179
KAZ	−0.04	0.00	0.00	0.00	0.03	0.00	0.01	1215
LKA	−0.04	0.00	0.00	0.01	0.03	0.00	0.01	24497
LTU	−0.02	−0.00	0.00	0.00	0.05	0.00	0.01	5170
LUX	−0.20	0.00	0.00	0.01	0.09	0.00	0.02	3760
LVA	−0.40	−0.00	0.00	0.01	0.14	0.00	0.01	3903
MAR	−0.04	0.00	0.00	0.01	0.03	0.00	0.01	12593
MNE	−0.07	−0.00	0.00	0.00	0.03	−0.00	0.01	2462
MKD	−0.50	0.00	0.00	0.00	0.03	−0.00	0.03	3198
MLT	−0.14	0.00	0.00	0.00	0.04	0.00	0.01	1857
MEX	−0.04	0.00	0.00	0.01	0.03	0.00	0.01	23360
MYS	−0.04	0.00	0.00	0.01	0.03	0.00	0.01	211978
NGA	−0.04	0.00	0.00	0.01	0.03	0.00	0.01	19468
NLD	−0.72	0.00	0.00	0.01	0.18	0.00	0.03	40837
NOR	−0.72	−0.00	0.00	0.00	0.18	−0.00	0.03	50002
NZL	−0.54	−0.00	0.00	0.01	0.11	−0.01	0.05	21111
OMN	−0.04	0.00	0.00	0.01	0.03	0.00	0.01	15488
PER	−0.04	0.00	0.00	0.01	0.03	0.01	0.01	13702
PHL	−0.04	−0.00	0.00	0.01	0.03	0.00	0.01	45621
PAK	−0.04	0.00	0.00	0.01	0.03	0.00	0.01	35893
POL	−0.72	−0.00	0.00	0.01	0.11	−0.00	0.02	73424
PRT	−0.22	−0.00	0.00	0.00	0.12	0.00	0.01	15706
ROM	−0.72	−0.00	0.00	0.01	0.18	0.00	0.03	20443
SRB	−0.12	0.00	0.00	0.01	0.08	0.00	0.01	11592
RUS	−0.72	0.00	0.00	0.01	0.18	0.01	0.04	27387
SAU	−0.04	0.00	0.00	0.01	0.03	0.00	0.01	19427
SWE	−0.72	−0.01	0.00	0.01	0.18	−0.01	0.03	94391
SGP	−0.54	0.00	0.00	0.01	0.11	0.00	0.03	135498
SVN	−0.11	−0.00	0.00	0.00	0.02	0.00	0.01	8317
SVK	−0.72	−0.00	0.00	0.00	0.03	0.00	0.02	2146
THA	−0.04	0.00	0.00	0.01	0.03	0.00	0.01	110234
TUN	−0.04	0.00	0.00	0.00	0.03	0.00	0.01	8215
TUR	−0.72	−0.00	0.00	0.01	0.18	0.00	0.03	72045
TWN	−0.22	0.00	0.00	0.01	0.06	0.00	0.01	161192
UKR	−0.10	−0.00	0.00	0.01	0.06	0.00	0.01	6656
USA	−0.72	−0.00	0.00	0.01	0.21	−0.00	0.03	1641248
VEN	−0.04	0.00	0.00	0.01	0.03	0.00	0.01	4306
VNM	−0.04	0.00	0.00	0.01	0.03	0.00	0.01	48546
ZAF	−0.04	0.00	0.00	0.01	0.03	0.00	0.01	88428

(*Continued*)

Table A.8. (*Continued*)

	Min	25%	Median	75%	Max	Mean	StdDev	No. of observations
				NI/TA Trend				
ARE	−0.03	−0.00	0.00	0.00	0.03	−0.00	0.01	8847
ARG	−0.03	−0.00	0.00	0.00	0.03	−0.00	0.01	14826
AUT	−0.41	−0.00	0.00	0.00	0.39	−0.00	0.02	24143
AUS	−0.45	−0.00	0.00	0.00	0.33	−0.00	0.05	334198
BIH	−0.19	−0.00	0.00	0.00	0.18	−0.00	0.01	6899
BGD	−0.03	−0.00	0.00	0.00	0.03	−0.00	0.00	16733
BEL	−0.41	−0.00	0.00	0.00	0.39	−0.00	0.01	34677
BGR	−0.40	−0.00	0.00	0.00	0.39	−0.00	0.02	13355
BHR	−0.03	−0.00	0.00	0.00	0.03	−0.00	0.00	3623
BRA	−0.03	−0.00	0.00	0.00	0.03	−0.00	0.01	59820
CAN	−0.41	−0.00	0.00	0.00	0.37	0.00	0.04	251066
CHE	−0.41	−0.00	0.00	0.00	0.39	−0.00	0.01	61108
CHL	−0.03	−0.00	0.00	0.00	0.03	−0.00	0.01	33958
CHN	−0.18	−0.00	-0.00	0.00	0.12	−0.00	0.01	332212
COL	−0.03	−0.00	0.00	0.00	0.03	−0.00	0.00	7250
CYP	−0.41	−0.00	0.00	0.00	0.39	−0.00	0.02	17858
CZE	−0.27	−0.00	0.00	0.00	0.26	−0.00	0.01	6946
DEU	−0.41	−0.00	0.00	0.00	0.39	−0.00	0.02	203741
DNK	−0.41	−0.00	0.00	0.00	0.39	−0.00	0.03	49811
EST	−0.32	−0.00	0.00	0.00	0.11	−0.00	0.02	2941
EGY	−0.03	−0.00	0.00	0.00	0.03	−0.00	0.01	21183
ESP	−0.41	−0.00	0.00	0.00	0.39	0.00	0.03	42064
FIN	−0.20	−0.00	0.00	0.00	0.29	−0.00	0.01	32772
FRA	−0.41	−0.00	0.00	0.00	0.39	−0.00	0.01	181414
GBR	−0.41	−0.00	0.00	0.00	0.39	−0.00	0.03	422041
GRC	−0.41	−0.00	0.00	0.00	0.39	−0.00	0.01	61460
HKG	−0.45	−0.00	0.00	0.00	0.33	−0.00	0.03	251784
HRV	−0.31	−0.00	0.00	0.00	0.39	−0.00	0.01	15402
HUN	−0.28	−0.00	0.00	0.00	0.14	−0.00	0.01	8487
IDN	−0.03	−0.00	0.00	0.00	0.03	−0.00	0.01	74219
IRL	−0.41	−0.00	0.00	0.00	0.39	−0.00	0.03	10223
ISR	−0.41	−0.00	-0.00	0.00	0.39	0.00	0.05	85540
IND	−0.14	−0.00	0.00	0.00	0.13	−0.00	0.01	697780
ISL	−0.41	−0.00	0.00	0.00	0.39	−0.00	0.02	5066
ITA	−0.41	−0.00	0.00	0.00	0.39	−0.00	0.01	68844
JAM	−0.03	−0.00	0.00	0.00	0.03	−0.00	0.01	6200
JOR	−0.03	−0.00	0.00	0.00	0.03	−0.00	0.01	30559
JPN	−0.45	−0.00	0.00	0.00	0.33	−0.00	0.01	899831
KOR	−0.45	−0.00	0.00	0.00	0.33	−0.00	0.03	334075
KWT	−0.03	−0.00	0.00	0.00	0.03	−0.00	0.01	27179
KAZ	−0.03	−0.00	0.00	0.00	0.03	−0.00	0.01	1215
LKA	−0.03	−0.00	0.00	0.00	0.03	−0.00	0.01	24497
LTU	−0.10	−0.00	0.00	0.00	0.12	−0.00	0.01	5170
LUX	−0.09	−0.00	0.00	0.00	0.15	0.00	0.01	3760
LVA	−0.28	−0.00	0.00	0.00	0.08	−0.00	0.01	3903
MAR	−0.03	−0.00	0.00	0.00	0.03	−0.00	0.00	12593
MNE	−0.05	−0.00	0.00	0.00	0.06	0.00	0.00	2462
MKD	−0.41	−0.00	0.00	0.00	0.34	−0.00	0.02	3198
MLT	−0.04	−0.00	0.00	0.00	0.03	−0.00	0.00	1857
MEX	−0.03	−0.00	0.00	0.00	0.03	0.00	0.01	23360
MYS	−0.03	−0.00	-0.00	0.00	0.03	−0.00	0.01	211978
NGA	−0.03	−0.00	0.00	0.00	0.03	−0.00	0.01	19468
NLD	−0.41	−0.00	0.00	0.00	0.39	−0.00	0.02	40837

(*Continued*)

Table A.8. (*Continued*)

	Min	25%	Median	75%	Max	Mean	StdDev	No. of observations
				NI/TA Trend				
NOR	−0.41	−0.00	0.00	0.00	0.39	−0.00	0.03	50002
NZL	−0.45	−0.00	0.00	0.00	0.33	−0.00	0.04	21111
OMN	−0.03	−0.00	0.00	0.00	0.03	0.00	0.01	15488
PER	−0.03	−0.00	0.00	0.00	0.03	−0.00	0.01	13702
PHL	−0.03	−0.00	0.00	0.00	0.03	−0.00	0.01	45621
PAK	−0.03	−0.00	0.00	0.00	0.03	0.00	0.00	35893
POL	−0.41	−0.00	0.00	0.00	0.39	−0.00	0.02	73424
PRT	−0.39	−0.00	0.00	0.00	0.39	−0.00	0.01	15706
ROM	−0.41	−0.00	0.00	0.00	0.39	−0.00	0.02	20443
SRB	−0.13	−0.00	0.00	0.00	0.06	−0.00	0.00	11592
RUS	−0.41	−0.00	0.00	0.00	0.39	−0.00	0.05	27387
SAU	−0.03	−0.00	0.00	0.00	0.03	0.00	0.01	19427
SWE	−0.41	−0.00	0.00	0.00	0.39	−0.00	0.03	94391
SGP	−0.45	−0.00	−0.00	0.00	0.33	−0.00	0.03	135498
SVN	−0.17	−0.00	0.00	0.00	0.06	−0.00	0.01	8317
SVK	−0.05	−0.00	0.00	0.00	0.06	−0.00	0.01	2146
THA	−0.03	−0.00	−0.00	0.00	0.03	−0.00	0.01	110234
TUN	−0.03	−0.00	0.00	0.00	0.03	−0.00	0.00	8215
TUR	−0.41	−0.00	−0.00	0.00	0.39	−0.00	0.02	72045
TWN	−0.45	−0.00	−0.00	0.00	0.28	−0.00	0.01	161192
UKR	−0.11	−0.00	0.00	0.00	0.13	−0.00	0.01	6656
USA	−0.41	−0.00	0.00	0.00	0.37	−0.00	0.02	1641248
VEN	−0.03	−0.00	0.00	0.00	0.03	−0.00	0.00	4306
VNM	−0.03	−0.00	−0.00	0.00	0.03	−0.00	0.01	48546
ZAF	−0.03	−0.00	0.00	0.00	0.03	−0.00	0.01	88428
				SIZE Level				
ARE	−4.25	−1.10	−0.01	1.05	4.25	0.01	1.59	9821
ARG	−6.35	−1.43	0.21	1.55	7.06	0.10	2.04	16164
AUT	−6.77	−1.53	−0.22	1.22	4.29	−0.20	2.01	25834
AUS	−8.86	−1.30	−0.16	1.49	7.03	0.24	2.10	358242
BIH	−6.04	−0.62	0.81	2.48	7.65	0.97	2.18	26605
BGD	−5.25	−1.29	−0.26	1.10	5.00	−0.15	1.70	18290
BEL	−6.77	−1.37	0.17	1.66	6.99	0.16	2.30	42257
BGR	−6.77	−1.67	−0.30	0.93	7.91	−0.35	1.84	20875
BHR	−3.60	−1.05	−0.15	1.31	3.33	0.03	1.48	4318
BRA	−6.35	−1.69	−0.06	1.33	7.08	−0.14	2.50	66575
CAN	−6.39	−1.59	−0.20	1.34	6.06	−0.13	2.24	277191
CHE	−6.77	−1.25	0.00	1.30	6.31	0.09	1.97	60832
CHL	−6.35	−1.15	0.05	1.27	4.29	−0.02	1.84	37345
CHN	−2.50	−0.66	−0.18	0.40	4.18	−0.06	0.90	359451
COL	−5.42	−1.41	−0.01	1.16	4.43	−0.20	1.70	8355
CYP	−4.64	−0.97	0.12	1.21	7.91	0.17	1.74	21768
CZE	−6.77	−1.51	−0.17	0.90	5.36	−0.22	1.93	9153
DEU	−6.77	−0.48	1.05	2.74	7.91	1.11	2.57	235883
DNK	−6.77	−0.34	0.86	2.25	7.40	1.01	1.99	50754
EST	−3.62	−0.58	0.22	1.30	5.13	0.35	1.67	3106
EGY	−6.35	−1.20	−0.06	1.43	5.40	0.10	1.80	24682
ESP	−6.77	−1.70	−0.25	1.24	5.37	−0.28	2.14	45350
FIN	−6.37	−1.77	−0.47	1.12	6.39	−0.30	1.98	33298
FRA	−6.77	−1.32	0.13	1.91	7.67	0.38	2.35	212020
GBR	−6.77	−1.15	0.25	1.92	7.91	0.48	2.26	457619
GRC	−6.77	−0.48	0.48	1.62	7.56	0.66	1.67	64495

(*Continued*)

Table A.8. (*Continued*)

