Asia-Pacific Finan Markets
DOI 10.1007/s10690-017-9233-2

Assessing Corporate Vulnerabilities in Indonesia: A Bottom-Up Default Analysis

Ken Miyajima[1] · Jorge A. Chan-Lau[2] · Weimin Miao[3] · Jongsoon Shin[4]

Abstract Under adverse macroeconomic conditions, the potential realization of corporate sector vulnerabilities could pose major risks to the economy. This paper assesses corporate vulnerabilities in Indonesia by using a Bottom-Up Default Analysis (BuDA)

The authors are grateful to the Indonesian authorities for their thoughtful comments and suggestions. This paper benefitted from comments by L. Breuer, H. E. Khor, S. G. Toh, E. Loukoianova, R. Perrelli, C. Pouvelle, L. Ratnovski and seminar participants at Bank Indonesia and the IMF. The Credit Research Initiative (CRI) at the Risk Management Institute, National University of Singapore, kindly provided the computer programs used in the analysis. We would like to also thank the editor and the anonymous referees for their helpful comments. The views expressed herein are those of the authors and do not necessarily represent those of NUS and the RMI, the IMF, its Executive Board, or IMF management. Any errors or omissions are the authors' sole responsibility.

✉ Ken Miyajima
kmiyajima@imf.org

Jorge A. Chan-Lau
jchanlau@imf.org

Weimin Miao
miaoweimin@nus.edu.sg

Jongsoon Shin
JShin2@imf.org

1 Monetary and Capital Markets Department, International Monetary Fund, 700 19th St NW, Washington, DC 20431, USA

2 Institute for Capacity Development, International Monetary Fund, 700 19th St NW, Washington, DC 20431, USA

3 The Risk Management Institute, National University of Singapore, 21 Heng Mui Keng Terrace, I3 Building #04-03, Singapore 119613, Singapore

4 Asia Pacific Department, International Monetary Fund, 700 19th St NW, Washington, DC 20431, USA

Published online: 14 October 2017

approach, which allows projecting corporate probabilities of default (PDs) under different macroeconomic scenarios. In particular, a protracted recession and the ensuing currency depreciation could erode buffers on corporate balance sheets, pushing up the probabilities of default (PDs) in the corporate sector to the high levels observed during the Global Financial Crisis. While this is a low-probability scenario, the results suggest the need to closely monitor vulnerabilities and strengthen contingency plans.

Keywords Corporate sector · Bottom-up default analysis · Default risk · Scenario analysis · Simulation · Indonesia · Hazard rate models

JEL Classification C52 · C63 · G10

1 Introduction

There has been a steady rise in corporate debt in emerging markets (EMs) during the past decade. The trend accelerated in the aftermath of the Global Financial Crisis, as lower yields in advanced economies amid unconventional monetary policy increased investors' demand for EM assets, especially corporate debt. The corporate debt of non-financial firms across major emerging market economies quadrupled between 2004 and 2014 (International Monetary Fund 2015). A rapid build-up of leverage and subsequent deleveraging is, if an economy is buffeted by adverse economic shocks, a potential risk that requires a close monitoring by policy institutions (Acharya et al. 2015; International Monetary Fund 2015).

At the same time, the composition of corporate debt has shifted away from loans toward bonds in EMs. Greater leverage can be used for investment to boost economic growth but also raised concerns, particularly as financial crises in EMs have been preceded by rapid leverage growth. Rising leverage could expose corporates to interest rate and currency risks unless these positions are adequately hedged (Chui et al. 2014). The sheer variety of forms and channels for dollar borrowing can generate different vulnerabilities (McCauley et al. 2015).

Some of these vulnerabilities could be potentially present in the non-financial corporate sector in Indonesia. Indonesia's macroeconomic performance has moderated in the past several years, affected by ongoing shifts in the global economy related to lower growth and rebalancing in China and a severe down-cycle in commodity prices, which also had a negative impact on peer economies (Fig. 1). Real GDP growth is estimated to have decelerated from 6.4% year-on-year in 2010 to around 5% in 2016, notwithstanding a moderate rebound from 2015. The growth deceleration was due mainly to unfavorable commodity price developments, which have pushed the nation's export prices by nearly 15% from their peak in end-2013 and early-2014. Since 2014, the exchange rate has remained broadly unchanged in real effective terms but depreciated more than 10% against the U.S. dollar. Despite economic growth having moderated, corporate leverage increased in Indonesia, notably in foreign currency (FX).

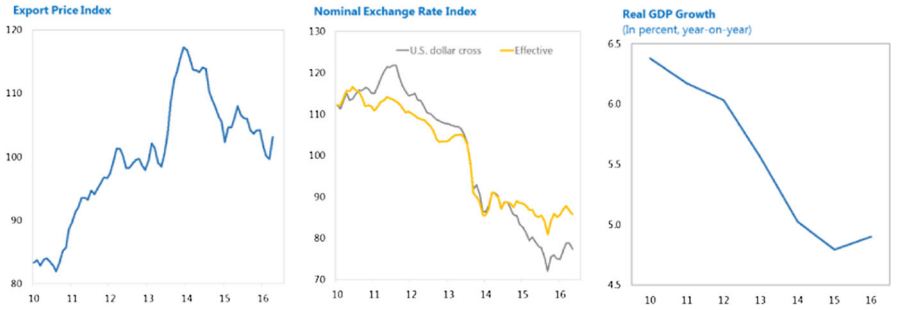

Fig. 1 Indonesia: indicators of external and real sector performance 1/. *Source*: Haver Analytics; and authors' calculations. 1/ Period average = 100 for export price and nominal exchange rate index

Against this backdrop, this paper assesses corporate sector vulnerabilities in Indonesia under plausible, low-probability adverse economic scenarios. The analysis relies on the Bottom-Up Default Analysis (BuDA) framework advanced by Duan et al. (2015), and currently implemented by the Credit Research Initiative at the Risk Management Institute, National University of Singapore. The BuDA framework exploits the information contained in equity prices together with balance-sheet indicators of profitability and liquidity, among others, to examine how macroeconomic conditions affect corporate probabilities of default (PDs). This approach complements those on debt service capacity (Chow 2015), and improves on other market-based approaches, such as that of Dwyer et al. (2004).

Our analysis suggests that risks in the corporate sector would be manageable in Indonesia even if the economy suffered very weak growth for a protracted period, accompanied by a large currency depreciation, owing to a relative low level of the aggregate corporate debt to GDP ratio. The qualitative assessment also indicates that on a system-wide basis, near-term refinancing risk is low. Moreover, the authorities have been proactively monitoring corporate vulnerabilities and encouraging proper currency risk management through the implementation of hedging regulations.

The remainder of the paper is organized as follows. Section 2 discusses key facts about the corporate sector by exploiting a range of macroeconomic and financial market data and by assessing debt repayment capacity. Section 3 describes the BuDA framework and Sect. 4 applies it to Indonesia. Section 5 concludes.

2 Corporate Performance and External Debt Risk in Indonesia

Indonesia's corporate sector is relatively strong and sound compared to its EM peers. First, aggregate corporate leverage is relatively low, evidenced by the fact that Indonesia's liabilities-to-asset ratio is below that of many EM corporates (Fig. 2). Many corporates in Indonesia also tend to rely on internal cash flows for funding rather than external financing. Second, corporate profitability is very high. Net income was about 14% of total assets in 2014, the highest among EM corporates (Fig. 2).

