# Predicting Default Probabilities and Implementing Trading Strategies for Emerging Markets Bond Portfolios

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# Abstract

In this paper we address two main issues: the computation of default probability implicit in emerging markets bond prices and the impact on portfolio risks and returns of expected changes in default probability. Using a reduced-form model, weekly estimates of default probabilities for U.S. Dollar denominated Global bonds of twelve emerging markets are extrapolated for the sample period 1997-2001. The estimation of a logit type econometric model shows that weekly changes of the default probabilities can be explained by means of some capital markets factors. Recursively estimating the logit model using rolling windows of data, out-of-sample forecasts for the dynamics of default probabilities are generated and used to form portfolios of bonds. The practical application provides interesting results, both in terms of testing the ability of a naive trading strategy based on model forecasts to outperform a "customized benchmark", and in terms of the model ability to actively manage the portfolio risk (evaluated in terms of VaR) with respect to a constant proportion allocation.



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# 1. Introduction

In the last decade, emerging markets have experienced a number of financial crises. Recent cases include the Asian turmoil of 1997, the 1998 Russian default and, more recently, the downgrade of Turkish bonds and the crisis of Argentina, culminating in its January 2002 default. All these events have given rise to significant contagion effects among emerging markets.

Much of the research on emerging markets applies to equities, whereas relatively few empirical contributions on bonds have been provided (for a comprehensive review, see Bekaert and Harvey (2002, 2003)). This could be explained by the difficulty in creating reliable and deep data sets of bond prices, interest rates, exchange rates and macroeconomic fundamentals to be used as numerical inputs for market analysis. Moreover, the outbreak of the interest versus emerging market bonds is recent, as it started in the early Nineties, when the sharp decrease of interest rates in developed countries forced investors to look for high yield bonds other than government bonds and when emerging countries began issuing larger and larger amounts of debt via new more liquid instruments, such as Brady bonds, Global bonds and Eurobonds.

Estimating the default probability implicit in emerging market bond prices has become extremely important for institutional investors (banks, mutual and pension funds, in particular), given the relatively high weight of these securities in their portfolios. However, the high returns offered by this type of bonds are mainly explained by credit risk considerations due either to default events (issuer does not pay interest or principal or both) or market losses caused by frequent downgrading and subsequent bond price volatility.

Knowing the degree of confidence that financial markets are currently using to discount a bond issuer's default is, therefore, at a practical level, extremely important under at least two different aspects. The first one consists in the computation of the risk the investor is undertaking over a given horizon. The second one regards the impact on portfolio risks and returns of different default probability expectations. In this paper we address both of these issues.

First, we extrapolate weekly estimates of default probabilities from a reduced-form model. The empirical work is based on U.S. Dollar denominated Global bonds of twelve emerging markets from February 1997 to July 2001.

Then, we show that default probabilities can be predicted by some capital markets factors (essentially interest rates, exchange rates and credit spreads) and use them as explanatory variables in logit type models for the prediction of the probability of a market increase/decrease in bond prices.

In the final part of the paper, we recursively estimate a logit model to produce out-of-sample forecasts for the probability of observing future appreciation/depreciation of the bonds. The practical application of the impact on portfolio returns of different default probability expectations provides interesting results, both in terms of testing the ability of a naive trading strategy based on model forecasts to outperform a "customized benchmark", and in terms of the model's capability to actively manage the portfolio risk (evaluated in terms of VaR) with respect to a constant proportion allocation.

The paper is organized as follows. Section 2 introduces the main features of emerging markets bonds. Section 3 illustrates the reduced-form valuation model used for the pricing of Global bonds. Section 4 describes the data used in the empirical work and section 5 shows the underlying default probabilities extrapolated by the estimation of the model. Section 6 provides empirical evidence on predicting the dynamics of default probabilities and on the performance, in terms of returns and VaR measures, of emerging markets bond portfolios built on such forecasts. Finally, section 7 contains some concluding remarks.

# 2. Emerging market bonds

In March 1989, the U.S. Government proposed a new debt initiative, the Brady Plan, which recognized that a full repayment of the debt for developing countries was no longer a reasonable goal. The Plan put pressure on commercial and investment banks to concede and to manage some form of debt and debt-service relief and also called for an increase in secondary market activity, in order to grant liquidity to these issues. The implementation of the Plan led to the birth of a new kind of emerging market (high yields) bonds: the Brady bonds.