	Min	25%	Median	75%	Max	Mean	StdDev	No. of observations
				SIZE Level				
HKG	−8.77	−1.44	−0.43	0.95	7.03	−0.13	1.85	271052
HRV	−6.77	−0.76	0.41	1.62	6.09	0.45	1.82	18594
HUN	−5.54	−1.29	0.42	2.16	6.29	0.46	2.38	9363
IDN	−6.35	−1.02	0.16	1.45	6.08	0.26	1.84	81798
IRL	−6.64	−1.95	−0.73	0.90	4.96	−0.56	2.04	11011
ISR	−6.77	−0.79	0.28	1.60	7.91	0.48	1.87	108171
IND	−5.33	−1.31	0.14	1.99	8.38	0.46	2.36	635871
ISL	−6.77	−1.07	−0.12	0.92	3.63	−0.11	1.58	6218
ITA	−6.77	−0.95	0.20	1.68	6.36	0.39	1.95	70316
JAM	−5.85	−1.61	−0.04	1.00	3.02	−0.30	1.80	6871
JOR	−3.88	−0.85	−0.05	1.11	6.20	0.22	1.52	34877
JPN	−9.57	−0.82	0.23	1.52	7.03	0.46	1.74	921406
KOR	−9.82	−0.48	0.30	1.34	7.03	0.51	1.72	385110
KWT	−3.49	−0.40	0.51	1.36	5.15	0.60	1.36	29642
KAZ	−6.07	−1.96	−0.33	1.26	5.50	−0.39	1.92	1740
LKA	−6.35	−0.88	0.05	1.25	5.26	0.22	1.55	26579
LTU	−4.61	−0.95	0.15	1.11	4.08	0.07	1.59	6583
LUX	−6.77	−2.26	−0.43	0.59	4.74	−0.64	2.24	4939
LVA	−5.38	−1.39	−0.17	2.18	5.91	0.28	2.36	5352
MAR	−6.35	−1.24	0.00	1.71	4.90	0.16	1.84	13099
MNE	−6.77	−2.87	−1.28	0.40	5.42	−1.23	2.35	8247
MKD	−6.46	−1.27	0.18	1.33	5.37	0.09	1.88	5571
MLT	−4.07	−1.02	−0.14	1.12	2.31	−0.05	1.37	2451
MEX	−6.35	−1.14	0.16	1.52	5.16	0.12	1.94	25091
MYS	−4.31	−0.26	0.65	1.76	6.47	0.81	1.59	223720
NGA	−6.35	−1.44	−0.31	1.55	6.22	−0.04	2.14	22844
NLD	−6.77	−2.08	−0.50	1.00	5.77	−0.41	2.22	41601
NOR	−6.77	−0.97	0.11	1.40	6.65	0.25	1.77	53454
NZL	−5.87	−1.49	−0.03	1.13	5.12	−0.16	1.90	23162
OMN	−6.35	−1.19	−0.06	1.01	4.71	−0.10	1.74	18103
PER	−6.35	−1.04	0.30	1.83	5.54	0.33	2.00	15926
PHL	−6.35	−1.46	−0.32	1.13	5.31	−0.08	1.84	49179
PAK	−6.35	−1.15	0.64	2.69	7.08	0.72	2.49	59269
POL	−5.88	−1.47	−0.08	1.38	7.91	0.02	2.15	91362
PRT	−6.77	−1.91	−0.28	1.37	4.68	−0.38	2.47	18100
ROM	−6.77	−0.98	0.26	1.58	7.91	0.29	2.09	54374
SRB	−6.77	−0.35	1.01	2.44	7.91	1.04	2.10	29734
RUS	−6.77	−1.90	−0.33	1.39	7.91	−0.23	2.41	34042
SAU	−4.48	−0.75	0.14	1.46	5.34	0.42	1.56	20855
SWE	−6.77	−0.83	0.89	2.53	7.91	0.99	2.41	100778
SGP	−4.67	−0.67	0.32	1.59	7.03	0.56	1.73	144697
SVN	−6.77	−0.56	0.74	2.31	7.91	1.05	2.43	12140
SVK	−6.14	−0.43	1.06	3.05	7.91	1.49	2.63	4987
THA	−5.99	−0.85	0.11	1.27	6.48	0.32	1.61	119943
TUN	−3.55	−0.96	0.01	1.11	3.11	0.08	1.28	9436
TUR	−5.21	−1.28	−0.07	1.24	6.88	0.06	1.88	76219
TWN	−5.02	−0.79	0.03	0.90	6.28	0.13	1.42	175348
UKR	−6.77	−1.03	0.07	1.04	7.91	−0.05	1.68	9827
USA	−6.39	−1.93	−0.58	0.87	6.06	−0.46	2.02	1708160
VEN	−6.35	−1.81	−0.24	1.13	7.08	−0.48	2.56	5819
VNM	−5.06	−1.21	−0.26	0.84	6.56	−0.09	1.67	52268
ZAF	−6.35	−1.54	0.20	1.92	6.55	0.19	2.34	94775

(*Continued*)

Table A.8. (*Continued*)

	Min	25%	Median	75%	Max	Mean	StdDev	No. of observations
				SIZE Trend				
ARE	−1.75	−0.13	−0.02	0.09	1.81	−0.01	0.23	9821
ARG	−1.75	−0.15	−0.02	0.11	1.96	−0.01	0.32	16164
AUT	−2.02	−0.12	−0.01	0.09	2.12	−0.02	0.27	25834
AUS	−1.56	−0.18	−0.00	0.17	1.86	0.00	0.39	358242
BIH	−2.02	−0.03	0.00	0.02	2.12	0.01	0.18	26605
BGD	−1.75	−0.13	−0.03	0.08	1.96	−0.03	0.27	18290
BEL	−2.02	−0.11	−0.02	0.07	2.12	−0.02	0.25	42257
BGR	−2.02	−0.14	0.00	0.14	2.12	0.01	0.36	20875
BHR	−0.80	−0.05	0.01	0.08	1.96	0.02	0.16	4318
BRA	−1.75	−0.16	−0.00	0.14	1.96	−0.01	0.34	66575
CAN	−1.88	−0.17	0.00	0.16	1.86	−0.01	0.37	277191
CHE	−2.02	−0.11	−0.01	0.08	2.12	−0.01	0.24	60832
CHL	−1.75	−0.10	−0.00	0.08	1.96	−0.00	0.21	37345
CHN	−0.88	−0.10	0.00	0.12	1.18	0.02	0.20	359451
COL	−1.45	−0.08	0.00	0.10	1.85	0.02	0.21	8355
CYP	−2.02	−0.17	0.00	0.17	2.12	0.01	0.35	21768
CZE	−2.02	−0.13	0.00	0.12	2.12	−0.01	0.26	9153
DEU	−2.02	−0.17	−0.03	0.09	2.12	−0.06	0.34	235883
DNK	−2.02	−0.15	−0.02	0.09	2.12	−0.03	0.28	50754
EST	−1.99	−0.12	−0.01	0.11	2.12	−0.01	0.26	3106
EGY	−1.75	−0.14	−0.02	0.10	1.96	0.00	0.26	24682
ESP	−2.02	−0.10	−0.00	0.10	2.12	0.01	0.26	45350
FIN	−2.02	−0.12	0.00	0.13	2.12	0.00	0.26	33298
FRA	−2.02	−0.11	0.00	0.12	2.12	0.00	0.28	212020
GBR	−2.02	−0.15	0.00	0.13	2.12	−0.01	0.34	457619
GRC	−2.02	−0.18	−0.03	0.13	2.12	−0.02	0.32	64495
HKG	−1.56	−0.16	−0.01	0.14	1.86	0.01	0.35	271052
HRV	−2.02	−0.13	−0.01	0.09	2.12	−0.02	0.24	18594
HUN	−2.02	−0.20	−0.05	0.08	2.01	−0.06	0.29	9363
IDN	−1.75	−0.17	−0.03	0.12	1.96	−0.01	0.33	81798
IRL	−2.02	−0.11	0.01	0.13	2.12	−0.00	0.30	11011
ISR	−2.02	−0.15	−0.02	0.10	2.12	−0.02	0.32	108171
IND	−1.75	−0.21	−0.03	0.14	2.05	−0.02	0.36	635871
ISL	−2.02	−0.11	0.00	0.11	2.12	0.01	0.29	6218
ITA	−2.02	−0.11	−0.01	0.09	2.12	−0.00	0.23	70316
JAM	−1.75	−0.11	0.00	0.12	1.96	0.02	0.28	6871
JOR	−1.75	−0.10	0.01	0.12	1.96	0.02	0.24	34877
JPN	−1.56	−0.12	−0.02	0.09	1.86	−0.01	0.22	921406
KOR	−1.56	−0.16	−0.02	0.13	1.86	−0.01	0.33	385110
KWT	−1.75	−0.13	−0.02	0.08	1.96	−0.01	0.22	29642
KAZ	−1.75	−0.12	0.00	0.11	1.96	0.01	0.39	1740
LKA	−1.75	−0.11	−0.01	0.09	1.96	0.00	0.22	26579
LTU	−2.02	−0.13	−0.01	0.11	2.12	−0.01	0.32	6583
LUX	−2.02	−0.09	0.00	0.10	2.12	0.01	0.22	4939
LVA	−2.02	−0.13	0.00	0.16	2.12	0.02	0.32	5352
MAR	−1.75	−0.10	−0.01	0.07	1.96	−0.01	0.19	13099
MNE	−2.02	−0.04	0.00	0.04	2.12	−0.02	0.33	8247
MKD	−1.45	−0.10	0.00	0.06	1.30	−0.01	0.19	5571
MLT	−1.23	−0.06	0.01	0.09	1.85	0.02	0.21	2451
MEX	−1.75	−0.12	−0.01	0.09	1.96	−0.02	0.24	25091
MYS	−1.75	−0.13	−0.02	0.09	1.96	−0.01	0.25	223720
NGA	−1.75	−0.15	−0.02	0.11	1.96	0.00	0.32	22844
NLD	−2.02	−0.10	0.00	0.11	2.12	−0.00	0.26	41601

(*Continued*)

Table A.8. (*Continued*)

	Min	25%	Median	75%	Max	Mean	StdDev	No. of observations
				SIZE Trend				
NOR	−2.02	−0.13	−0.00	0.13	2.12	0.00	0.33	53454
NZL	−1.56	−0.09	0.01	0.11	1.86	0.01	0.25	23162
OMN	−1.75	−0.09	0.00	0.10	1.96	0.01	0.23	18103
PER	−1.75	−0.12	0.00	0.12	1.96	0.01	0.27	15926
PHL	−1.75	−0.15	−0.02	0.12	1.96	0.01	0.31	49179
PAK	−1.75	−0.18	−0.04	0.10	1.96	−0.03	0.28	59269
POL	−2.02	−0.22	−0.04	0.12	2.12	−0.05	0.37	91362
PRT	−2.02	−0.14	−0.02	0.09	2.12	−0.02	0.25	18100
ROM	−2.02	−0.13	0.00	0.19	2.12	0.05	0.39	54374
SRB	−2.02	−0.07	0.00	0.06	2.12	0.01	0.24	29734
RUS	−2.02	−0.16	−0.00	0.10	2.12	−0.03	0.31	34042
SAU	−1.75	−0.11	−0.01	0.10	1.96	0.00	0.21	20855
SWE	−2.02	−0.15	−0.00	0.14	2.12	−0.00	0.34	100778
SGP	−1.56	−0.14	−0.02	0.09	1.86	−0.02	0.26	144697
SVN	−2.02	−0.15	−0.02	0.08	2.12	−0.05	0.32	12140
SVK	−2.02	−0.06	0.00	0.11	2.12	0.03	0.31	4987
THA	−1.75	−0.14	−0.01	0.12	1.96	0.00	0.27	119943
TUN	−1.75	−0.11	−0.03	0.05	1.93	−0.02	0.20	9436
TUR	−2.02	−0.16	−0.03	0.12	2.12	−0.01	0.29	76219
TWN	−1.56	−0.12	−0.02	0.10	1.86	−0.01	0.21	175348
UKR	−2.02	−0.19	0.00	0.15	2.12	−0.02	0.41	9827
USA	−1.88	−0.15	−0.01	0.13	1.86	−0.02	0.33	1708160
VEN	−1.75	−0.17	−0.02	0.12	1.96	0.01	0.41	5819
VNM	−1.59	−0.15	−0.01	0.12	1.96	−0.01	0.25	52268
ZAF	−1.75	−0.16	−0.01	0.13	1.96	−0.02	0.35	94775
				M/B				
ARE	0.34	0.87	1.03	1.27	8.35	1.16	0.56	8623
ARG	0.19	0.85	1.03	1.33	26.66	1.50	2.50	14400
AUT	0.14	0.94	1.06	1.36	22.24	1.31	1.15	22846
AUS	0.16	0.90	1.31	2.35	15.59	2.26	2.74	328245
BIH	0.14	0.42	0.69	1.01	16.86	0.85	1.01	5912
BGD	0.25	1.05	1.42	2.19	26.66	2.14	2.73	16220
BEL	0.14	0.94	1.09	1.45	22.24	1.46	1.52	33133
BGR	0.14	0.66	0.92	1.26	22.24	1.19	1.42	11674
BHR	0.33	0.92	1.04	1.25	6.26	1.17	0.49	3370
BRA	0.19	0.84	1.07	1.58	26.66	2.38	4.98	57648
CAN	0.20	0.96	1.29	2.08	77.28	2.38	5.23	247427
CHE	0.16	1.00	1.16	1.67	22.24	1.61	1.52	56624
CHL	0.19	0.86	1.12	1.65	26.66	1.58	2.35	32461
CHN	0.66	1.47	2.11	3.22	49.16	2.83	2.88	330863
COL	0.23	0.80	1.04	1.28	26.66	1.20	0.95	6843
CYP	0.14	0.60	0.79	1.03	22.24	1.06	1.49	16994
CZE	0.15	0.67	0.93	1.17	9.28	1.03	0.61	6628
DEU	0.14	1.00	1.21	1.69	22.24	1.71	1.94	197087
DNK	0.14	0.96	1.06	1.47	22.24	1.60	1.88	46540
EST	0.17	0.93	1.15	1.67	22.24	1.62	1.85	2893
EGY	0.21	0.96	1.18	1.74	26.66	1.61	1.70	20841
ESP	0.14	0.96	1.11	1.47	22.24	1.41	1.23	40283
FIN	0.14	1.00	1.23	1.74	22.24	1.65	1.64	31538
FRA	0.14	0.95	1.14	1.57	22.24	1.59	1.82	175438
GBR	0.14	0.97	1.33	2.09	22.24	2.08	2.64	413553
GRC	0.14	0.85	1.08	1.56	22.24	1.60	1.96	60530

(*Continued*)

Table A.8. (*Continued*)