Nonetheless, risks started to emerge as FX denominated corporates debt increased rapidly over the past years. FX corporate debt (including that owned to domestic

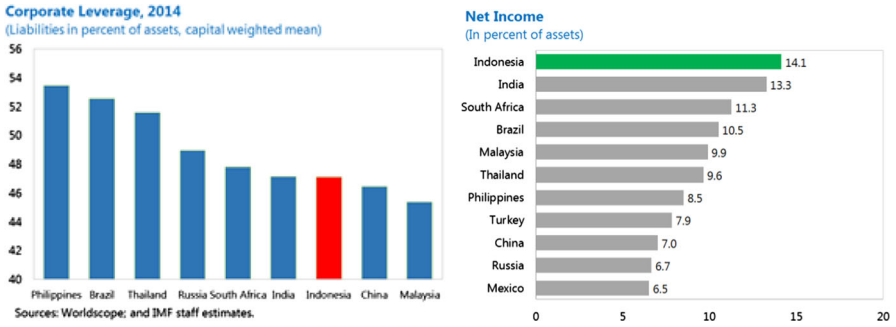

Fig. 2 Corporate leverage and profitability in emerging markets, 2014 1/. *Sources*: Worldscope; Bloomberg L.P.; Datastream; and authors' calculations. 1/ Net income of listed companies, capitalization-weighted average

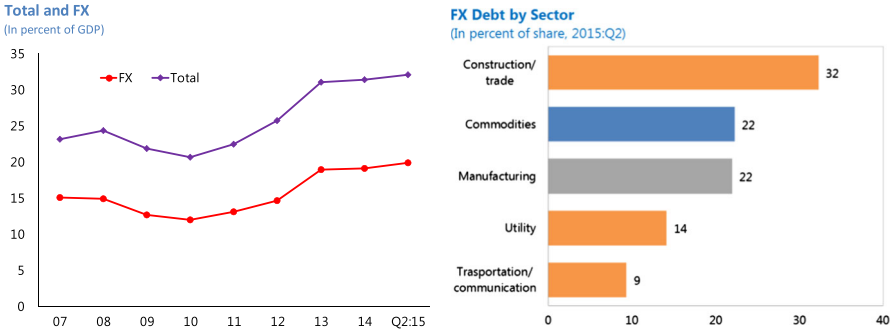

Fig. 3 Indonesia: corporate debt by currency and sector. *Sources*: Bank Indonesia; CEIC; and authors' calculations

banks) doubled from 2010, reaching around 20% of GDP in the second quarter of 2015 (Fig. 3). The level remains relatively low but the fast pace of increases could be a risk factor. Around 90% of debt securities issued in 2014 were FX denominated, and FX debt now accounts for around 60% of the total corporate debt. Looking at the distribution, FX corporate debt is concentrated in the commodities and selected non-tradable sectors (Fig. 3). FX debt issuance moderated in 2015, after supply (i.e., higher risk aversion towards EMs generally) and demand (i.e., weak private investment amid the prolonged commodity price down cycle) factors both weakened. However, external borrowing could accelerate, as infrastructure spending is expected to rise in the coming years, driven by the government's push for economic development.

Looking ahead, several risks need to be monitored carefully if commodity prices remain subdued and the rupiah weak. These are currency mismatches, refinancing risk, and default risk (Fig. 4).

- *Currency mismatches* While Bank Indonesia (BI)'s hedging regulations have helped corporates manage currency risk (see Box), a portion of the FX debt is estimated to be unhedged partly as hedge costs are generally high. Some corporates appeared to be using derivatives instruments which knock out if the rupiah

depreciates substantially, in which case FX exposure would jump, causing losses and potentially defaults.

- *Refinancing risk* Rollover needs of FX debt securities are set to rise in 2016 and a large proportion of maturing debt is leveraged or high-yield. The capacity of those corporates to rollover could be adversely affected by BI's new requirements that only corporates with investment grade credit ratings can issue FX debt starting from 2016. However, there are mitigating factors: two-thirds of non-bank private corporates' external debt maturing within a year is owned to affiliates and the rollover needs within a year appear manageable.
- *Default risks* The interest coverage ratio has fallen sharply. For a fifth of the sector, the interest coverage ratio fell below one.[1] Corporates in the resource sector were under the greatest pressure. This is mirrored in a recent rise in nonperforming loans (NPLs) and special mention loans in the banking system.

Box 1. Bank Indonesia's Foreign Exchange Regulations on Corporates

FX regulations. To encourage corporates with external debt to enhance risk management, BI introduced a set of prudential measures in October 2014.

- *Hedge ratio*. It is defined as the ratio of the total value hedged to the net short-term foreign liability position. The minimum hedge ratio is 20 percent in 2015 and 25 percent in 2016. It is applied to the net foreign currency liabilities with a maturity period up to three months, and those that mature between three and six months. Exemptions are made for export-oriented corporates—corporates with a ratio of export revenue to total revenue exceeding 50 percent in the previous calendar year—with financial statements issued in U.S. dollars.

Indonesia: Bank Indonesia's Foreign Exchange (FX) Regulations on Corporates

	Phase 1 2015	Phase 2 2016	Phase 3 2017 onwards
Object of regulation	Governs all foreign currency debt		
Hedge ratio ? 3 months 3-6 months	 20 percent 20 percent	 25 perent 25 percent	
Liquidity ratio (? 3 months)	50 percent	70 percent	
Credit rating	Not applicable	Minimum rating of BB-	
Counterpart of hedging transaction	Not necessarily be done with a bank in Indonesia		Must be done with a bank in Indonesia
Sanctions	As of 2015:Q4	Administrative sanctions will be imposed	

Source: Bank Indonesia.

- *Liquidity ratio.* It is the ratio of short-term foreign currency assets to short-term foreign currency liabilities. The minimum ratio is 50 percent in 2015 and 70 percent in 2016.
- *Credit rating requirement.* Nonbank corporates should have a credit rating of no less than BB or equivalent issued by an authorized rating agency, including Moody's (Ba3), S&P (BB-), and Fitch (BB-). The validity of the credit rating is up to two years. Corporates can use a parent company's credit rating for the external debt of parent companies or external debt secured by parent companies. Exemptions are made for external debt related to infrastructure projects, external debt secured by multilateral institutions, refinancing, and trade credit.

Reporting requirement. BI has strengthened monitoring of corporate external borrowing. Corporates with external borrowing should submit quarterly reports to BI, starting from 2015. The report covers a corporate's hedging ratio, liquidity ratio, and credit rating, and all supporting documentation.

Sanctions. To implement these regulations effectively, BI will impose administrative sanctions from 2016, in the form of warning letters to "related parties" in the transactions, including the lenders providing the non-compliant debt, the Ministry of Finance, the Minister of State Owned Enterprises (in the case of borrowers that are state-owned enterprises), the Financial Services Authority (OJK) and the Indonesia Stock Exchange (in the case of listed-company borrowers).

[1] The interest coverage ratio is earnings before interest and taxes (EBIT) over interest expenses for the same period. Bank Indonesia's analysis showed that interest coverage ratio was above one for all economic sectors, due likely to differences in methodology and data sources.