So far, several countries have taken advantage of the program by issuing different types of Brady bonds. The Brady Program helped and accelerated the issue of other kinds of emerging markets bonds, by that way contributing to the development of the emerging debt market. At present, the majority of debt is from Latin America, with Argentina, Brazil, Mexico and Venezuela covering about 70% - 80% of the outstanding market.

Nowadays the emerging markets bond market is capturing the interest of both individual and institutional investors because of its uniqueness in at least two respects: first, yields are extremely high, and, second, some issues are very large and liquid (which was one of Brady's main aims). Moreover, these features support an active over-the-counter derivatives market, so that investors can take views on country risk, bond spreads or volatility, as well as hedging their own portfolios through the use of customized options and/or futures.

As widely known, at present, developing countries issue several types of bonds in different markets. Usually, we distinguish between locally traded bonds (Government, Agencies, and Corporate securities quite illiquid, except for some issues, traded exclusively in the local bond markets and rarely present in institutional investors' portfolios), Brady bonds and Eurobonds (otherwise known as Sovereign bonds).

Among Eurobonds, the most liquid (and therefore reliable for our analysis) type of bonds issued by developing countries are the so called Global bonds, usually long-term, plain vanilla, uncollateralized bonds, whose cash flows are easily computed and discounted at each point in time, the only need being the term structure of risk-free interest rates and coupon payment dates.

Market prices of Brady discount bonds have been used in the empirical investigation of Claessens and Pennacchi (1996), Izvorski (1998) and Pages (2001), whereas Eurobonds have been used by Merrick (2001) and Duffie, Pedersen and Singleton (2003).

In this paper, we prefer to use Global bonds to extrapolate default probabilities because of the following reasons: (i) the simplicity of the calculations involved by using simple plain vanilla bonds in comparison to the higher level of difficulty arising when dealing with some complicated structures as in the case of Bradies; (ii) the fact that they usually have a 20-30 year maturity horizon and, therefore, their pricing reflects the mid to long term assessment of the sustainability of one country debt profile; (iii) no assumptions on future term structures, future commodity prices or macroeconomic fundamentals are required, contrary to the case of some types of Bradies (for example, the future coupons of some issues of Mexican Bradies are linked to the price of Mexican oil and this introduces discretionary elements in the evaluation of the implied default probability); (iv) the implied default probability measure is "pure", as Global bonds are usually uncollateralized, different from the Bradies for which collateral guarantees (generally cash deposits retained by the Federal Reserve system) are requested.

# 3. The pricing model

Several models for the pricing of defaultable bonds have been proposed in the literature. Usually, three main approaches are distinguished (for a recent comprehensive review, see Duffie and Singleton (2003)):

i) Merton's (1974) option pricing based model, which computes the payoff at maturity as the face value of the defaultable bond minus the value of a put option on the issuer's value with an exercise price equal to the face value of the bond.

ii) Structural models, which relax one of the unrealistic assumptions of Merton's model, that is that default occurs only at maturity of the debt, when the issuer's assets are no longer sufficient to face its obligations towards bondholders. On the contrary, these models assume that default may occur at any time between issuance and maturity of the debt and that default is triggered when the issuer's assets reach a lower threshold level (see, for example, Black and Cox (1976) and Longstaff and Schwartz (1995)).

iii) Reduced-form models, which do not condition default explicitly on issuer's value, and therefore are, in general, easier to implement. They also differ from typical structural models in the degree of predictability of default, as they can easily accommodate defaults coming as sudden surprises (see, for example, Jarrow, Lando and Turnbull (1997) and Duffie and Singleton (1999)).

The reduced-form approach appears to be particularly suitable for the pricing of emerging market bonds, as it relies only on market data. Recent examples include Merrick (2001), Pages (2001) and Duffie, Pedersen and Singleton (2003).

There exists also a large economic literature modelling sovereign debt as a function of reputation costs and sanctions, in that the decision to default of a country depends on the cost of future access to credit markets and the threat of economic and political retaliations (see, for example, Eaton and Gersovitz (1981), Bulow and Rogoff (1989) and Gibson and Sundaresan (2001)).