	Min	25%	Median	75%	Max	Mean	StdDev	No. of observations
				M/B				
HKG	0.16	0.73	1.00	1.57	15.59	1.58	2.01	250572
HRV	0.14	0.70	0.92	1.15	22.24	1.08	1.10	14306
HUN	0.14	0.75	0.99	1.33	14.22	1.20	0.94	8249
IDN	0.19	0.87	1.07	1.53	26.66	1.47	1.51	72297
IRL	0.14	0.98	1.20	1.69	22.24	1.66	1.76	9834
ISR	0.14	0.91	1.03	1.38	22.24	1.63	2.47	84893
IND	0.19	0.77	1.00	1.50	14.05	1.55	1.90	541041
ISL	0.31	1.09	1.26	1.61	22.24	1.46	0.87	4896
ITA	0.19	0.95	1.06	1.36	22.24	1.31	1.12	66563
JAM	0.19	0.86	1.03	1.38	23.38	1.28	0.92	6053
JOR	0.19	0.81	1.03	1.37	26.66	1.24	1.03	29137
JPN	0.16	0.85	1.00	1.25	15.59	1.23	1.08	898396
KOR	0.16	0.81	0.99	1.34	15.59	1.34	1.37	331714
KWT	0.19	0.84	1.09	1.48	26.66	1.29	0.88	26617
KAZ	0.23	0.86	0.98	1.13	9.35	1.09	0.57	1079
LKA	0.24	0.93	1.11	1.52	26.66	1.51	1.66	24063
LTU	0.36	0.80	0.98	1.34	8.24	1.16	0.61	5130
LUX	0.32	0.75	0.99	1.27	22.24	2.27	4.92	3394
LVA	0.14	0.56	0.75	1.00	9.24	0.87	0.64	3602
MAR	0.19	1.06	1.26	1.82	15.95	1.62	0.96	12167
MNE	0.14	0.31	0.46	0.76	22.24	0.69	1.27	2127
MKD	0.14	0.63	0.89	1.00	22.24	1.16	2.28	2899
MLT	0.25	0.98	1.07	1.54	15.76	1.41	0.94	1751
MEX	0.19	0.81	1.06	1.49	10.84	1.26	0.71	22112
MYS	0.19	0.77	0.99	1.40	26.66	1.36	1.52	211337
NGA	0.19	0.88	1.12	1.74	26.66	1.70	1.95	18171
NLD	0.14	0.99	1.22	1.67	22.24	1.64	1.73	39493
NOR	0.14	0.95	1.12	1.69	22.24	1.75	2.12	48165
NZL	0.16	0.99	1.29	2.01	15.59	2.00	2.33	20775
OMN	0.19	0.98	1.15	1.49	7.38	1.32	0.60	14588
PER	0.19	0.79	1.10	1.61	26.66	1.46	1.31	12812
PHL	0.19	0.78	1.07	1.78	26.66	2.30	4.43	44139
PAK	0.19	0.85	1.02	1.37	26.66	1.36	1.45	34925
POL	0.14	0.85	1.09	1.62	22.24	1.62	2.07	70969
PRT	0.14	0.90	1.02	1.24	22.24	1.16	0.68	15156
ROM	0.14	0.63	0.86	1.17	22.24	1.18	1.93	16319
SRB	0.14	0.65	0.84	1.10	22.24	1.00	0.90	9437
RUS	0.14	0.73	1.02	1.44	22.24	1.43	2.03	24570
SAU	0.19	1.21	1.78	2.97	26.66	2.52	2.23	19155
SWE	0.14	1.04	1.40	2.27	22.24	2.21	2.58	90578
SGP	0.16	0.81	1.02	1.42	15.59	1.36	1.35	134779
SVN	0.14	0.66	0.84	1.02	22.24	0.92	0.62	7791
SVK	0.14	0.70	0.90	1.05	3.18	0.90	0.32	1716
THA	0.19	0.87	1.09	1.52	26.66	1.38	1.13	109546
TUN	0.19	0.97	1.08	1.41	8.34	1.35	0.75	7984
TUR	0.14	0.94	1.19	1.79	22.24	2.17	3.71	71190
TWN	0.28	0.93	1.14	1.61	15.59	1.44	0.95	161131
UKR	0.14	0.83	1.14	1.85	22.24	1.81	2.32	6090
USA	0.20	1.03	1.32	2.12	77.28	2.16	3.62	1628381
VEN	0.19	0.62	0.93	1.25	26.66	4.53	8.89	4028
VNM	0.19	0.82	0.95	1.16	26.66	1.12	0.76	47352
ZAF	0.19	0.89	1.20	1.84	26.66	1.77	2.44	87021

(*Continued*)

Table A.8. (*Continued*)

	Min	25%	Median	75%	Max	Mean	StdDev	No. of observations
				SIGMA				
ARE	0.01	0.09	0.12	0.16	0.43	0.13	0.06	7561
ARG	0.03	0.09	0.11	0.15	0.65	0.13	0.06	14010
AUT	0.01	0.06	0.09	0.14	1.16	0.12	0.10	23544
AUS	0.02	0.13	0.23	0.33	1.03	0.25	0.16	322861
BIH	0.03	0.11	0.15	0.20	0.73	0.17	0.09	5040
BGD	0.03	0.09	0.11	0.14	0.67	0.12	0.05	17237
BEL	0.02	0.07	0.09	0.12	1.42	0.11	0.08	35566
BGR	0.02	0.13	0.17	0.27	1.11	0.22	0.14	12336
BHR	0.03	0.07	0.09	0.12	0.24	0.10	0.04	2365
BRA	0.01	0.09	0.13	0.21	1.16	0.18	0.14	54078
CAN	0.03	0.10	0.17	0.28	1.07	0.22	0.17	256805
CHE	0.01	0.06	0.09	0.13	1.42	0.11	0.07	55804
CHL	0.01	0.06	0.08	0.11	0.80	0.09	0.06	28174
CHN	0.03	0.08	0.11	0.13	0.43	0.11	0.05	350776
COL	0.01	0.06	0.08	0.11	0.48	0.10	0.06	5984
CYP	0.02	0.15	0.21	0.28	1.42	0.25	0.17	17102
CZE	0.03	0.09	0.13	0.17	0.42	0.13	0.06	6830
DEU	0.01	0.09	0.14	0.24	1.42	0.22	0.22	213935
DNK	0.01	0.07	0.10	0.15	1.29	0.13	0.11	44856
EST	0.01	0.07	0.12	0.19	0.66	0.15	0.10	2922
EGY	0.01	0.08	0.11	0.17	1.16	0.14	0.08	21412
ESP	0.01	0.06	0.09	0.13	0.95	0.10	0.06	38681
FIN	0.01	0.08	0.11	0.15	1.42	0.13	0.09	31396
FRA	0.01	0.08	0.11	0.16	1.42	0.13	0.09	187179
GBR	0.01	0.08	0.12	0.19	1.42	0.15	0.10	398307
GRC	0.01	0.10	0.14	0.19	0.90	0.16	0.09	62005
HKG	0.02	0.11	0.16	0.23	1.03	0.18	0.11	261353
HRV	0.01	0.10	0.13	0.19	0.78	0.16	0.09	13241
HUN	0.02	0.09	0.13	0.19	0.74	0.16	0.10	8190
IDN	0.01	0.12	0.17	0.26	1.16	0.21	0.13	69299
IRL	0.03	0.08	0.11	0.19	1.42	0.16	0.15	9434
ISR	0.01	0.09	0.13	0.20	1.15	0.16	0.10	90793
IND	0.04	0.14	0.18	0.23	1.00	0.22	0.13	554648
ISL	0.03	0.07	0.10	0.14	0.61	0.12	0.07	4606
ITA	0.01	0.07	0.09	0.13	0.76	0.11	0.06	67908
JAM	0.03	0.12	0.15	0.19	0.84	0.17	0.07	5078
JOR	0.01	0.10	0.13	0.15	0.74	0.13	0.05	27771
JPN	0.02	0.08	0.11	0.15	1.03	0.13	0.07	898957
KOR	0.02	0.11	0.15	0.21	0.81	0.16	0.08	374472
KWT	0.01	0.10	0.12	0.16	0.58	0.13	0.05	25797
KAZ	0.01	0.10	0.14	0.20	1.03	0.17	0.12	882
LKA	0.03	0.10	0.14	0.19	1.16	0.16	0.09	24240
LTU	0.03	0.08	0.12	0.18	1.02	0.14	0.10	5973
LUX	0.02	0.07	0.09	0.13	0.51	0.11	0.05	3265
LVA	0.03	0.10	0.14	0.22	0.97	0.17	0.09	3163
MAR	0.02	0.08	0.10	0.12	0.82	0.11	0.05	11291
MNE	0.05	0.14	0.17	0.22	0.73	0.20	0.11	1187
MKD	0.01	0.08	0.11	0.15	0.54	0.13	0.07	2791
MLT	0.02	0.05	0.07	0.09	0.59	0.08	0.06	1424
MEX	0.01	0.07	0.09	0.13	1.16	0.11	0.07	20490
MYS	0.01	0.10	0.14	0.20	1.16	0.16	0.11	218309
NGA	0.01	0.11	0.14	0.17	0.55	0.14	0.06	18982
NLD	0.02	0.07	0.09	0.13	1.26	0.11	0.08	40091

(*Continued*)

Table A.8. (*Continued*)

	Min	25%	Median	75%	Max	Mean	StdDev	No. of observations
				SIGMA				
NOR	0.03	0.10	0.14	0.20	1.10	0.17	0.11	46869
NZL	0.02	0.06	0.09	0.14	1.03	0.13	0.11	20401
OMN	0.01	0.06	0.08	0.12	0.98	0.10	0.06	9555
PER	0.02	0.08	0.12	0.16	0.62	0.13	0.07	11030
PHL	0.01	0.11	0.16	0.25	1.03	0.20	0.12	42565
PAK	0.03	0.11	0.15	0.23	1.16	0.21	0.18	47455
POL	0.01	0.12	0.16	0.25	1.42	0.21	0.14	85989
PRT	0.01	0.07	0.10	0.15	1.18	0.13	0.10	14459
ROM	0.01	0.15	0.21	0.32	1.42	0.26	0.16	22087
SRB	0.01	0.12	0.17	0.25	0.72	0.19	0.09	6277
RUS	0.03	0.10	0.14	0.22	1.25	0.18	0.11	21293
SAU	0.02	0.06	0.09	0.13	0.64	0.10	0.06	20065
SWE	0.01	0.09	0.14	0.25	1.42	0.20	0.17	95203
SGP	0.02	0.10	0.15	0.23	1.03	0.19	0.15	138569
SVN	0.01	0.07	0.10	0.15	1.18	0.14	0.13	8096
SVK	0.01	0.08	0.11	0.15	0.59	0.12	0.08	1170
THA	0.01	0.09	0.13	0.18	1.16	0.15	0.10	115158
TUN	0.01	0.06	0.07	0.09	0.52	0.08	0.04	8438
TUR	0.01	0.10	0.13	0.18	1.25	0.15	0.07	74732
TWN	0.02	0.08	0.10	0.12	0.63	0.10	0.04	172182
UKR	0.01	0.14	0.19	0.28	1.05	0.23	0.15	4401
USA	0.03	0.09	0.14	0.22	1.07	0.18	0.12	1659788
VEN	0.01	0.13	0.18	0.24	0.69	0.20	0.10	3797
VNM	0.01	0.11	0.14	0.19	0.61	0.15	0.06	49334
ZAF	0.01	0.09	0.13	0.22	1.16	0.19	0.18	83469

Table A.9. Exits classified as "Defaults".

Default	
Action Type	**Subcategory**
Bankruptcy filling	Administration, Arrangement, Canadian CCAA, Chapter 7, Chapter 11, Chapter 15, Conservatorship, Insolvency , Japanese CRL, Judicial Management, Liquidation, Pre-Negotiation Chapter 11, Protection, Receivership, Rehabilitation, Rehabilitation (Thailand 1997), Reorganization, Restructuring, Section 304, Supreme court declaration, Winding up, Work out, Sued by creditor, Petition Withdrawn, Other
Delisting	Bankruptcy
Default Corporate Action	Bankruptcy, Coupon & Principal Payment, Coupon Payment Only, Debt Restructuring, Interest Payment, Loan Payment, Principal Payment, ADR (Japan only), Declared Sick (India Only), Regulatory Action (Taiwan only), Financial Difficulty and Shutdown (Taiwan only), Buyback option, Other

Table A.10. Exits classified as "Other Exits".

Other Exits	
Action Type	**Subcategory**
Delisting	Acquired/Merged, Assimilated with underlying shares, Bid price below minimum, Cancellation of listing, Failure to meet listing requirements, Failure to pay listing fees, Inactive security, Insufficient assets, Insufficient capital and surplus, Insufficient number of market makers, Issue postponed, Lack of market maker interest, Lack of public interest, Liquidated, Not available, Not current in required filings, NP/FP finished, Privatized, Reorganization, Security called for redemptions, the company's request, Scheme of arrangement, Selective capital reduction of the company, From exchange to OTC, Privatised, Other

Table A.11. Number of defaults and other exits of 78 economies from 1994 to 2015.

Economy: ARE		
Year	**Defaults**	**Others**
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	0
2000	0	0
2001	0	0
2002	0	0
2003	0	0
2004	0	0
2005	0	0
2006	0	0
2007	0	2
2008	0	0
2009	0	0
2010	0	1
2011	0	0
2012	1	4
2013	0	2
2014	0	3
2015	0	3

Economy: ARG		
Year	**Defaults**	**Others**
1994	0	6
1995	0	14
1996	0	9
1997	1	11
1998	2	8
1999	2	10
2000	1	6
2001	5	6
2002	11	6
2003	5	5
2004	0	3
2005	0	2
2006	0	2
2007	0	0
2008	1	0
2009	1	4
2010	2	1
2011	0	1
2012	1	2
2013	0	2
2014	1	2
2015	0	0

Economy: AUT		
Year	**Defaults**	**Others**
1994	0	0
1995	0	2
1996	1	1
1997	0	5
1998	0	7
1999	0	10
2000	0	8
2001	2	16
2002	0	8
2003	0	14
2004	0	12
2005	1	10
2006	0	4
2007	0	6
2008	2	7
2009	1	4
2010	1	13
2011	0	10
2012	1	5
2013	0	9
2014	0	3
2015	0	4

Economy: AUS		
Year	**Defaults**	**Others**
1994	0	5
1995	0	8
1996	3	14
1997	2	48
1998	4	45
1999	4	47
2000	9	37
2001	31	52
2002	12	57
2003	12	44
2004	7	46
2005	6	51
2006	6	66
2007	6	84
2008	30	52
2009	33	69
2010	5	67
2011	0	90
2012	2	72
2013	5	72
2014	6	64
2015	2	55

Economy: BIH		
Year	**Defaults**	**Others**
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	0
2000	0	0
2001	0	0
2002	0	0
2003	0	0
2004	0	0
2005	0	0
2006	0	1
2007	0	0
2008	0	254
2009	0	557
2010	0	73
2011	0	50
2012	0	19
2013	0	19
2014	0	18
2015	4	6

Economy: BGD		
Year	**Defaults**	**Others**
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	0
2000	0	1
2001	0	1
2002	0	0
2003	0	2
2004	0	0
2005	0	0
2006	0	3
2007	0	0
2008	0	1
2009	0	5
2010	0	5
2011	0	2
2012	0	1
2013	0	0
2014	0	1
2015	0	0

(*Continued*)

Table A.11. (*Continued*)

Economy: BEL		
Year	Defaults	Others
1994	0	1
1995	0	0
1996	0	0
1997	0	15
1998	0	16
1999	1	4
2000	1	6
2001	2	7
2002	3	8
2003	2	9
2004	0	10
2005	3	9
2006	2	6
2007	1	11
2008	1	9
2009	2	2
2010	0	9
2011	1	5
2012	2	2
2013	2	8
2014	1	13
2015	0	5

Economy: BGR		
Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	1	0
1999	0	5
2000	0	0
2001	0	0
2002	1	0
2003	2	2
2004	2	2
2005	2	7
2006	0	0
2007	3	4
2008	0	2
2009	0	11
2010	2	6
2011	0	3
2012	0	15
2013	0	8
2014	3	10
2015	1	6

Economy: BHR		
Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	0
2000	0	0
2001	0	0
2002	0	0
2003	0	0
2004	1	0
2005	0	1
2006	0	1
2007	0	0
2008	1	0
2009	0	1
2010	0	2
2011	1	1
2012	0	0
2013	0	1
2014	0	0
2015	0	0

Economy: BRA		
Year	Defaults	Others
1994	1	0
1995	2	1
1996	0	1
1997	7	21
1998	8	47
1999	3	48
2000	2	49
2001	0	50
2002	3	35
2003	2	33
2004	1	24
2005	1	24
2006	0	26
2007	0	14
2008	0	29
2009	0	23
2010	0	21
2011	0	20
2012	6	16
2013	10	6
2014	6	14
2015	2	6