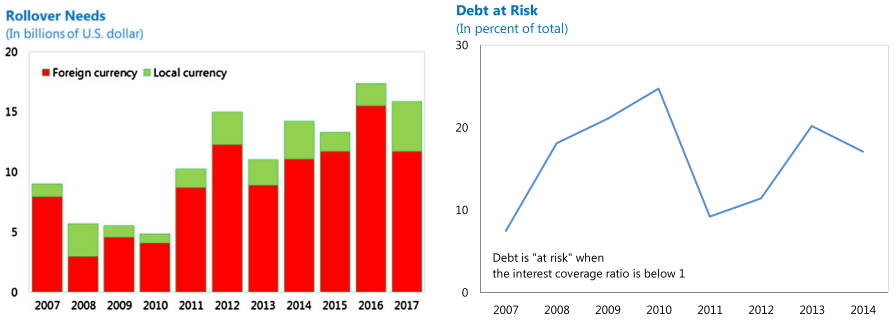

Fig. 4 Indonesia: corporate debt rollover needs and debt at risk. *Sources*: Bank Indonesia; Dealogic; Orbis; and authors' calculations

3 Bottom-Up Scenario Analysis of Corporate Default Probability

This section provides a bottom-up forward-looking assessment of corporate sector vulnerabilities. In a nutshell, corporate default probabilities are projected under different macroeconomic assumptions via both economy-wide and firm-specific risk factors selected as risk transmission channel. These risk factors are assumed to be influenced by the macroeconomic variables and serve as input to the forward intensity model to produce default probabilities of individual firms.

3.1 Projection of PDs Using the Bottom-Up Default Analysis (BuDA) Framework

PDs of individual firms under different macroeconomic scenarios are calculated upon the projection of economy-wide and firm-specific risk factors. The projection is obtained by BuDA, a Bottom-Up Default Analysis platform jointly developed by researchers from the Credit Research Initiative (CRI) at the Risk Management Institute, National University of Singapore (NUS-RMI) and the International Monetary Fund, with the active support of the CRI team (Duan et al. 2015). [2]

BuDA builds up on three key elements: (i) the forward intensity model of Duan et al. (2012) for multiperiod corporate default prediction; (ii) the stress-testing regression (risk-factor forecasting regression) and a sensible way of handling mix-frequency data for parameter estimation in Duan et al. (2014); and (iii) the CRI database of the economy-wide and firm-specific risk factors that covers over 60,000 exchange-listed firms in 119 economies.[3]

[2] The BuDA platform serves to support applied economic surveillance work. See for instance, Chapter 3 in International Monetary Fund (2015), and Chapter 2 in International Monetary Fund (2016).

[3] The firm-specific factors selected for BuDA provide the best fit to the data, among a large number of different firm-specific factors initially tested guided by theory and practice. While the paper focuses on 1-year ahead PDs, the model performs well in forecasting default events up to a 5-year horizon. The model maximizes a quasi-likelihood function calibrated using data for thousands of firms in EMs. Information on interconnectedness, which could be useful to further refine the model, is not available for all the countries and firms included in the estimation.

BuDA follows a two-step approach to project PDs of individual firms in a given economy and industrial sector:

- In the first step, conditional on the paths of the economic and financial variables included in the macroeconomic scenarios, BuDA simulates paths by using the estimated risk-factor forecasting regression model for a set of economy-wide and firm-specific risk factors proven effective for predicting default risk at the firm level.
- In the second step, conditional on the simulated paths of the risk factors, BuDA generates simulated paths for individual firm's PDs via the Duan–Sun–Wang (DSW) forward intensity model calibrated by the CRI.

The Matlab implementation of BuDA integrates the dataset and models' computation engines required in these two steps.

3.1.1 The Risk Factors

Results by Duan et al. (2012) narrow the choice of risk factors for default prediction in the United States to a set of twelve variables. These twelve variables are then used by the CRI default prediction system and have been proven very effective so far for economies around the world, including Indonesia. The economy-wide, common risk factors are the domestic stock index return, and a representative short-term interest rate. The remaining ten risk factors come from six firm-specific attributes, four of which are used in terms of both trend and cycle. Two firm-specific attributes are based on financial statements, namely liquidity and profitability. The other four are market-based, namely volatility-adjusted leverage,[4] relative size, market misevaluation, and idiosyncratic volatility. Table 1 presents all the risk factors used in BuDA.

Liquidity is measured as the ratio of cash and short-term investments to total assets; and profitability is measured as the ratio of net income to total assets. Both measures of liquidity and profitability use publicly available data and easy to construct. The measure of the volatility-adjusted leverage is the distance-to-default (DTD), estimated using the Merton-based structural default prediction model (1974) with the KMV assumption (Crosbie and Bohn 2003) on the debt maturity and size. In contrast to the traditional DTD, the one used in BuDA corrects for the higher leverage financial firms exhibit relative to non-financial firms, following Duan et al. (2012).

The relative size of the firm is set equal to the natural logarithm of the ratio of the market capitalization of the firm to the median market capitalization of the firms in the economy. Larger firms are less likely to default than smaller firms are. Market misvaluation is measured as the market-to-book asset ratio. Finally, the idiosyncratic volatility of a firm is set equal to the standard deviation of the residuals obtained after regressing a firm's equity returns on the returns of the domestic market index.

[4] See Duan et al. (2012) for detail on volatility-adjusted leverage.

Table 1 Common and firm-specific risk factors. *Source*: Authors

Description	Data generation 1/
Common	
Return on domestic stock market index	Raw observation
Short-term domestic interest rates	Raw observation
Firm-specific: financial statement-based	
Liquidity (cash and short-term investments/total assets)	Trend and cycle
Profitability (net income/total assets)	Trend and cycle
Firm-specific: market-based	
Distance to default (volatility-adjusted leverage) 2/	Trend and cycle
Size (market capitalization to median market capitalization)	Trend and cycle
Market misevaluation (market capitalization	Raw observation
Idiosyncratic volatility	Raw observation

1/ Trend represents the 12-month average. Cycle represents the difference between the raw observation and the 12-month average
2/ Using both financial statement and market-based information

3.1.2 The Risk-Factor Forecasting Regression

One of the features of the BuDA platform is a module that forecasts risk factors conditional on a set of macroeconomic and financial variables. To analyze corporate sector vulnerability, BuDA typically involves a large number of firms. Estimating individual equations for each firm-specific risk factor for each individual firm increases the dimension of parameters to very high levels. Instead of estimating individual equations, BuDA follows the two-stage regression approach in Duan et al. (2014) for forecasting firm-specific risk factors. In the first stage, it forecasts the average value of the firm-specific risk factor for all firms in a given industrial group of the economy using a regression of the form:

$$\Delta \bar{Y}_{i,j,t} = \beta^{Y}_{i,j,0} + \sum_{k=1}^{n} \beta^{Y}_{i,j,k} Z_{k,t} + \sum_{q=1}^{p} \gamma^{Y}_{i,j,q} \bar{Y}_{i,j,t-q} + \epsilon^{Y}_{i,j,t}, \tag{1}$$

where n is the number of economic and financial variables included in the regression; $\bar{Y}_{i,j,t}$ is the i-th country-industry average of the j-th firm-specific risk factor at time t; p is the number of lags of the independent variable included in the regression; $Z_{k,t}$ is the k-th economic or financial variable included in the macroeconomic scenario; Δ is the one-period difference operator; and $\epsilon^{Y}_{i,j,t}$ is the error term or innovation.[5]

[5] The country average factor in this paper is analogous to the market return in the CAPM model. For instance, in the CAPM model, the returns of an individual firm are regressed on the returns of the aggregated market, to which the individual firm contributes. In this case, for the risk factors, this paper uses the country average as a common risk factor, and model firm-specific deviations from it.

Similarly, the regression equations for the economy-wide factors in each economy are of the form:

$$\Delta X_{m,t} = \beta^X_{m,0} + \sum_{k=1}^{n} \beta^X_{m,k} Z_{k,t} + \sum_{q=1}^{p} \gamma^X_{m,q} X_{m,t-q} + \epsilon^X_{m,t}, \tag{2}$$

where $X_{m,t}$ is the m-th economy-wide risk factor, and $\epsilon^X_{m,t}$ is the error term or innovation.