Economy: CAN		
Year	Defaults	Others
1994	0	0
1995	0	1
1996	0	2
1997	6	87
1998	8	222
1999	14	337
2000	10	210
2001	20	267
2002	7	116
2003	13	94
2004	8	89
2005	3	86
2006	3	103
2007	4	116
2008	10	104
2009	17	112
2010	4	86
2011	5	96
2012	8	94
2013	7	90
2014	5	87
2015	7	83

Economy: CHE		
Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	4
1997	5	9
1998	0	17
1999	0	12
2000	0	10
2001	2	9
2002	1	7
2003	2	11
2004	1	8
2005	1	6
2006	0	14
2007	0	6
2008	0	8
2009	0	7
2010	0	8
2011	2	7
2012	1	9
2013	0	4
2014	0	11
2015	1	14

(*Continued*)

Table A.11. (*Continued*)

Economy: CHL		
Year	Defaults	Others
1994	0	2
1995	0	2
1996	0	0
1997	0	4
1998	0	11
1999	0	9
2000	0	25
2001	1	15
2002	1	6
2003	0	8
2004	0	8
2005	0	13
2006	0	18
2007	0	16
2008	0	9
2009	0	7
2010	0	11
2011	0	13
2012	0	11
2013	0	8
2014	0	4
2015	0	8

Economy: CHN		
Year	Defaults	Others
1994	2	0
1995	10	0
1996	12	0
1997	16	0
1998	35	1
1999	25	4
2000	27	5
2001	50	14
2002	51	13
2003	43	12
2004	109	11
2005	96	15
2006	65	16
2007	63	24
2008	54	12
2009	53	16
2010	43	5
2011	16	3
2012	17	4
2013	13	7
2014	5	2
2015	2	9

Economy: COL		
Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	3
1997	0	12
1998	1	34
1999	0	33
2000	0	22
2001	0	5
2002	1	5
2003	1	3
2004	0	2
2005	0	8
2006	0	8
2007	0	7
2008	0	14
2009	0	2
2010	0	4
2011	0	6
2012	1	2
2013	0	2
2014	0	3
2015	0	0

Economy: CYP		
Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	1
1997	0	0
1998	0	2
1999	0	1
2000	0	3
2001	0	4
2002	0	1
2003	0	3
2004	0	4
2005	0	4
2006	0	5
2007	0	7
2008	0	11
2009	0	9
2010	0	11
2011	0	11
2012	0	24
2013	2	33
2014	0	14
2015	0	12

Economy: CZE		
Year	Defaults	Others
1994	0	4
1995	0	19
1996	0	63
1997	0	355
1998	1	29
1999	4	129
2000	7	26
2001	2	41
2002	1	23
2003	0	17
2004	0	12
2005	0	15
2006	0	11
2007	0	3
2008	0	2
2009	0	4
2010	0	0
2011	1	2
2012	0	1
2013	0	4
2014	0	2
2015	0	0

Economy: DEU		
Year	Defaults	Others
1994	0	4
1995	0	2
1996	4	9
1997	3	19
1998	2	16
1999	1	21
2000	2	25
2001	27	24
2002	38	77
2003	18	51
2004	8	29
2005	4	40
2006	5	38
2007	5	47
2008	21	68
2009	11	87
2010	2	89
2011	5	268
2012	10	459
2013	16	68
2014	5	73
2015	9	40

(*Continued*)

Table A.11. (*Continued*)

Economy: DNK

Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	5
1998	0	8
1999	0	11
2000	2	9
2001	5	14
2002	4	12
2003	1	8
2004	1	8
2005	1	10
2006	0	6
2007	1	3
2008	0	13
2009	5	9
2010	0	14
2011	2	13
2012	2	12
2013	4	11
2014	2	13
2015	0	4

Economy: EST

Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	0
2000	0	3
2001	0	3
2002	0	3
2003	0	0
2004	0	0
2005	0	1
2006	0	1
2007	0	1
2008	0	0
2009	0	2
2010	0	1
2011	0	0
2012	0	0
2013	0	0
2014	0	1
2015	0	0

Economy: EGY

Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	0
2000	0	0
2001	0	0
2002	0	3
2003	0	3
2004	0	8
2005	1	20
2006	0	120
2007	0	183
2008	0	137
2009	0	108
2010	0	57
2011	0	12
2012	0	9
2013	0	10
2014	0	11
2015	1	9

Economy: ESP

Year	Defaults	Others
1994	0	5
1995	0	20
1996	0	21
1997	0	15
1998	0	29
1999	0	28
2000	0	27
2001	0	22
2002	2	23
2003	0	52
2004	0	20
2005	0	19
2006	0	15
2007	1	16
2008	2	10
2009	0	8
2010	1	8
2011	0	7
2012	3	8
2013	6	8
2014	0	9
2015	2	10

Economy: FIN

Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	1	5
1999	0	8
2000	0	11
2001	1	9
2002	1	5
2003	1	5
2004	0	9
2005	0	5
2006	0	7
2007	0	5
2008	1	3
2009	1	2
2010	0	3
2011	1	1
2012	0	4
2013	2	2
2014	0	4
2015	3	3

Economy: FRA

Year	Defaults	Others
1994	0	1
1995	0	2
1996	0	5
1997	1	62
1998	0	58
1999	2	122
2000	4	50
2001	11	55
2002	12	49
2003	8	53
2004	8	54
2005	3	36
2006	11	24
2007	15	38
2008	9	44
2009	16	36
2010	2	77
2011	3	40
2012	8	47
2013	4	42
2014	11	29
2015	7	35

(*Continued*)

Table A.11. (*Continued*)

Economy: GBR

Year	Defaults	Others
1994	0	3
1995	0	2
1996	0	5
1997	0	36
1998	1	159
1999	3	206
2000	3	172
2001	10	124
2002	17	107
2003	7	146
2004	3	97
2005	3	123
2006	0	202
2007	3	184
2008	20	237
2009	51	232
2010	5	186
2011	8	157
2012	37	154
2013	15	133
2014	6	121
2015	7	122

Economy: GRC

Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	2
1998	0	2
1999	0	2
2000	0	7
2001	0	14
2002	0	21
2003	0	10
2004	0	11
2005	0	20
2006	0	41
2007	0	20
2008	0	17
2009	0	17
2010	0	12
2011	0	18
2012	0	24
2013	0	23
2014	0	18
2015	1	4

Economy: HKG

Year	Defaults	Others
1994	0	4
1995	0	5
1996	0	10
1997	0	8
1998	2	19
1999	9	8
2000	5	10
2001	9	19
2002	6	21
2003	6	30
2004	1	33
2005	2	45
2006	3	28
2007	2	17
2008	7	21
2009	7	12
2010	1	18
2011	0	20
2012	3	22
2013	5	20
2014	2	18
2015	8	16

Economy: HRV

Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	1
2000	0	1
2001	0	0
2002	0	0
2003	0	2
2004	0	2
2005	0	0
2006	0	10
2007	0	71
2008	0	69
2009	0	31
2010	1	28
2011	0	22
2012	1	30
2013	0	23
2014	1	18
2015	0	7

Economy: HUN

Year	Defaults	Others
1994	0	0
1995	0	2
1996	0	3
1997	0	6
1998	0	1
1999	0	2
2000	1	5
2001	0	4
2002	0	7
2003	0	1
2004	0	4
2005	0	3
2006	0	5
2007	0	3
2008	0	0
2009	0	0
2010	0	0
2011	0	2
2012	1	2
2013	0	6
2014	0	3
2015	0	4

Economy: IDN

Year	Defaults	Others
1994	0	0
1995	0	2
1996	1	0
1997	2	0
1998	20	0
1999	26	1
2000	15	11
2001	17	2
2002	9	9
2003	3	4
2004	4	14
2005	2	20
2006	0	6
2007	2	10
2008	0	6
2009	5	9
2010	3	1
2011	0	5
2012	1	4
2013	2	7
2014	2	1
2015	1	1

(*Continued*)

Table A.11. (*Continued*)

Economy: IRL		
Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	2
1998	0	4
1999	0	3
2000	0	2
2001	0	7
2002	0	5
2003	0	7
2004	0	3
2005	0	2
2006	0	2
2007	0	2
2008	0	3
2009	1	4
2010	0	4
2011	0	2
2012	0	4
2013	1	1
2014	0	1
2015	1	2

Economy: ISR		
Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	10
1997	0	19
1998	0	23
1999	0	20
2000	8	39
2001	0	65
2002	3	77
2003	0	71
2004	0	27
2005	3	24
2006	0	23
2007	0	19
2008	0	25
2009	0	21
2010	1	25
2011	2	39
2012	0	51
2013	2	41
2014	1	39
2015	4	20

Economy: IND		
Year	Defaults	Others
1994	0	9
1995	2	18
1996	8	89
1997	12	169
1998	17	90
1999	29	80
2000	26	142
2001	36	167
2002	27	1615
2003	29	250
2004	20	1068
2005	51	133
2006	29	115
2007	41	73
2008	46	110
2009	88	53
2010	11	80
2011	16	65
2012	39	78
2013	52	117
2014	34	42
2015	36	70

Economy: ISL		
Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	0
2000	0	8
2001	1	6
2002	0	11
2003	0	17
2004	0	11
2005	0	7
2006	0	4
2007	0	2
2008	6	10
2009	2	3
2010	0	3
2011	0	0
2012	0	0
2013	0	0
2014	0	1
2015	0	0

Economy: ITA		
Year	Defaults	Others
1994	0	2
1995	0	8
1996	2	6
1997	0	19
1998	0	14
1999	0	9
2000	0	20
2001	0	20
2002	1	13
2003	4	23
2004	6	11
2005	1	15
2006	0	18
2007	1	15
2008	1	16
2009	3	19
2010	2	10
2011	0	21
2012	2	19
2013	2	22
2014	1	13
2015	1	9

Economy: JAM		
Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	1
1997	0	1
1998	0	0
1999	2	1
2000	0	0
2001	0	1
2002	0	0
2003	0	0
2004	0	0
2005	0	0
2006	0	0
2007	0	1
2008	0	1
2009	0	1
2010	0	0
2011	0	1
2012	0	2
2013	0	0
2014	0	0
2015	0	1

(*Continued*)

Table A.11. (*Continued*)

Economy: JOR

Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	1
1997	0	1
1998	0	0
1999	0	0
2000	0	1
2001	0	1
2002	0	5
2003	0	2
2004	0	3
2005	0	3
2006	0	1
2007	0	6
2008	0	1
2009	0	0
2010	0	0
2011	0	16
2012	0	5
2013	0	4
2014	0	23
2015	0	2

Economy: JPN

Year	Defaults	Others
1994	0	5
1995	2	5
1996	5	7
1997	8	14
1998	15	22
1999	9	39
2000	13	55
2001	16	58
2002	30	96
2003	20	97
2004	12	87
2005	10	90
2006	3	83
2007	6	100
2008	36	108
2009	28	135
2010	9	126
2011	4	100
2012	7	98
2013	4	73
2014	0	44
2015	5	68

Economy: KOR

Year	Defaults	Others
1994	18	0
1995	2	4
1996	6	2
1997	53	4
1998	81	9
1999	32	40
2000	14	43
2001	22	25
2002	16	40
2003	12	31
2004	9	52
2005	9	53
2006	3	12
2007	2	16
2008	10	20
2009	8	77
2010	10	88
2011	3	65
2012	5	67
2013	15	48
2014	6	27
2015	2	42

Economy: KWT

Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	0
2000	0	0
2001	0	0
2002	0	0
2003	0	0
2004	0	0
2005	0	0
2006	0	0
2007	0	0
2008	0	0
2009	1	1
2010	0	0
2011	0	2
2012	0	16
2013	0	2
2014	0	6
2015	0	6

Economy: KAZ

Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	0
2000	0	0
2001	0	0
2002	0	0
2003	0	1
2004	0	5
2005	0	0
2006	0	5
2007	0	4
2008	0	1
2009	5	7
2010	3	6
2011	0	5
2012	2	0
2013	0	2
2014	1	9
2015	0	0

Economy: LKA

Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	0
2000	0	2
2001	0	0
2002	0	4
2003	0	1
2004	0	7
2005	0	11
2006	0	7
2007	0	5
2008	0	5
2009	0	5
2010	0	3
2011	0	3
2012	0	4
2013	0	1
2014	0	4
2015	0	4

(*Continued*)

Table A.11. (*Continued*)

Economy: LTU

Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	0
2000	0	2
2001	0	0
2002	0	2
2003	0	6
2004	0	2
2005	0	0
2006	0	2
2007	0	3
2008	0	0
2009	0	2
2010	0	2
2011	1	5
2012	0	0
2013	1	1
2014	0	0
2015	0	0

Economy: LUX

Year	Defaults	Others
1994	0	0
1995	0	2
1996	0	5
1997	0	5
1998	0	6
1999	0	9
2000	0	5
2001	0	11
2002	0	2
2003	0	5
2004	0	0
2005	0	2
2006	0	1
2007	0	2
2008	0	5
2009	0	4
2010	1	4
2011	0	4
2012	0	3
2013	0	1
2014	0	2
2015	0	0

Economy: LVA

Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	0
2000	0	2
2001	0	6
2002	0	3
2003	0	8
2004	0	1
2005	0	1
2006	0	3
2007	0	2
2008	0	0
2009	0	2
2010	0	2
2011	1	1
2012	0	1
2013	0	0
2014	0	0
2015	1	0

Economy: MAR

Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	1
2000	0	0
2001	0	1
2002	0	0
2003	0	3
2004	0	0
2005	0	3
2006	0	1
2007	0	0
2008	0	1
2009	0	1
2010	0	4
2011	0	1
2012	0	0
2013	0	3
2014	0	2
2015	0	2

Economy: MNE

Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	0
2000	0	0
2001	0	0
2002	0	0
2003	0	7
2004	0	7
2005	0	5
2006	0	6
2007	0	10
2008	0	38
2009	0	33
2010	0	3
2011	0	136
2012	0	38
2013	0	15
2014	0	10
2015	0	2

Economy: MKD

Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	0
2000	0	0
2001	0	0
2002	0	0
2003	0	0
2004	0	0
2005	0	1
2006	0	3
2007	0	2
2008	0	0
2009	0	0
2010	0	0
2011	0	0
2012	2	2
2013	0	0
2014	0	1
2015	0	0

(*Continued*)

Table A.11. (*Continued*)

Economy: MLT		
Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	0
2000	0	0
2001	0	0
2002	0	0
2003	0	0
2004	0	0
2005	0	0
2006	0	0
2007	0	1
2008	0	0
2009	0	0
2010	0	0
2011	0	0
2012	0	0
2013	0	0
2014	0	0
2015	0	2

Economy: MEX		
Year	Defaults	Others
1994	0	20
1995	0	0
1996	0	2
1997	1	9
1998	0	4
1999	2	11
2000	2	11
2001	1	7
2002	1	8
2003	3	4
2004	1	6
2005	0	19
2006	1	1
2007	0	9
2008	2	2
2009	2	0
2010	3	2
2011	0	7
2012	0	4
2013	5	2
2014	3	2
2015	1	2

Economy: MYS		
Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	1
1998	16	1
1999	9	0
2000	13	0
2001	19	3
2002	13	3
2003	8	17
2004	8	27
2005	5	21
2006	16	29
2007	15	62
2008	24	34
2009	23	28
2010	25	29
2011	13	34
2012	11	35
2013	5	23
2014	2	17
2015	0	11

Economy: NGA		
Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	0
2000	0	0
2001	0	0
2002	0	0
2003	0	4
2004	0	0
2005	0	27
2006	0	9
2007	0	6
2008	0	18
2009	0	10
2010	0	5
2011	0	18
2012	0	1
2013	0	15
2014	0	6
2015	0	0

Economy: NLD		
Year	Defaults	Others
1994	0	2
1995	0	0
1996	1	0
1997	0	13
1998	1	8
1999	0	17
2000	1	19
2001	8	18
2002	8	11
2003	5	13
2004	0	9
2005	0	8
2006	1	8
2007	0	7
2008	1	11
2009	4	3
2010	0	8
2011	0	6
2012	0	6
2013	1	6
2014	2	5
2015	2	6

Economy: NOR		
Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	5
1998	0	11
1999	0	25
2000	2	28
2001	3	18
2002	4	10
2003	4	25
2004	0	9
2005	0	14
2006	0	30
2007	1	35
2008	4	27
2009	7	31
2010	2	36
2011	1	12
2012	1	12
2013	1	21
2014	1	14
2015	4	14

(*Continued*)

Table A.11. (*Continued*)

Economy: NZL			Economy: OMN			Economy: PER		
Year	Defaults	Others	Year	Defaults	Others	Year	Defaults	Others
1994	0	1	1994	0	0	1994	0	10
1995	0	0	1995	0	0	1995	0	2
1996	0	0	1996	0	1	1996	0	6
1997	0	4	1997	0	0	1997	0	20
1998	0	4	1998	0	2	1998	0	12
1999	0	11	1999	0	2	1999	0	37
2000	0	7	2000	0	2	2000	0	33
2001	0	14	2001	0	1	2001	0	15
2002	0	7	2002	0	0	2002	0	26
2003	0	3	2003	0	0	2003	0	11
2004	0	8	2004	0	1	2004	0	16
2005	0	11	2005	0	2	2005	0	3
2006	0	8	2006	0	11	2006	0	2
2007	0	9	2007	0	7	2007	0	3
2008	1	6	2008	0	9	2008	0	3
2009	0	4	2009	0	0	2009	0	9
2010	1	13	2010	0	9	2010	0	6
2011	0	3	2011	0	8	2011	0	3
2012	0	4	2012	0	4	2012	0	4
2013	2	7	2013	0	2	2013	0	9
2014	0	7	2014	0	4	2014	0	9
2015	0	1	2015	0	3	2015	0	0

Economy: PHL			Economy: PAK			Economy: POL		
Year	Defaults	Others	Year	Defaults	Others	Year	Defaults	Others
1994	0	0	1994	0	0	1994	0	0
1995	0	0	1995	0	1	1995	0	0
1996	0	0	1996	0	4	1996	0	0
1997	0	0	1997	0	3	1997	0	1
1998	1	3	1998	0	10	1998	0	3
1999	4	1	1999	0	7	1999	0	3
2000	1	3	2000	0	5	2000	1	7
2001	2	1	2001	0	17	2001	1	5
2002	8	1	2002	0	35	2002	3	18
2003	5	2	2003	0	15	2003	3	15
2004	7	3	2004	0	30	2004	0	8
2005	5	0	2005	0	16	2005	1	9
2006	3	1	2006	0	15	2006	1	8
2007	2	6	2007	0	11	2007	0	10
2008	3	0	2008	0	11	2008	0	2
2009	2	1	2009	0	42	2009	0	10
2010	1	1	2010	1	41	2010	0	5
2011	0	6	2011	0	63	2011	0	13
2012	1	6	2012	0	67	2012	8	14
2013	1	7	2013	0	9	2013	5	30
2014	0	1	2014	1	9	2014	3	28
2015	0	2	2015	0	8	2015	10	29

(*Continued*)

Table A.11. (*Continued*)

Economy: PRT

Year	Defaults	Others
1994	0	1
1995	0	0
1996	0	0
1997	0	0
1998	0	20
1999	0	12
2000	0	13
2001	0	12
2002	0	9
2003	0	3
2004	0	3
2005	0	4
2006	0	3
2007	0	8
2008	0	2
2009	0	1
2010	0	2
2011	1	0
2012	2	3
2013	0	4
2014	1	0
2015	1	0

Economy: ROM

Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	0
2000	0	6
2001	0	4
2002	0	0
2003	0	2
2004	0	3
2005	1	4
2006	0	37
2007	0	158
2008	0	35
2009	0	177
2010	0	10
2011	0	3
2012	0	5
2013	2	7
2014	0	5
2015	3	21

Economy: SRB

Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	0
2000	0	0
2001	0	0
2002	0	0
2003	0	0
2004	0	0
2005	0	0
2006	0	415
2007	0	566
2008	0	491
2009	0	351
2010	0	149
2011	0	292
2012	0	224
2013	0	181
2014	6	75
2015	9	69

Economy: RUS

Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	1
1997	0	0
1998	2	3
1999	1	6
2000	0	2
2001	0	17
2002	0	72
2003	0	4
2004	5	5
2005	0	10
2006	2	58
2007	0	45
2008	2	5
2009	12	54
2010	3	18
2011	13	67
2012	7	236
2013	2	59
2014	6	34
2015	2	13

Economy: SAU

Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	0
2000	0	0
2001	0	0
2002	0	0
2003	0	0
2004	0	0
2005	0	0
2006	0	0
2007	0	1
2008	0	0
2009	0	1
2010	0	0
2011	0	0
2012	0	0
2013	1	0
2014	0	5
2015	1	1

Economy: SWE

Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	21
1998	1	18
1999	1	26
2000	2	35
2001	4	34
2002	8	24
2003	3	24
2004	1	18
2005	2	15
2006	0	22
2007	1	13
2008	2	29
2009	4	25
2010	2	28
2011	3	32
2012	0	40
2013	3	19
2014	3	27
2015	2	20

(*Continued*)

Table A.11. (*Continued*)

Economy: SGP		
Year	Defaults	Others
1994	0	0
1995	1	0
1996	2	0
1997	1	6
1998	5	4
1999	4	10
2000	1	10
2001	2	24
2002	2	18
2003	1	9
2004	2	7
2005	5	7
2006	2	14
2007	0	15
2008	3	26
2009	14	16
2010	2	27
2011	0	33
2012	2	18
2013	0	25
2014	0	28
2015	2	18

Economy: SVN		
Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	1
1998	0	1
1999	0	5
2000	0	4
2001	0	5
2002	0	22
2003	0	7
2004	0	8
2005	0	19
2006	0	19
2007	0	12
2008	0	1
2009	3	11
2010	0	6
2011	0	9
2012	2	5
2013	2	9
2014	2	4
2015	0	4

Economy: SVK		
Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	1
1997	0	16
1998	0	66
1999	1	44
2000	1	29
2001	1	27
2002	0	351
2003	0	92
2004	0	38
2005	1	54
2006	0	49
2007	0	22
2008	0	23
2009	0	16
2010	0	1
2011	0	12
2012	0	11
2013	0	6
2014	0	13
2015	0	10

Economy: THA		
Year	Defaults	Others
1994	0	0
1995	1	0
1996	6	0
1997	22	16
1998	21	10
1999	23	23
2000	34	6
2001	23	6
2002	9	11
2003	7	8
2004	1	6
2005	4	10
2006	1	4
2007	1	8
2008	4	9
2009	12	8
2010	6	5
2011	2	8
2012	1	5
2013	1	2
2014	0	8
2015	1	2

Economy: TUN		
Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	0
2000	0	0
2001	0	0
2002	0	0
2003	0	0
2004	0	0
2005	0	0
2006	0	0
2007	0	0
2008	0	4
2009	0	0
2010	0	1
2011	0	0
2012	0	0
2013	0	0
2014	0	0
2015	0	0

Economy: TUR		
Year	Defaults	Others
1994	0	0
1995	0	0
1996	1	0
1997	0	1
1998	0	1
1999	0	1
2000	2	6
2001	0	6
2002	0	10
2003	0	5
2004	0	1
2005	0	0
2006	0	5
2007	0	5
2008	0	0
2009	0	3
2010	0	0
2011	0	2
2012	0	5
2013	0	4
2014	0	13
2015	0	1

(*Continued*)

Table A.11. (*Continued*)

Economy: TWN		
Year	Defaults	Others
1994	0	0
1995	0	1
1996	0	0
1997	0	0
1998	3	2
1999	8	5
2000	8	9
2001	9	12
2002	7	28
2003	1	13
2004	5	9
2005	3	18
2006	3	13
2007	2	19
2008	3	12
2009	1	4
2010	1	9
2011	0	6
2012	0	4
2013	0	4
2014	2	5
2015	0	4

Economy: UKR		
Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	2
2000	0	27
2001	0	4
2002	0	0
2003	0	6
2004	0	1
2005	0	0
2006	0	1
2007	0	16
2008	1	29
2009	1	13
2010	0	1
2011	0	12
2012	0	14
2013	0	16
2014	0	3
2015	0	9

Economy: USA		
Year	Defaults	Others
1994	22	204
1995	21	280
1996	18	356
1997	52	573
1998	81	914
1999	97	974
2000	118	830
2001	180	760
2002	124	532
2003	83	468
2004	37	373
2005	35	382
2006	22	388
2007	23	457
2008	59	382
2009	112	319
2010	29	322
2011	34	305
2012	42	276
2013	32	244
2014	29	213
2015	41	274

Economy: VEN		
Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	2
1997	0	0
1998	0	5
1999	0	5
2000	0	4
2001	1	8
2002	0	5
2003	0	4
2004	0	4
2005	0	0
2006	0	0
2007	0	1
2008	0	17
2009	0	9
2010	0	5
2011	0	14
2012	0	5
2013	0	1
2014	0	0
2015	0	0

Economy: VNM		
Year	Defaults	Others
1994	0	0
1995	0	0
1996	0	0
1997	0	0
1998	0	0
1999	0	0
2000	0	0
2001	0	0
2002	0	0
2003	0	0
2004	0	0
2005	0	0
2006	0	2
2007	0	3
2008	0	2
2009	0	29
2010	0	12
2011	1	13
2012	0	12
2013	0	25
2014	0	16
2015	0	18

Economy: ZAF		
Year	Defaults	Others
1994	0	3
1995	0	4
1996	0	12
1997	0	13
1998	3	63
1999	3	71
2000	6	86
2001	10	101
2002	10	83
2003	1	59
2004	3	37
2005	2	34
2006	2	19
2007	0	33
2008	0	20
2009	1	18
2010	2	18
2011	1	18
2012	5	18
2013	3	23
2014	0	20
2015	1	21

APPENDIX B. PERFORMANCE ANALYSIS

Table B.1. Accuracy ratios (AR) and Area Under Receiver Operating Characteristic (AUROC) for three calibration groups and different economies.

	AR				AUROC			
Economy	**1 mth**	**1 yr**	**2 yr**	**5 yr**	**1 mth**	**1 yr**	**2 yr**	**5 yr**
AUS	0.81385	0.66125	0.54721	0.39111	0.90695	0.83106	0.77479	0.69951
CHN	0.60175	0.55299	0.47682	0.34954	0.80104	0.77858	0.74313	0.68915
HKG	0.72475	0.49305	0.39157	0.22293	0.86239	0.74685	0.69658	0.6141
IND	0.72878	0.6637	0.60559	0.48909	0.86442	0.83231	0.80386	0.7474
IDN	0.74853	0.67899	0.5788	0.39261	0.87433	0.84053	0.7922	0.70612
JPN	0.91011	0.8274	0.77393	0.6415	0.95506	0.91383	0.88732	0.82228
MYS	0.84781	0.77742	0.70229	0.51429	0.92394	0.88921	0.85252	0.76302
PHL	0.69236	0.63846	0.61088	0.5078	0.84623	0.81999	0.8071	0.75963
SGP	0.78646	0.64508	0.48053	0.29912	0.89325	0.82287	0.74122	0.65264
KOR	0.88555	0.7409	0.66328	0.60767	0.94279	0.87097	0.83305	0.80797
TWN	0.8642	0.76178	0.67889	0.56799	0.93211	0.8811	0.84003	0.78614
THA	0.8706	0.78987	0.74395	0.62207	0.93533	0.89559	0.87359	0.81675
USA	0.9394	0.82109	0.71302	0.52057	0.96971	0.91101	0.85795	0.76562
CAN	0.93934	0.78498	0.65771	0.47734	0.96968	0.89282	0.8299	0.7424
BEL	0.76893	0.71529	0.66384	0.44976	0.88448	0.8579	0.83257	0.72719
DNK	0.8642	0.79464	0.67032	0.54959	0.93212	0.89769	0.83631	0.77798
FRA	0.86651	0.68004	0.6264	0.55627	0.93326	0.84028	0.81379	0.77981
DEU	0.86929	0.70051	0.58877	0.47082	0.93467	0.85101	0.79636	0.74068
ITA	0.89599	0.77219	0.58844	0.37152	0.948	0.88629	0.79492	0.68839
NLD	0.8114	0.77264	0.64264	0.52228	0.90573	0.88675	0.82263	0.76489
NOR	0.96012	0.83811	0.69293	0.38644	0.98006	0.91928	0.8472	0.69632
POL	0.86048	0.72994	0.55353	0.32804	0.93025	0.86533	0.77791	0.66738
RUS	0.90093	0.50975	0.17065	0.027165	0.95048	0.75574	0.58836	0.52268
ZAF	0.90238	0.83045	0.698	0.3843	0.95121	0.91551	0.85	0.69641
SWE	0.89108	0.76867	0.66171	0.38607	0.94555	0.88458	0.83152	0.69551
GBR	0.89046	0.73912	0.59773	0.42225	0.94524	0.86986	0.79977	0.71386
BRA	0.84101	0.75181	0.64264	0.4069	0.92052	0.87627	0.82238	0.70677
MEX	0.81638	0.7392	0.67243	0.51309	0.90822	0.8702	0.8378	0.76207
Developed Asia-Pacific	0.86242	0.73787	0.65869	0.5481	0.93122	0.86921	0.83008	0.77653
Emerging MKT	0.84855	0.77471	0.7013	0.54284	0.9243	0.88774	0.85172	0.77584
North America	0.93937	0.8182	0.70906	0.5187	0.9697	0.90955	0.85592	0.76447
Europe	0.88033	0.74459	0.62088	0.45494	0.94018	0.8726	0.81131	0.73014

Note: *This table only shows the economies with more than 20 defaults in the testing period.