Note that in Eqs. (1) and (2) the sample frequency of the risk factors is monthly while that of some of the economic variables is quarterly. It is not possible to use the mixed-data sampling (MIDAS) regression (Ghysels et al. 2007), since it does not accommodate the case of a dependent variable sampled at a higher frequency than the explanatory variables. A suitable interpolation converting data from quarterly to monthly could help but the estimation bias may arise. To mitigate the estimation bias, BuDA deduces from Eqs. (1) and (2) to a time-aggregated form that allows for maximum likelihood estimation.[6]

After estimating the time-aggregated form of Eqs. (1) and (2), the second stage involves modeling the difference between the value of the firm-specific risk factor of an individual firm and industry average. This difference, d, is given by:

$$d\left(Y^k_{i,j,t}, \bar{Y}_{i,j,t}\right) = Y^k_{i,j,t} - \bar{Y}_{i,j,t}, \tag{3}$$

where $Y^k_{i,j,t}$ denotes the value of the j-th firm-specific factor of firm k in the i-th industry, and $\bar{Y}_{i,j,t}$ denotes the i-th industry average value of the j-th firm-specific factor. BuDA assumes the difference follows an autoregressive process of order p, $AR\,(p)$, estimated over a two-year moving window. To reduce potential biases, BuDA uses the so-called LASSO-OLS hybrid to estimate the autoregressive process.[7] The LASSO-OLS hybrid uses LASSO for model selection and OLS for coefficient estimation.

3.2 The Duan–Sun–Wang (DSW) Forward Intensity Model

BuDA uses the DSW forward intensity model to calculate PDs of individual firms using the risk factors as input based on a forward time structure. The DSW model is a reduced form model, more specifically, a doubly stochastic Poisson intensity model

[6] See Duan et al. (2014) for details. The default settings in BuDA, used in our analysis, are 12-month aggregation, and the use of two lags of the dependent variable in Eqs. (1) and (2).

[7] The "LASSO-OLS hybrid" is originated from the "LARS-OLS hybrid" proposed by Efron et al. (2004), with the variable selection in the first step replaced from LARS to LASSO. LARS is short for least angle regression, an efficient model selection algorithm; while LASSO is short for least absolute shrinkage and selection operator, a model selection method. A simple modification of the LARS implements the LASSO. BuDA uses AR (3) by default.

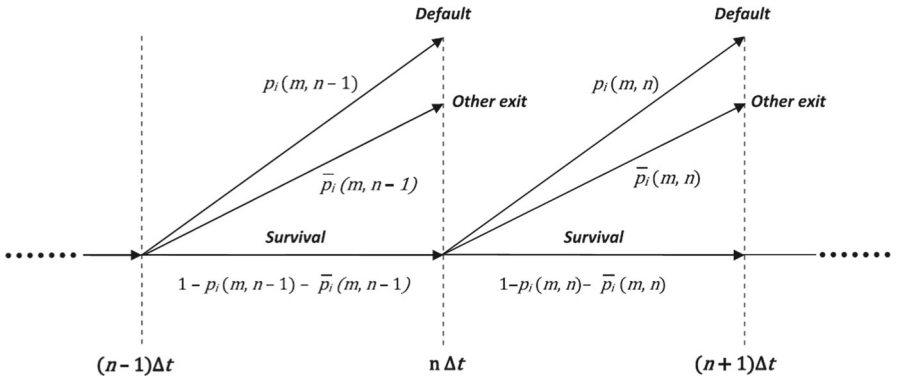

Fig. 5 Survival tree for firm i, viewed from time $t = m\Delta t$. *Source*: Authors

operating on forward time instead of spot time as in Duffie et al. (2007).[8] It has the advantage, however, of not having to introduce an auxiliary model for state variables, which inevitably has a dimensionality many times higher than the number of firms. In short, the DSW model allows predicting the PD of a firm at different horizons using only as inputs the current value of the risk factors at the time of default prediction.

Contrary to earlier default prediction models, the DSW model takes into account a firm's exit for reasons other than default such as merges and acquisitions. This is an important but somewhat neglected feature: the "survival" of a public firm requires that the firm remains listed in the exchange and has not defaulted. Since exit for other reasons greatly exceeds the number of defaults, an accurate default prediction model should accommodate the two competing risks of both default and other exit.

The default and other exit are modeled using two independent Poisson processes, each with their own intensity function where the risk factors serve as inputs. This assumption allows for the realization of only one of three possible states at any point in time: survival, default, or other exit.[9]

Figure 5 illustrates the modelling strategy in a discrete time framework, where $p_i\ (m, n-1)$ and $\bar{p}_i\ (m, n-1)$ are the probabilities that the firm exits due to default or other reasons between periods $(n-1)\ \Delta t$ and $n\ \Delta t$, respectively. These two probabilities are conditional on information only available at the end of the m-th period. The figure highlights the dependence on past probabilities. For instance, the probability that the firm defaults between periods $(n-1)\ \Delta t$ and $n\ \Delta t$ measured at time $m\Delta t$ is:

[8] See Duffie and Singleton (2003), Lando (2004) and Bielecki and Rutkowski (2004) for an extensive treatment of mathematical credit risk.

[9] Default and other exits are competing as opposed to independent risks, as both events are mutually exclusive. When modeled as two independent processes, the probability of their joint occurrence happens to equal zero, which blurs the distinction between competing and independent risks. Hence, the modeling assumption of two doubly stochastic Poisson processes appears acceptable, as first introduced by Duffie et al. (2007); and adopted by Duan et al. (2012), whose model this paper uses. The interested reader is referred to these two publications for further details.

$$\text{Prob}_{t=m\Delta t}\left[\tau_i = n, \tau_i < \bar{\tau}_i\right] = p_i\left(m, n-1\right)\prod_{j=m}^{n-2}\left[1 - p_i\left(m, j\right) - \bar{p}_i\left(m, j\right)\right], \quad (4)$$

where τ_i and $\bar{\tau}_i$ are the default time and other exit time measured in months. The cumulative default probability of defaulting at or before $n\,\Delta t$ at time $m\,\Delta t$ is:

$$\text{Prob}_{t=m\Delta t}\left[m < \tau_i \le n, \tau_i < \bar{\tau}_i\right] = \sum_{k=m}^{n-1}\left\{p_i\left(m, k\right)\prod_{j=m}^{k-1}\left[1 - p_i\left(m, j\right) - \bar{p}_i\left(m, j\right)\right]\right\}. \quad (5)$$

Note that these formula implies that the firm continues to be listed, which yields $p_i\left(m, m-1\right) = 0$, and $\bar{p}_i\left(m, m-1\right) = 0$.

For modeling purposes, the conditional probabilities of default and other exit are functions of their forward intensities, $h_i\left(m, n\right)$ and $\bar{h}_i\left(m, j\right)$, respectively:

$$p_i\left(m, n\right) = 1 - \exp\left[-\Delta t\, h_i\left(m, n\right)\right], \quad (6)$$

$$\bar{p}_i\left(m, n\right) = \exp\left[-\Delta t\, h_i\left(m, n\right)\right]\left[1 - \exp\left[-\Delta t\, \bar{h}_i\left(m, n\right)\right]\right], \quad (7)$$

and where the forward intensities are exponentials of an affine function of the risk factors:

$$h_i\left(m, n\right) = \exp\left[\beta\left(n - m\right).Z_i\left(m\right)\right], \quad (8)$$

$$\bar{h}_i\left(m, n\right) = \exp\left[\bar{\beta}\left(n - m\right).Z_i\left(m\right)\right], \quad (9)$$

and $\beta\left(n - m\right)$ and $\bar{\beta}\left(n - m\right)$ are coefficient vectors dependent on the number of months between the observation date and the beginning of the forward period $(n - m)$, and $Z_i\left(m\right)$ is a vector collecting the economy-wide and firm specific risk factors together with a unit vector, i.e. $Z_i\left(m\right) = \left(1, X\left(m\right), Y_i\left(m\right)\right)$. Note that these coefficients are not the ones corresponding to Eqs. (1) and (2).