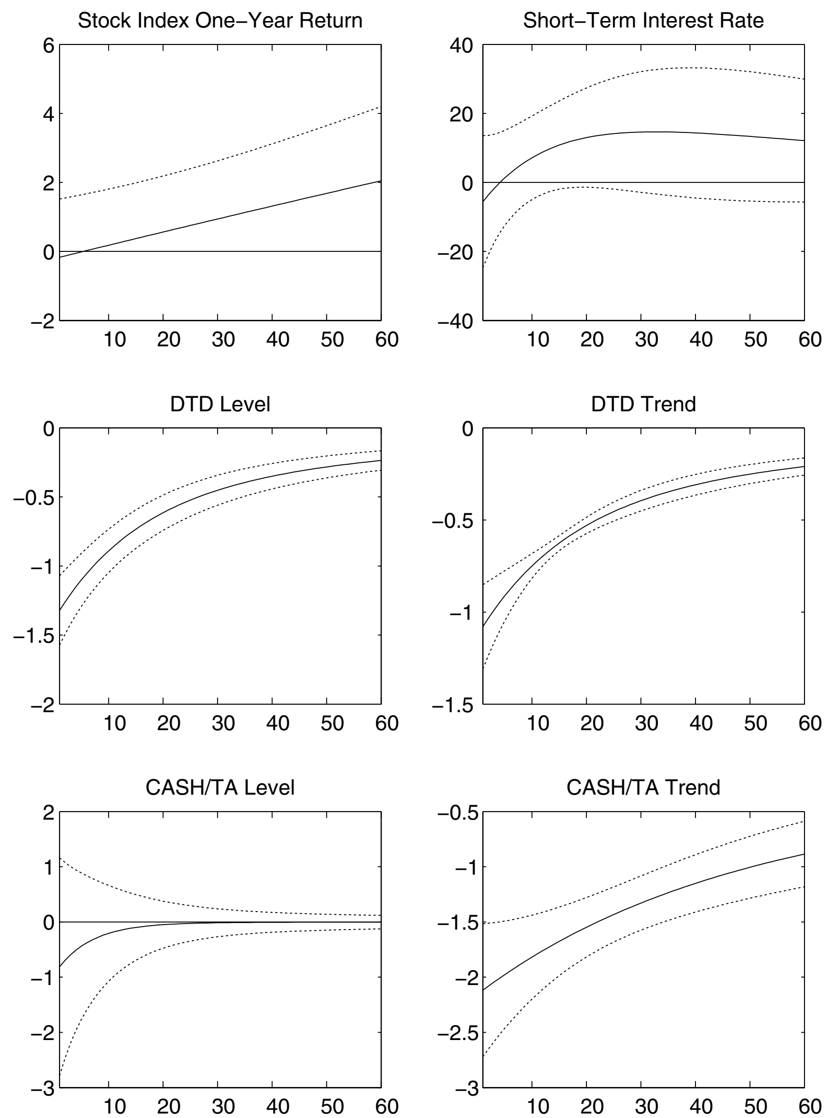


Figure B.1. Plots of US default parameters across all horizons for the Stock index one-year return, short-term interest rate, DTD Level, DTD Trend, CASH/TA Level and CASH/TA Trend. Solid lines are the parameter estimates and dashed lines are the 90% confidence level. Horizontal axis is the horizon in months.

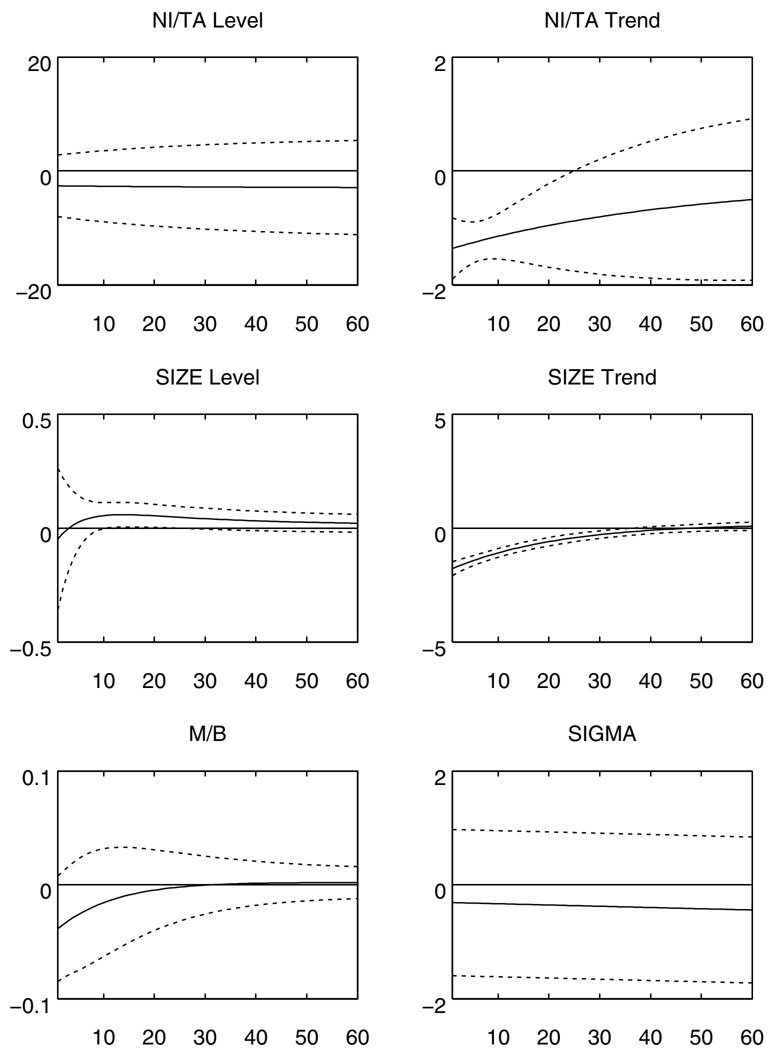
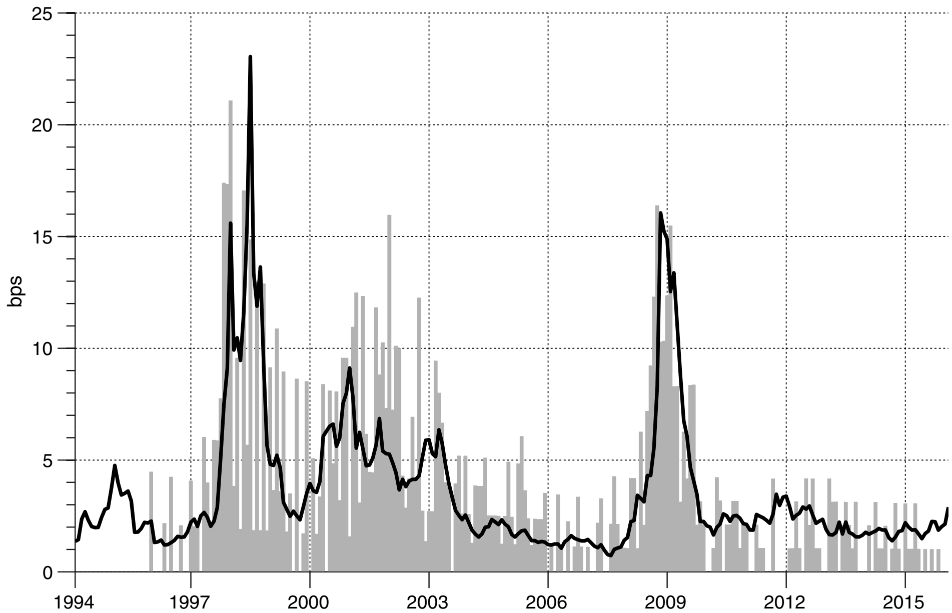
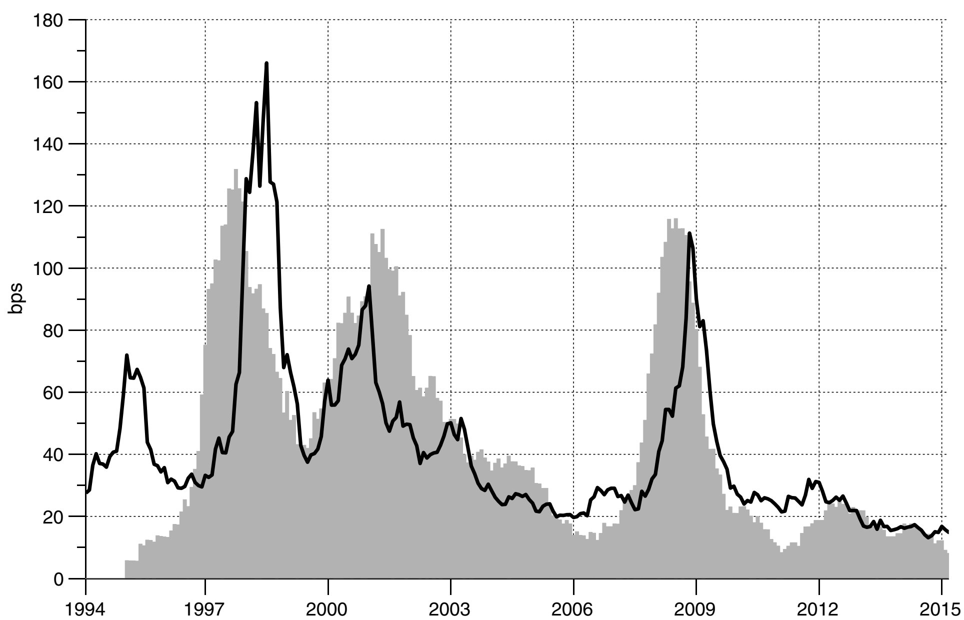


Figure B.2. Plots of US default parameters across all horizons for the NI/TA Level, NI/TA Trend, SIZE Level, SIZE Trend, M/B and SIGMA. Solid lines are the parameter estimates and dashed lines are the 90% confidence level. Horizontal axis is the horizon in months.

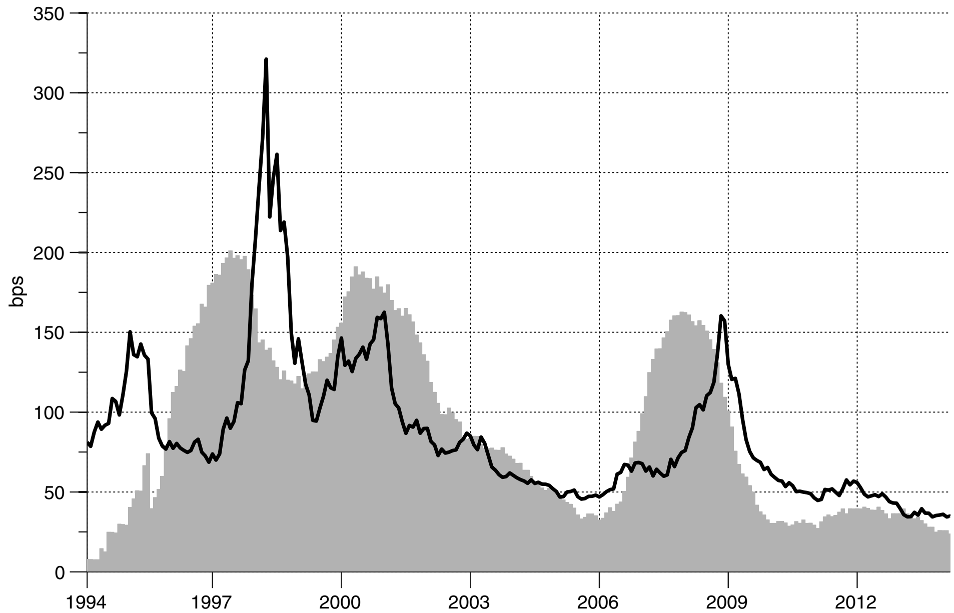


(a) Predicted default rates (line) vs. actual default rates (bars), horizon = 1 month



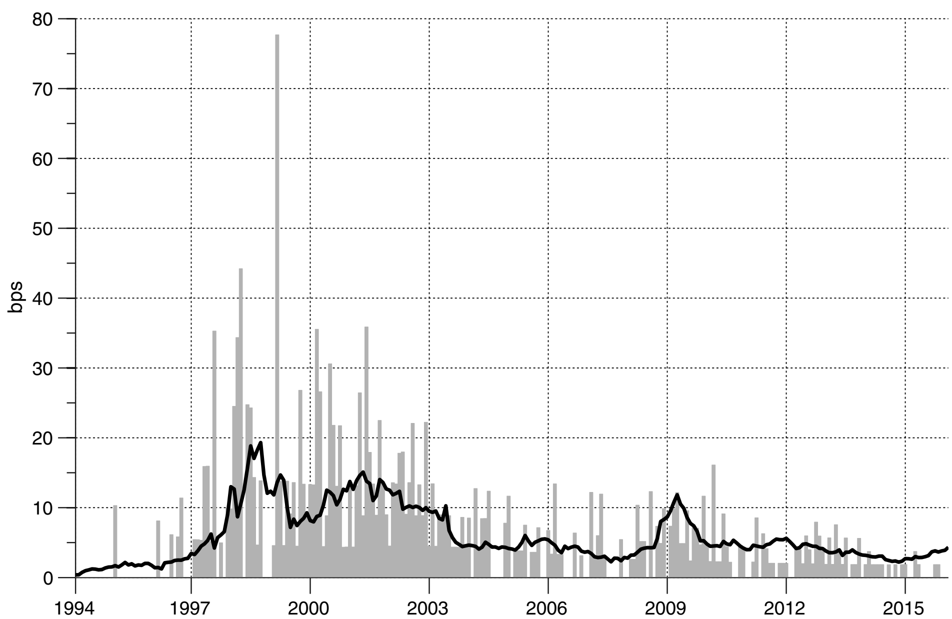
(b) Predicted default rates (line) vs. actual default rates (bars), horizon = 12 months

Figure B.3. Performance test for the Developed Asia, in sample.



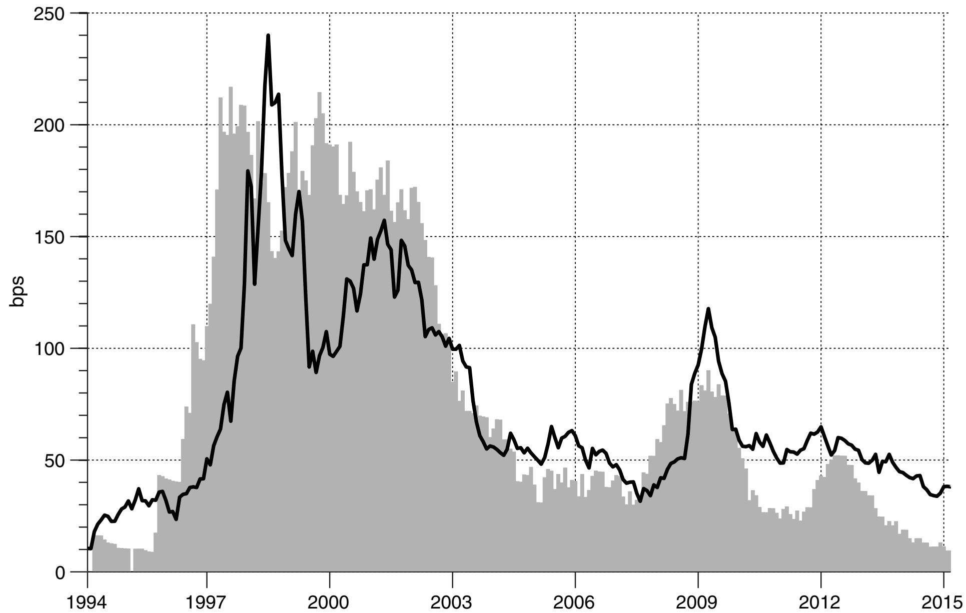
(c) Predicted default rates (line) vs. actual default rates (bars), horizon = 24 months

Figure B.3. (*Continued*)

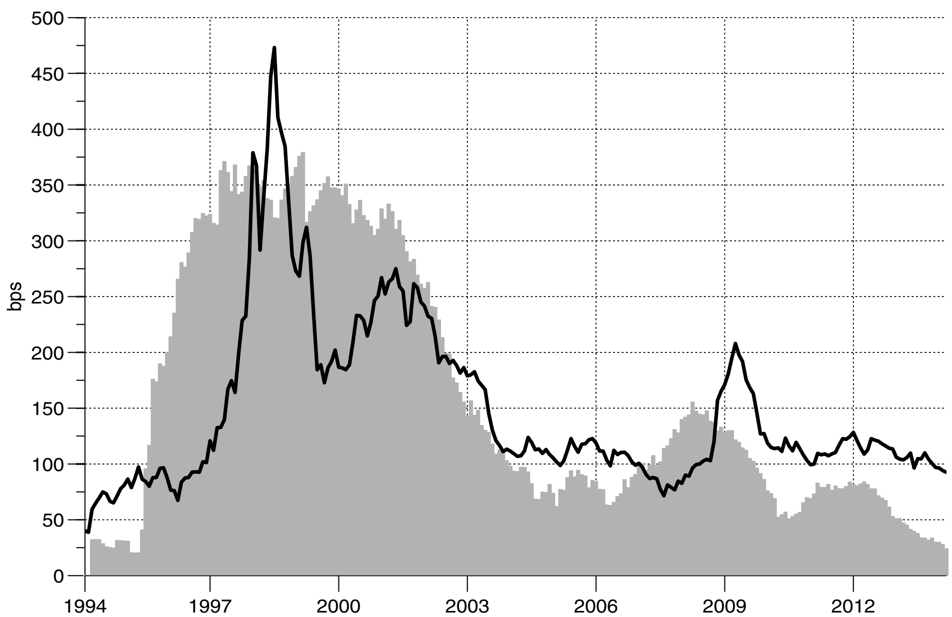


(a) Predicted default rates (line) vs. actual default rates (bars), horizon = 1 month

Figure B.4. Performance test for the Emerging Market, in sample.

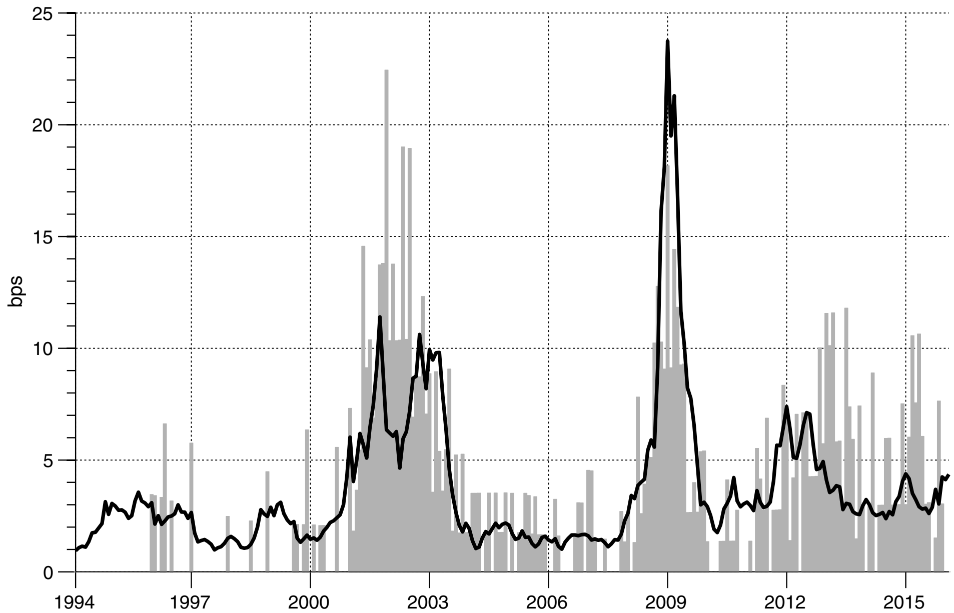


(b) Predicted default rates (line) vs. actual default rates (bars), horizon = 12 months

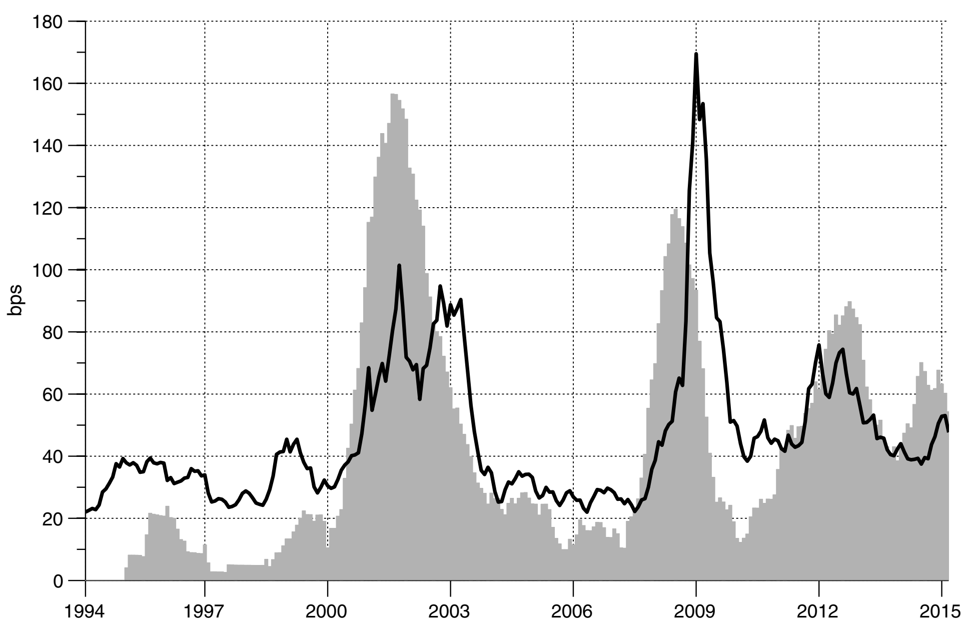


(c) Predicted default rates (line) vs. actual default rates (bars), horizon = 24 months

Figure B.4. (*Continued*)

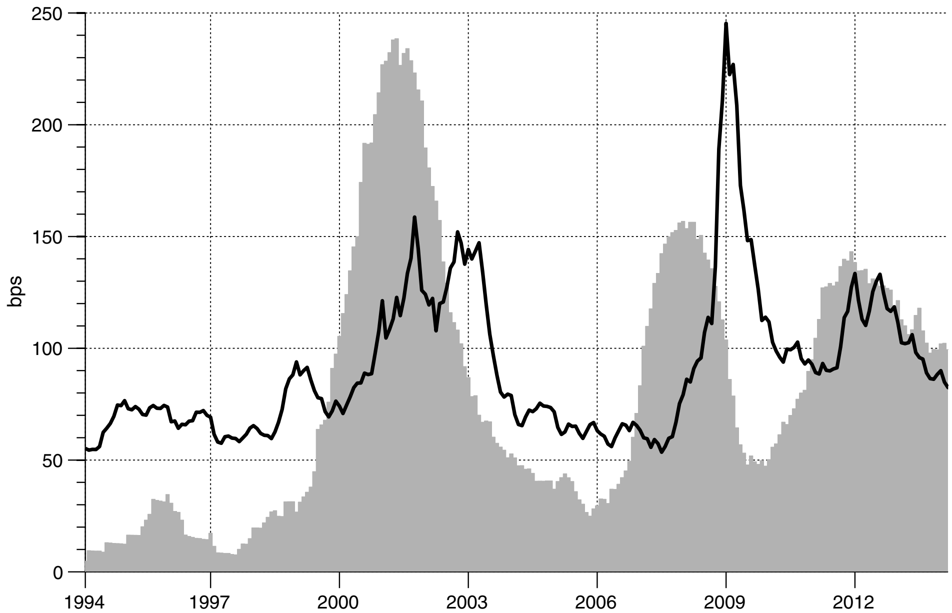


(a) Predicted default rates (line) vs. actual default rates (bars), horizon = 1 month



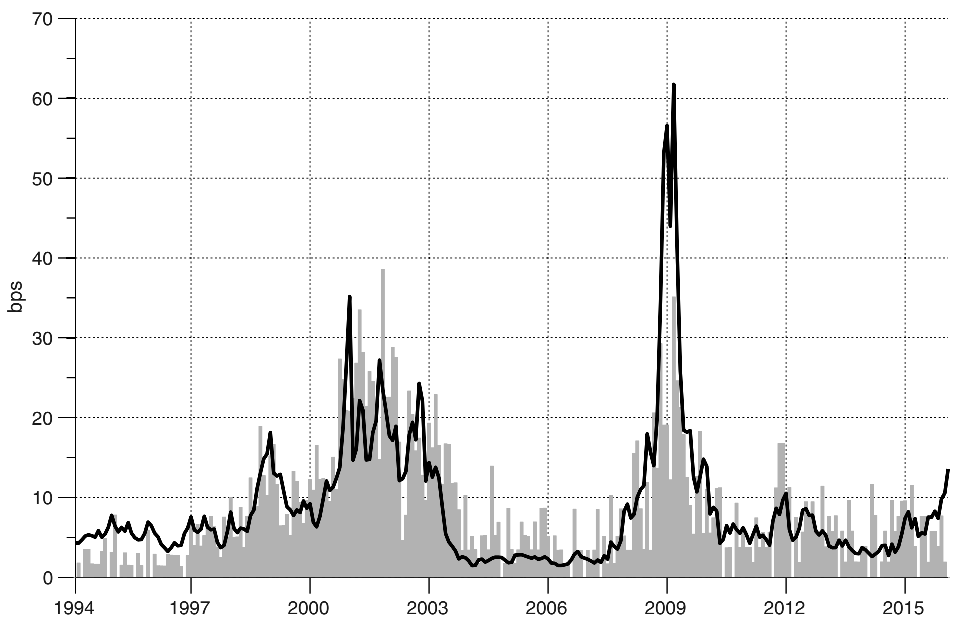
(b) Predicted default rates (line) vs. actual default rates (bars), horizon = 12 months

Figure B.5. Performance test for the Europe group, in sample.



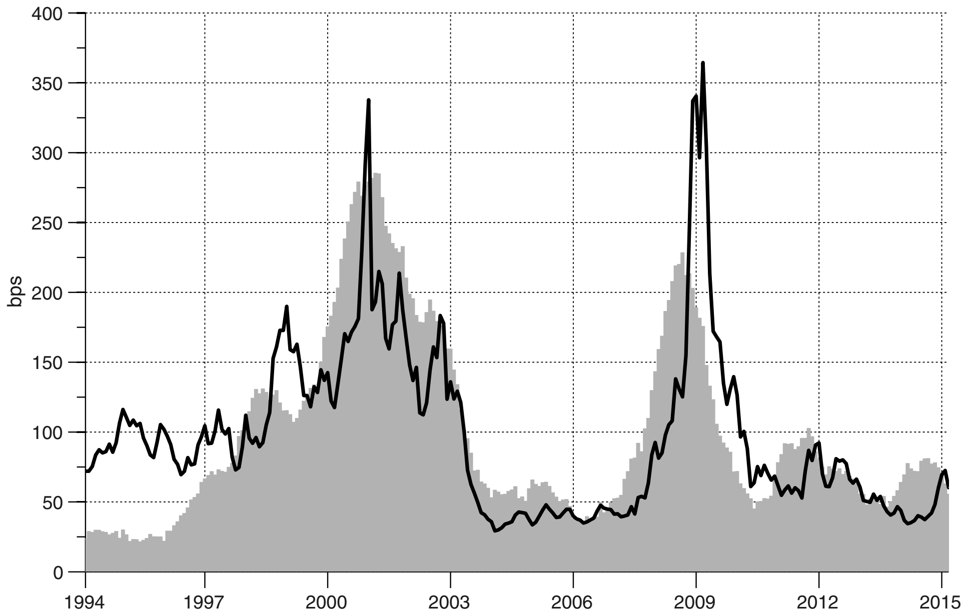
(c) Predicted default rates (line) vs. actual default rates (bars), horizon = 24 months

Figure B.5. (*Continued*)

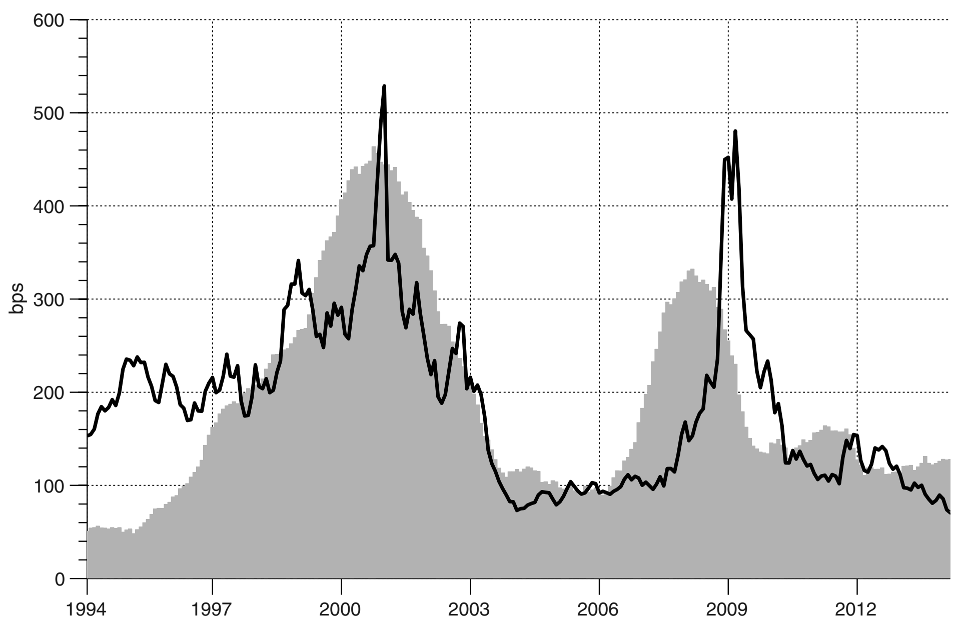


(a) Predicted default rates (line) vs. actual default rates (bars), horizon = 1 month

Figure B.6. Performance test for North America group, in sample.