BuDA estimates PDs for horizons ranging from 1 to 60 months, which requires estimating one set of coefficients β and $\bar{\beta}$, for each horizon, for sixty sets, one for each horizon. To keep the estimation tractable, the coefficients are constrained to follow Nelson–Siegel functional form of the forward-starting time. The sequential Monte Carlo pseudo-Bayesian estimation method developed in Duan and Fulop (2013) yields the parameters after pooling firms together in combined geographical regions, based on similar stages of development and geographical location. For example, in the case of Latin American economies, the estimation of the model uses pooled data including firms in the region as well as in emerging Asia Pacific, the Middle East, and Africa. For details on the estimation method and individual economies included in the estimation groups, see RMI-CRI (2015).

3.3 The Simulation-Based Projection of PDs

BuDA simulates PD projections for different horizons covered by the macroeconomic scenarios. Conditional on the path of the macroeconomic scenarios, the simulation

Table 2 Data for simulating corporate PDs in Indonesia. *Sources*: NUS and authors

Macroeconomic variables	Firm-specific risk factors
Real GDP growth	Distance to default
Unemployment rate	Liquidity (cash/total assets)
CPI inflation	Profitability (net income/total assets)
Nominal effective exchange rate	Size (relative to median)
Short-term interest rate	Market-to-book value
Common risk factors	Idiosyncratic volatility
Jakarta composite index	
SBI yield, 3 months	

generated 1000 realizations of the PDs of the individual firms considered in the sample. To generate these paths, estimated Eqs. (1) and (2) are used to generate paths of the firm-specific and economy-wide risk factors.

For each industry of the economy, a single realization of the industry average firm-specific risk factor was obtained after drawing a random realization of the error terms in the corresponding set of equations. Once the path of the industry average firm-specific risk factor was fixed, Eq. (3) was used to obtain the path of the firm-specific risk factors for individual firms. Similarly, to obtain one conditional path for the economy-wide risk factors, a random realization was drawn of the error terms in Eq. (2).

The simulated paths of the risk factors are used as an input to the DSW forward intensity model to generate PD projections for individual firms. For each round of simulation, BuDA calculates the median of the PDs for the sample of firms, and then reports its average across simulations, as well as other percentiles. The calculations reported here use the average value of median PD projections. The accuracy of the PD model in predicting future corporate defaults in EMs is high.[10]

4 Case Study: Indonesia

The variables used for the scenario analysis for Indonesia are summarized in Table 2. Macroeconomic conditions are characterized by variables commonly used in the literature of stress testing. GDP growth proxies for the growth in incomes and earnings of firms. The unemployment rate affects the consumption and spending of households and in turn corporate sales. Inflation can signal macroeconomic uncertainty, as high inflation raises costs and impairs credit quality but also reduces real debt burden. Exchange rate performance affects firms through net exports and balance sheet channels. Short-term interest rates are an indicator of the cost of funding for corporates. Common risk factors are the domestic equity price index and short-term interest rates,

[10] The predictive accuracy of the PD model for corporate defaults in EMs over a 1-year horizon is 77%, if the accuracy ratio is used, and 89% percent, if the area under the receiver operating characteristic curve is used. A perfect predictive model would score 100% under both measures, and an uninformative model 50%.

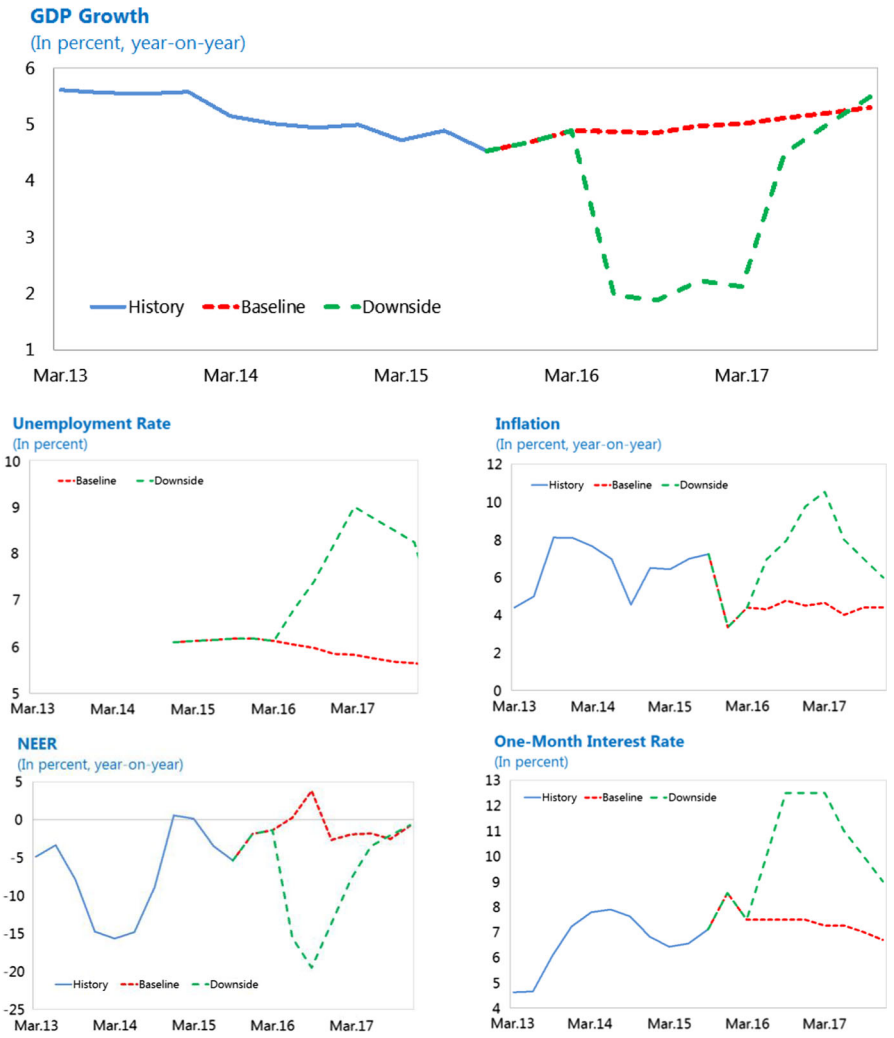

Fig. 6 Projected macroeconomic variables. *Sources*: CEIC; and authors' estimates

which define the market conditions and in turn affect the state of individual firms. Firm specific factors for more than 400 corporates (both financial and nonfinancial) capture characteristics including liquidity, profitability, and size.

The simulation starts by assuming two different paths of quarterly macroeconomic variables through 2017 (Fig. 6).

- The baseline scenario assumes GDP growth would moderately increase to around 5.3%. The unemployment rate would decline gradually to 5.7%, while inflation would fall to 4.4% year-on-year. The rupiah's movement would range between −3 and 4% year-on-year every quarter. The 1-month JIBOR interest rate would decline moderately to 6.7%.

Table 3 Common risk regression estimates (p-values in parentheses). *Source*: Authors

	Stock market return, one-year trailing returns	Short term interest rate
Constant	0.049	−0.421
	(0.003)	(0.100)
GDP growth	−0.026	−0.189
	(0.219)	(0.066)
Unemployment	−0.101	1.135
	(0.768)	(0.481)
Inflation	−0.023	0.531
	(0.007)	(1.302)
NEER	0.080	−0.052
	(0.207)	(0.006)
One-month interest rate	−0.206	0.012
	(0.003)	(0.126)
R-squared	0.597	0.421

- The downside scenario is characterized by a sharp drop in GDP growth to below 2% year-on-year. The unemployment rate would jump to 9% and return to somewhat above 8%. Inflation would surge to above 10% on account of exchange rate pass-through before returning to 6%. The rupiah would depreciate by 14–20% year-on-year for three quarters. The JIBOR interest rate would jump to exceed 12% for three quarters and return to 9%.

Conditional on the path of the macroeconomic variables, the simulation generated 1000 paths for the firm specific and common risk factors using estimates of Eqs. (1) and (2) respectively. Equation (1), which corresponds to the firm-specific risk factors, is estimated separately for each risk factor in different business sectors. The only exception is the equation for idiosyncratic volatility in the diversified, technology, and utilities sectors, where lack of sufficient data required pooling together the data in the three sectors. Tables 3 and 4 present the results of the estimations.

Several key observations emerge from estimated results.

- First, the firm-specific factors may have recently taken less supportive values than in previous periods after growth slowdown and rupiah depreciation have weakened corporate balance sheet conditions amid rising corporate foreign currency leverage. Under the baseline scenario, the median corporate PD is projected to rise to levels somewhat higher than those during the taper tantrum in 2013 and to moderate somewhat toward the end of 2017 (Fig. 7, upper panel, red broken line). This is the case despite projected macro fundamentals being broadly comparable to those in 2013—GDP growth is somewhat lower, but the rupiah's performance is more favorable and inflation is lower.
- Second, weaker macroeconomic performance would naturally lift corporate PD to higher levels. The median PD under the downside scenario would rise to about one half of the maximum registered during the Lehman crisis (Fig. 7, upper panel,

Table 4 Firm-specific risk factor regression estimates, by sector (*p*-values in parentheses). *Source*: Authors

	Firm-specific risk factor					
	Distance to default	Liquidity	Profitability	Relative size	Market valuation	Idiosyncratic volatility
Sector: basic materials						
Constant	0.057	0.000	0.000	−0.015	0.077	0.009
	(0.008)	(0.452)	(0.440)	(0.624)	(0.002)	(0.000)
GDP growth	0.042	0.001	0.000	−0.002	−0.004	−0.007
	(0.308)	(0.262)	(0.351)	(0.613)	(0.348)	(0.000)
Unemployment	−0.282	−0.011	−0.002	0.046	−0.097	0.003
	(0.102)	(0.125)	(0.087)	(0.857)	(0.173)	(0.608)
Inflation	−0.013	0.001	0.000	0.001	−0.004	0.001
	(0.039)	(0.102)	(0.616)	(0.702)	(0.150)	(0.086)
NEER	0.019	−0.027	0.025	−0.277	0.114	0.048
	(0.421)	(0.526)	(0.652)	(0.000)	(0.054)	(0.331)
One-month interest rate	−0.065	0.007	−0.204	0.226	−0.187	−0.084
	(0.960)	(0.854)	(0.001)	(0.000)	(0.005)	(0.138)
R-squared	0.342	0.222	0.493	0.246	0.352	0.449
Sector: communications						
Constant	0.219	0.008	0.001	0.064	0.143	0.011
	(0.027)	(0.479)	(0.006)	(0.136)	(0.047)	(0.006)
GDP growth	0.053	0.002	0.000	−0.036	−0.006	−0.003
	(0.735)	(0.173)	(0.599)	(0.328)	(0.333)	(0.370)
Unemployment	0.193	0.011	0.002	−0.006	0.105	−0.008
	(0.448)	(0.675)	(0.170)	(0.752)	(0.639)	(0.386)
Inflation	−0.067	0.000	0.000	0.008	−0.019	−0.002
	(0.026)	(0.857)	(0.210)	(0.522)	(0.043)	(0.185)
NEER	−0.042	−0.177	−0.082	−0.327	−0.082	0.182
	(0.331)	(0.075)	(0.132)	(0.000)	(0.409)	(0.047)
One-month interest rate	−0.030	0.114	−0.264	0.271	−0.011	−0.234
	(0.979)	(0.267)	(0.009)	(0.000)	(0.820)	(0.009)
R-squared	0.314	0.359	0.662	0.387	0.548	0.326
Sector: consumer cyclicals						
Constant	0.043	0.005	0.000	−0.022	0.057	0.009
	(0.095)	(0.002)	(0.385)	(0.275)	(0.006)	(0.004)
GDP growth	0.046	0.000	0.000	−0.001	0.001	−0.005
	(0.079)	(0.965)	(0.067)	(0.737)	(0.922)	(0.000)
Unemployment	−0.209	0.009	−0.002	0.161	−0.012	0.003
	(0.228)	(0.028)	(0.100)	(0.636)	(0.578)	(0.954)
Inflation	−0.010	0.000	0.000	−0.004	−0.003	0.001
	(0.253)	(0.392)	(0.844)	(0.744)	(0.330)	(0.137)

Table 4 continued

	Firm-specific risk factor					
	Distance to default	Liquidity	Profitability	Relative size	Market valuation	Idiosyncratic volatility
NEER	−0.022	−0.005	0.010	−0.249	0.001	0.216
	(0.202)	(0.952)	(0.78)	(0.000)	(0.947)	(0.000)
One-month interest rate	−0.011	−0.060	−0.128	0.178	−0.050	−0.254
	(0.429)	(0.302)	(0.036)	(0.003)	(0.407)	(0.000)
R-squared	0.250	0.306	0.497	0.324	0.237	0.390
Sector: consumer non-cyclicals						
Constant	0.086	0.005	0.000	0.050	0.067	0.008
	(0.045)	(0.002)	(0.201)	(0.009)	(0.026)	(0.000)
GDP growth	0.060	0.001	0.001	0.024	0.007	−0.006
	(0.177)	(0.782)	(0.007)	(0.075)	(0.994)	(0.000)
Unemployment	−0.151	0.000	−0.001	0.120	−0.062	0.004
	(0.589)	(0.405)	(0.373)	(0.280)	(0.322)	(0.626)
Inflation	−0.013	0.000	0.000	−0.009	−0.001	0.001
	(0.128)	(0.272)	(0.365)	(0.175)	(0.618)	(0.111)
NEER	−0.010	−0.106	−0.070	−0.241	−0.095	0.181
	(0.433)	(0.052)	(0.347)	(0.000)	(0.310)	(0.000)
One-month interest rate	−0.024	0.047	−0.023	0.159	0.046	−0.223
	(0.716)	(0.398)	(0.653)	(0.017)	(0.694)	(0.000)
R-squared	0.265	0.341	0.433	0.423	0.218	0.486
Sector: diversified						
Constant	0.052	0.005	0.000	0.007	0.069	0.009
	(0.062)	(0.014)	(0.431)	(0.525)	(0.001)	(0.000)
GDP growth	0.048	0.000	0.000	0.015	−0.001	−0.006
	(0.081)	(0.544)	(0.065)	(0.134)	(0.742)	(0.000)
Unemployment	−0.147	−0.001	−0.002	0.051	−0.044	0.006
	(0.429)	(0.921)	(0.092)	(0.977)	(0.213)	(0.721)
Inflation	−0.010	0.000	0.000	0.001	−0.003	0.001
	(0.161)	(0.624)	(0.359)	(0.883)	(0.199)	(0.325)
NEER	0.015	−0.028	−0.008	0.015	0.106	0.298
	(0.725)	(0.705)	(0.985)	(0.727)	(0.080)	(0.000)
One-month interest rate	−0.049	−0.029	−0.084	−0.085	−0.165	−0.337
	(0.925)	(0.622)	(0.162)	(0.239)	(0.007)	(0.000)
R-squared	0.259	0.165	0.459	0.352	0.258	0.532
Sector: energy						
Constant	0.070	0.004	0.000	0.008	0.098	0.010
	(0.082)	(0.111)	(0.898)	(0.344)	(0.009)	(0.013)