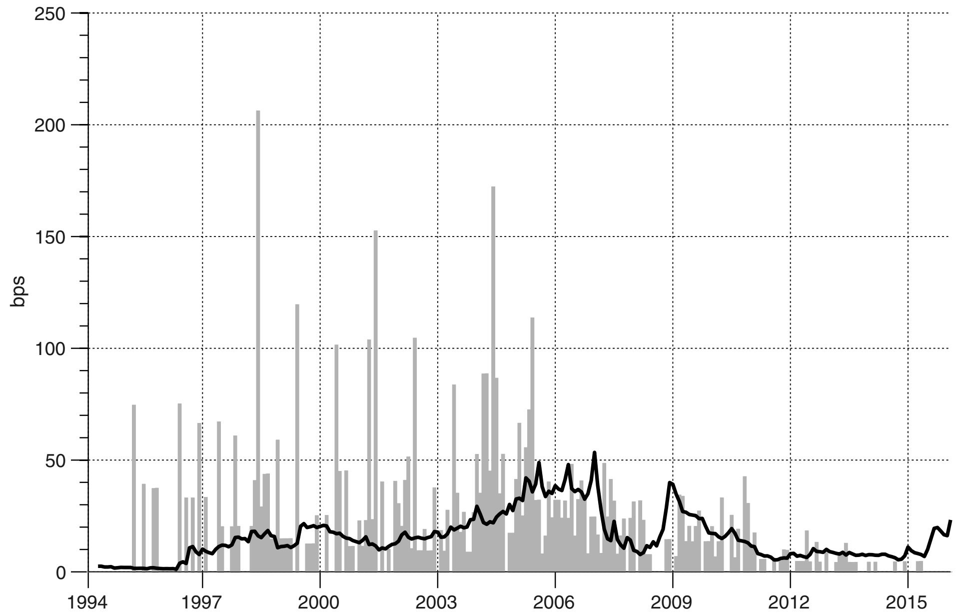


(b) Predicted default rates (line) vs. actual default rates (bars), horizon = 12 months

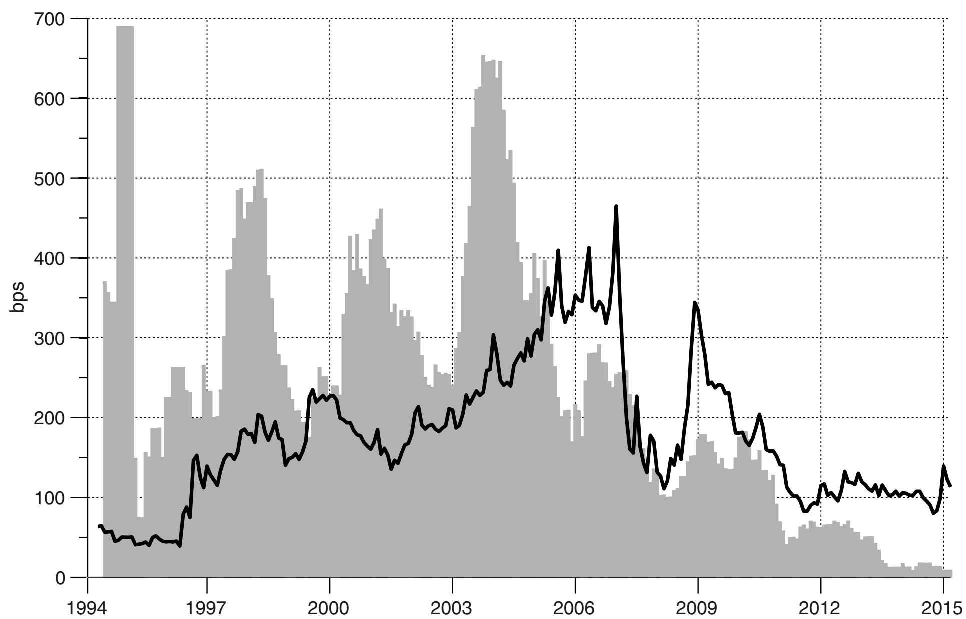


(c) Predicted default rates (line) vs. actual default rates (bars), horizon = 24 months

Figure B.6. (*Continued*)

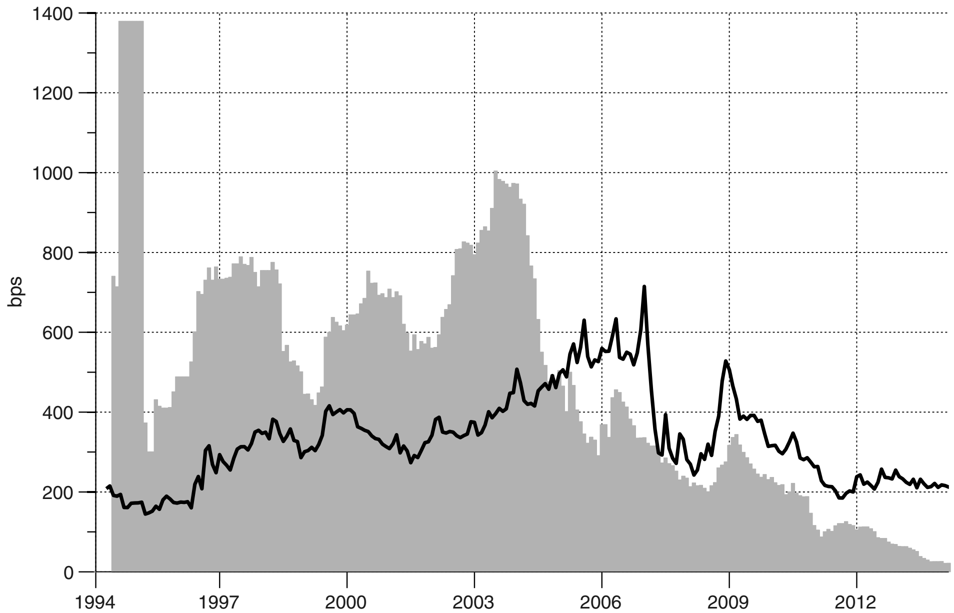


(a) Predicted default rates (line) vs. actual default rates (bars), horizon = 1 month



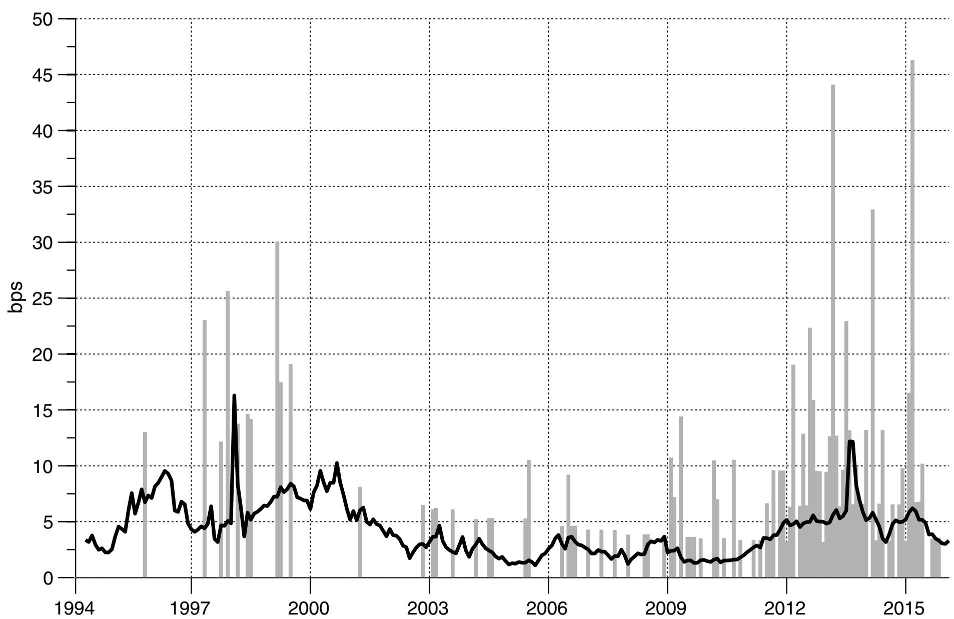
(b) Predicted default rates (line) vs. actual default rates (bars), horizon = 12 months

Figure B.7. Performance test for China, in sample.



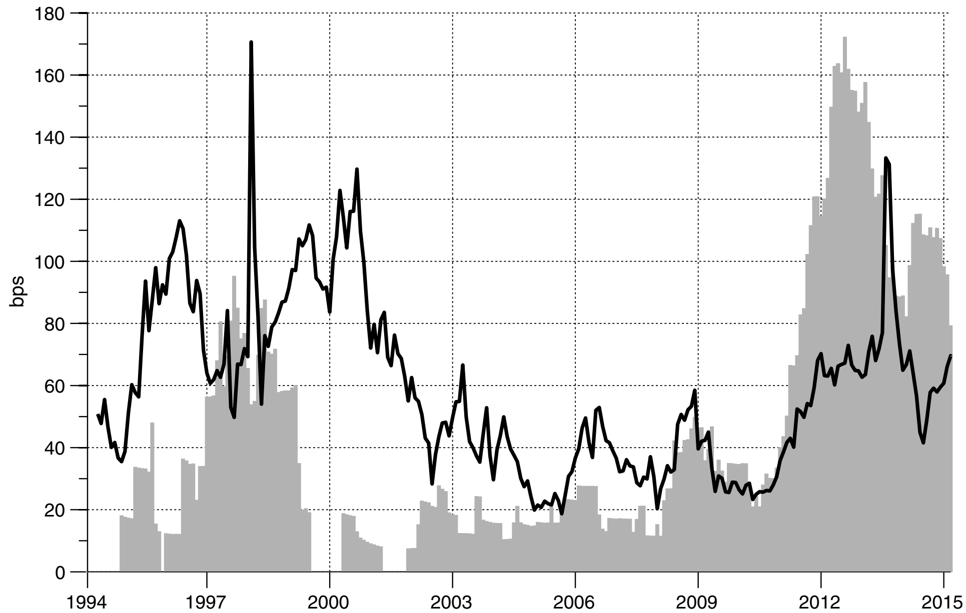
(c) Predicted default rates (line) vs. actual default rates (bars), horizon = 24 months

Figure B.7. (*Continued*)

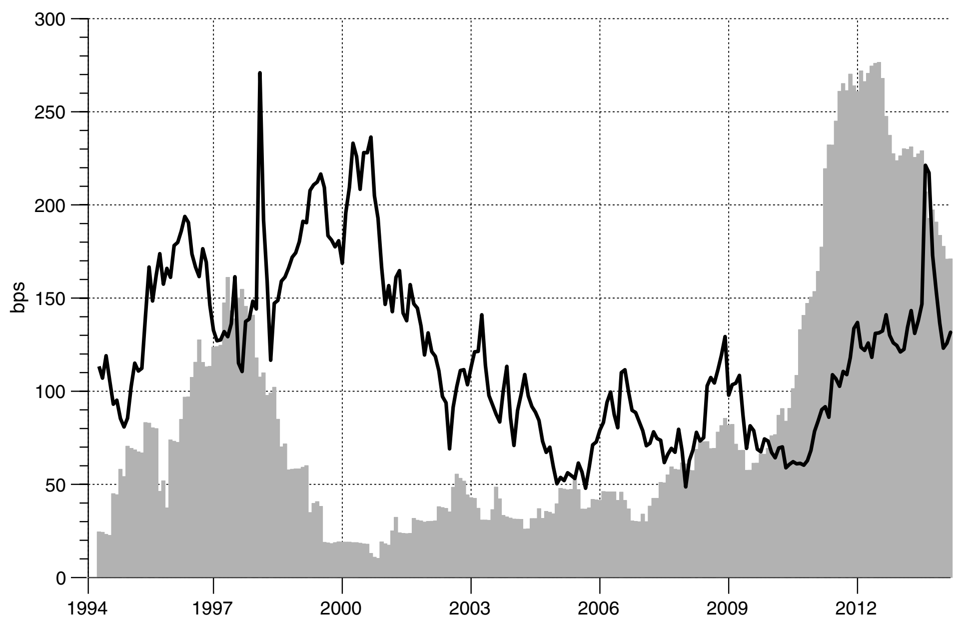


(a) Predicted default rates (line) vs. actual default rates (bars), horizon = 1 month

Figure B.8. Performance test for India, in sample.



(b) Predicted default rates (line) vs. actual default rates (bars), horizon = 12 months



(c) Predicted default rates (line) vs. actual default rates (bars), horizon = 24 months

Figure B.8. (*Continued*)

REFERENCES

Anderson, L., J. Sidenius and S. Basu (2003), All Your Hedges in One Basket. *Risk*, pp. 67–72.

Basel Committee on Banking Supervision (BCBS)(2005b) Studies on the Validation of Internal Rating Systems (revised), Working Paper No. 14.

Chopin, N. (2012), A Sequential Particle Filter Method for Static Models. *Biometrika*, 89, pp. 539–551.

CRI (2012), NUS-RMI Credit Research Initiative Technical Report. *Global Credit Review*, 2, pp. 109–167.

Crosbie, P. and J. Bohn (2003), Modeling Default Risk. Moody's KMV technical document.

Del Moral, P., A. Doucet and A. Jasra (2006), Sequential Monte Carlo Samplers. *Journal of Royal Statistical Society B*, 68, pp. 411–436.

Duan, J.-C. (1994), Maximum Likelihood Estimation Using Price Data of the Derivative Contract. *Mathematical Finance*, 4, pp. 155–167.

Duan, J.-C. (2000), Correction: Maximum Likelihood Estimation Using Price Data of the Derivative Contract. *Mathematical Finance*, 10, pp. 461–462.

Duan, J.-C. (2010), Clustered Defaults. National University of Singapore Working Paper.

Duan, J.-C. (2014), Actuarial Par Spread and Empirical Pricing of CDS by Decomposition. *Global Credit Review*, 04, pp. 51–65.

Duan, J.-C. and K. Shrestha (2011), Statistical Credit Rating Methods. *Global Credit Review*, pp. 43–64.

Duan, J.-C. and E. Van Laere (2012), A Public Good Approach to Credit Ratings From Concept to Reality. *Journal of Banking & Finance*, 36, pp. 3239–3247.

Duan, J.-C. and T. Wang (2012), Measuring Distance-to-Default for Financial and Non-Financial Firms. *Global Credit Review*, 02, pp. 95–108.

Duan, J.-C., J. Sun and T. Wang (2012), Multiperiod Corporate Default Prediction — A Forward Intensity Approach. *Journal of Econometrics*, 170, pp. 191–209.

Duan, J. C. and A. Fulop (2013), Multiperiod Corporate Default Prediction with the Partially-Conditioned Forward Intensity. National University of Singapore Working Paper.

Duffie, D., L. Saita and K. Wang (2007), Multi-Period Corporate Default Prediction with Stochastic Covariates. *Journal of Financial Economics*, 83, pp. 635–665.

Duffie, D., A. Eckner, G. Horel and L. Saita (2009), Frailty Correlated Default. *Journal of Finance*, pp. 2089–2123.

Kiefer, N. M., T. J. Vogelsang and H. Bunzel (2000), Simple Robust Testing of Regression Hypotheses. *Econometrica*, 68, pp. 695–714.

Merton, R. C. (1974), On the Pricing of Corporate Debt: The Risk Structure of Interest Rates. *Journal of Finance*, 29, pp. 449–470.

Nelson, C. R. and A. F. Siegel (1987), Parsimonious Modeling of Yield Curves. *Journal of Business*, 60, pp. 473–489.

Shao, X. (2010), A Self-Normalized Approach to Confidence Interval Construction in Time Series. *Journal of the Royal Statistical Society: Series B*, 72, pp. 343–366.

Shumway, T. (2001), Forecasting Bankruptcy More Accurately: A Simple Hazard Model. *Journal of Business*, 74, pp. 101–124.