Table 4 continued

	Firm-specific risk factor					
	Distance to default	Liquidity	Profitability	Relative size	Market valuation	Idiosyncratic volatility
GDP growth	0.185	−0.001	0.001	−0.008	0.047	−0.008
	(0.343)	(0.865)	(0.797)	(0.694)	(0.545)	(0.050)
Unemployment	−0.208	−0.013	−0.003	−0.174	−0.281	0.040
	(0.498)	(0.234)	(0.082)	(0.185)	(0.042)	(0.016)
Inflation	−0.046	0.000	0.000	0.001	0.007	0.001
	(0.097)	(0.623)	(0.743)	(0.520)	(0.890)	(0.056)
NEER	−0.010	−0.069	−0.037	−0.263	−0.267	−0.112
	(0.514)	(0.428)	(0.469)	(0.000)	(0.000)	(0.355)
One-month interest rate	−0.050	0.026	−0.037	0.222	0.177	0.074
	(0.216)	(0.742)	(0.704)	(0.002)	(0.018)	(0.709)
R-squared	0.3519	0.1977	0.4236	0.2319	0.3614	0.3779
Sector: financials						
Constant	0.050	0.005	0.000	0.017	0.089	0.010
	(0.097)	(0.029)	(0.765)	(0.279)	(0.000)	(0.001)
GDP growth	0.033	0.000	0.000	0.022	0.001	−0.007
	(0.265)	(0.782)	(0.266)	(0.167)	(0.905)	(0.000)
Unemployment	−0.191	−0.005	−0.002	−0.093	−0.059	0.014
	(0.577)	(0.471)	(0.082)	(0.174)	(0.082)	(0.556)
Inflation	−0.012	0.000	0.000	0.002	−0.002	0.001
	(0.193)	(0.963)	(0.231)	(0.998)	(0.201)	(0.202)
NEER	0.012	−0.035	−0.044	−0.108	0.026	0.263
	(0.866)	(0.833)	(0.619)	(0.115)	(0.635)	(0.000)
One-month interest rate	−0.046	−0.022	−0.039	0.022	−0.111	−0.300
	(0.582)	(0.691)	(0.518)	(0.574)	(0.065)	(0.000)
R-squared	0.213	0.018	0.461	0.403	0.334	0.459
Sector: industrials						
Constant	0.057	0.006	0.000	−0.002	0.088	0.009
	(0.054)	(0.122)	(0.355)	(0.883)	(0.002)	(0.003)
GDP growth	0.049	0.001	0.000	0.012	−0.003	−0.006
	(0.196)	(0.445)	(0.084)	(0.584)	(0.649)	(0.000)
Unemployment	−0.239	−0.001	−0.002	0.279	−0.069	0.006
	(0.220)	(0.615)	(0.124)	(0.016)	(0.302)	(0.901)
Inflation	−0.009	0.000	0.000	−0.003	−0.004	0.000
	(0.264)	(0.813)	(0.258)	(0.397)	(0.256)	(0.458)
NEER	0.015	−0.027	−0.019	−0.351	0.045	0.194
	(0.896)	(0.812)	(0.871)	(0.000)	(0.326)	(0.000)

Table 4 continued

	Firm-specific risk factor					
	Distance to default	Liquidity	Profitability	Relative size	Market valuation	Idiosyncratic volatility
One-month interest rate	−0.049	−0.044	−0.091	0.189	−0.118	−0.232
	(0.683)	(0.642)	(0.151)	(0.006)	(0.051)	(0.000)
R-squared	0.235	0.230	0.452	0.450	0.307	0.386
Sector: technology						
Constant	0.239	0.032	0.000	0.017	0.170	0.009
	(0.524)	(0.088)	(0.665)	(0.516)	(0.007)	(0.000)
GDP growth	0.517	0.003	0.000	−0.109	−0.078	−0.006
	(0.957)	(0.892)	(0.631)	(0.792)	(0.335)	(0.000)
Unemployment	9.206	−0.045	−0.005	−0.201	−0.263	0.006
	(0.974)	(0.994)	(0.250)	(0.685)	(0.128)	(0.721)
Inflation	0.215	0.001	0.001	−0.009	0.000	0.001
	(0.379)	(0.904)	(0.036)	(0.557)	(0.931)	(0.325)
NEER	−0.177	−0.149	−0.041	−0.138	0.335	0.298
	(0.904)	(0.233)	(0.441)	(0.322)	(0.509)	(0.000)
One-month interest rate	0.002	−0.011	−0.127	0.060	−0.448	−0.337
	(0.566)	(0.879)	(0.686)	(0.799)	(0.787)	(0.000)
R-squared	0.528	0.466	0.230	0.577	0.534	0.532
Sector: utilities						
Constant	0.052	0.005	0.000	0.007	0.069	0.009
	(0.062)	(0.014)	(0.431)	(0.525)	(0.001)	(0.000)
GDP growth	0.048	0.000	0.000	0.015	−0.001	−0.006
	(0.081)	(0.544)	(0.065)	(0.134)	(0.742)	(0.000)
Unemployment	−0.147	−0.001	−0.002	0.051	−0.044	0.006
	(0.429)	(0.921)	(0.092)	(0.977)	(0.213)	(0.721)
Inflation	−0.010	0.000	0.000	0.001	−0.003	0.001
	(0.161)	(0.624)	(0.359)	(0.883)	(0.199)	(0.325)
NEER	0.015	−0.028	−0.008	0.015	0.106	0.298
	(0.725)	(0.705)	(0.985)	(0.727)	(0.080)	(0.000)
One-month interest rate	−0.049	−0.029	−0.084	−0.085	−0.165	−0.337
	(0.925)	(0.622)	(0.162)	(0.239)	(0.007)	(0.000)
R-squared	0.259	0.165	0.459	0.352	0.258	0.532

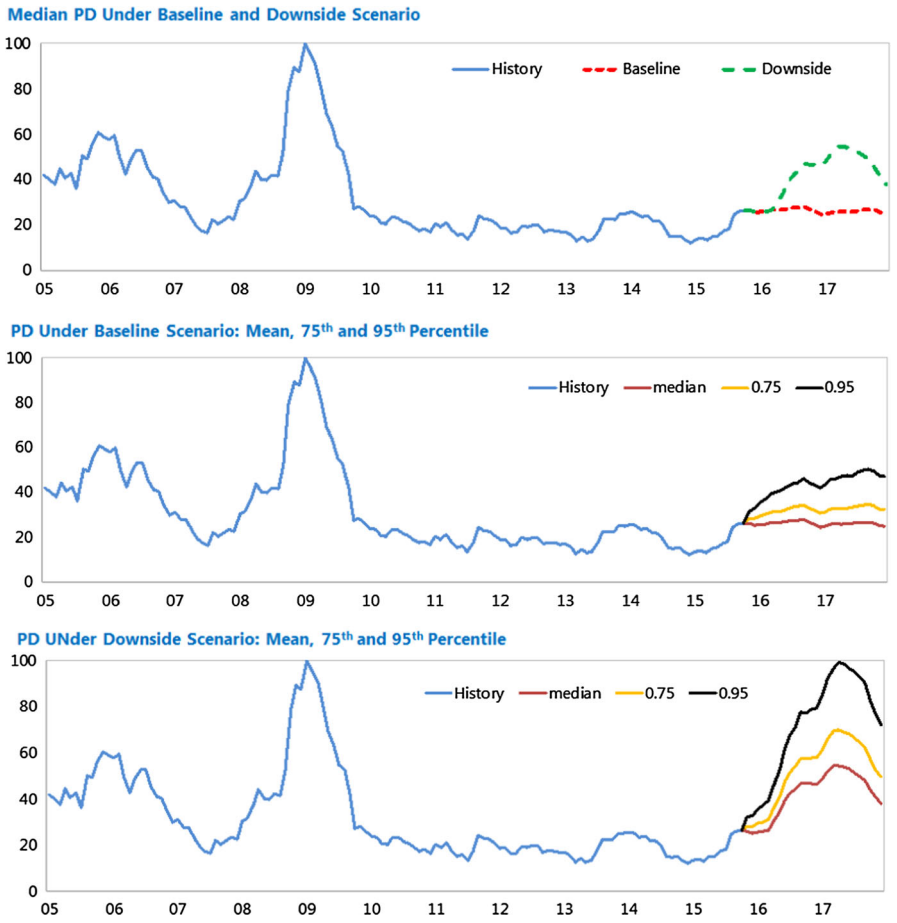

Fig. 7 Indonesia: GDP growth and corporate default probability (Lehman peak = 100). *Sources*: Authors' estimates

green solid line). This reflects a sharp GDP growth slowdown and deterioration in other macro variables. However, the PD would decline as economic activity regains momentum.

- Third, corporate distress can worsen materially if weak macroeconomic performance is accompanied by severe financial market jitters. Under the downside scenario, the 95th percentile estimate, with remote chance of occurrence, rises to very close to the maximum registered during the global financial crisis (Fig. 7, lower panel, light green broken line). It has been well documented that cross-border spillovers of a negative shock could be large in an environment of elevated uncertainty and financial market volatility. Under such circumstances, what is considered as a low-probability outcome (with a high impact) could become a real threat.

5 Concluding Remarks

Overall, the risk from the corporate sector remains manageable in Indonesia and the authorities have strengthened the framework to monitor corporate vulnerabilities. The aggregate corporate debt-to-GDP ratio remains low, and, on a system wide basis, near-term refinancing risk appears moderate. The authorities are monitoring corporate vulnerabilities closely, and the implementation of the BI's hedging regulations has helped corporates manage currency risks. The authorities' ongoing work to upgrade the framework and inter-agency coordination on corporate surveillance is also moving in the right direction.

Nonetheless, close monitoring and granular analysis of maturing FX debt are warranted. Even though the overall risk of the corporate sector is manageable, in the past a group of corporates faced heightened debt risks, some of which are connected to large business groups. Close monitoring, therefore, would be needed of corporates with FX debt and rupiah income, as well as those with unhedged, non-affiliated, or maturing FX debt, together with bank linkages. Strengthening of policy coordination should also continue, coupled with data analysis to assess the dimensions of the debt problems of specific corporates in vulnerable groups. The authorities should consider reviewing the corporate resolution framework (including the bankruptcy regime) to ensure that it is capable of dealing with large and systemically connected conglomerates. In the medium-term, deeper financial markets will help reduce the costs of hedging and develop domestic corporate bond issuance and trading.

References

Acharya, V. et al. (2015). *Corporate debt in emerging economies: A threat to financial stability*, Report by the Committee on International Economic Policy and Reform Brookings Institute. Washington: Brookings Institution.

Bielecki, T., & Rutkowski, M. (2004). *Credit risk*. Berlin: Springer.

Chow, J. (2015). Stress testing corporate balance sheets in emerging economies, IMF Working Paper No. 15/216 (Washington: International Monetary Fund).

Chui, M., Fender, I., & Sushko, V. (2014). Risks related to EME corporate balance sheets: The role of leverage and currency mismatch. BIS Quarter Review (September). http://www.bis.org/publ/qtrpdf/r_qt1409f.htm.

Crosbie, P. J., & Bohn, J. R. (2003). *Modeling default risk: Modeling methodology* (United Kingdom: Moody's KMV Company). Available via the Internet: http://www.macs.hw.ac.uk/mcneil/F79CR/Crosbie_Bohn.pdf.

Duan, J. C., & Fulop, A. (2013). Multiperiod corporate default prediction with partially-conditioned forward intensity. RMI Working Paper No. 12/04 (Singapore: National University of Singapore, Risk Management Institute).

Duan, J. C., Miao, W., & Chan-Lau, J. A. (2015). BuDA: A bottom-up default analysis tool (Unpublished; Risk Management Institute. National University of Singapore and International Monetary Fund).

Duan, J. C., Miao, W., & Wang, T. (2014). Stress testing with a bottom-up corporate default prediction model, RMI Working Paper (Singapore: Risk Management Institute, National University of Singapore). Available via the Internet: http://www.rmi.nus.edu.sg/duanjc/index_files/files/CreditStressTesting_Aug-5-2014.pdf

Duan, J. C., Sun, J., & Wang, T. (2012). Multiperiod corporate default prediction—A forward intensity approach. *Journal of Econometrics*, *170*, 191–209.

Duan, J. C., & Wang, T. (2012). Measuring distance-to-default for financial and nonfinancial firms. *Global Credit Review*, *2*, 98–108.

Duffie, D., Saita, L., & Wang, K. (2007). Multi-period corporate default prediction with stochastic covariates. *Journal of Financial Economics*, *83*, 635–65.

Duffie, D., & Singleton, K. (2003). *Credit risk : Pricing, measurement, and management*. Princeton: Princeton University Press.

Dwyer, W. D., Kocagil, A. E., & Stein, R. M. (2004). Next-generation technology for predicting private firm credit risk, (United Kingdom: Moody's KMV Company). Available via the Internet: https://www.moodys.com/sites/products/ProductAttachments/RiskCalc%203.1%20Whitepaper.pdf.

Efron, B., Hastie, T., Johnstone, I., & Tibshirani, R. (2004). Least angle regression. *The Annals of Statistics*, *32*(2), 407–499.

Ghysels, E., Sinko, A., & Valkanov, R. (2007). MIDAS regressions: Further results and new directions. *Econometric Reviews*, *26*(1), 53–90.

International Monetary Fund (2015). Corporate leverage in emerging markets—A Concern?," Chapter 3 In Global Financial Stability Report, October. Washington.

International Monetary Fund (2016). The growing importance of financial spillovers from emerging market economies, Chapter 2 In Global Financial Stability Report, April. Washington.

Lando, D. (2004). *Credit risk modeling: theory and applications*. Princeton: Princeton University Press.

McCauley, R. N., McGuire, P., & Sushko, V. (2015). Dollar credit to emerging market economies. *BIS Quarterly Review*, *4*, 27–41.

Merton, R. (1974). On the pricing of corporate debt: The risk structure of interest rates. *Journal of Finance*, *29*, 449–70.

RMI-CRI (2015). NUS-RMI Credit Research Initiative Technical Report, Version: 2016 Update 1. Global Credit Review, *5*, 1–91.