Our pricing model can be viewed as an application of the discrete-time version of a reduced-form model. In fact, the model considers the discrete-time process generating the market price of bonds and uses that price and the term structure of interest rates as the only available sources of information to extract the default probability through the use of a closed formula.

The model works as follows. Assuming no arbitrage conditions, the market price of a defaultable asset should be a function of the default probability term structure, as well as of the future cash flows discounted using the current risk-free term structure.

Interpreting the coupon bond as a portfolio of zero-coupon bonds, we get the following expression for the market price of a defaultable bond:

$$V_t = \sum_{i=1}^{N} c_{t_i} \cdot \exp\left(-r_{t_i} \cdot t_i\right) \cdot \left[\left(1 - p_{t_i}\right) + \delta \cdot p_{t_i}\right] \qquad (1)$$

where $t_i$ indicates the time to $i$-th maturity, $c_{t_i}$ the $i$-th cash flow, $r_{t_i}$ the risk-free interest rate for the $i$-th maturity, $p_{t_i}$ the risk-neutral probability that default occurs before $t_i$ and $\delta$ the recovery ratio.

As in Izvorski (1998), we assume that $p_{t_i}$ is a properly defined function of a constant semi-annual risk neutral default probability ($p$, constant for all maturities) which changes only for the effect of changes in the term structure of risk-free interest rates, or for the effect of macroeconomic and/or political events that investors discount through prices.

Following Duffee (1999), we also assume that, once a country defaults on some issues, just a fraction (the recovery ratio) of both coupon and principal will be paid for by the issuer in all the subsequent payments. This is a restrictive hypothesis, which does not allow us to account for the possibility that economic conditions could improve in the future and, therefore, the country repayment capacity be re-established. However, in our opinion, this drawback is a very marginal one. In fact, under the hypothesis that a default occurs prior to maturity, after the moratorium period, a new bond could be issued for an amount equivalent to the recovery ratio and for a maturity corresponding to the old one.

A third assumption concerns the recovery ratio, which we assume to be known and constant. Some more sophisticated models infer it from the historical recovery rates (those observed during past defaults) for identically rated issuers, some others describe the recovery ratio by means of a random variable. We believe that this is not a drastic drawback, since one can also extrapolate default probabilities conditionally on different measures of recovery ratio.

Given these assumptions, the following equilibrium relationship between the market price of a defaultable bond and its expected cash flows can be derived:

$$V_t = \sum_{i=1}^{N} c_{t_i} \cdot \exp\left(-r_{t_i} \cdot t_i\right) \cdot \left[(1-p)^i + \delta\left(1-(1-p)^i\right)\right] \qquad (2)$$

where $p_{t_i} = 1-(1-p)^i$.

Given the term structure of risk-free interest rates, the bond price and the recovery rate, the equation above can be solved with respect to the risk-neutral probability of default *p*. In our application, all computations are carried out conditionally on the recovery rate parameter δ. In evaluating the bonds, we adopt a conservative hypothesis and fix it equal to 20%, based on bond managers' experience [1].

From equation (2) it is straightforward to recover, for each emerging market, the defaultable term structure:

$$y_{t_i} = r_{t_i} - \frac{1}{t_i} \ln\left[(1-p)^i + \delta\left(1-(1-p)^i\right)\right] \qquad (3)$$

where $y_{t_i}$ is the credit-risky interest rate for the *i*-th maturity.

# 4. The data

In the empirical work, we consider long-term (usually 10 to 30 years to maturity at the time of issuance) U.S. Dollar denominated Global bonds of twelve emerging markets, namely Argentina, Brazil, Colombia, Mexico, Russia, Venezuela, Panama, South Africa, Turkey, China, Philippines and South Korea. The sample contains weekly market values of Global bond prices (mean of bid and ask quotes), ranging from 14 February 1997 to 27 July 2001 [2]. The main features of these issues are reported in table 1. For each country we choose the most liquid long-term bond, which involves relatively small bid-ask spreads. In fact, we can observe that bid-ask spreads, expressed as a percentage of the ask quotation, are around 1% for all countries, with the only exception of Colombia.

As we consider only U.S. Dollar denominated emerging markets Global bonds, USD Libor and swap rates are used to fit the risk-free term structure. As for the Libor rates,

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1 See, for example, Xu and Nencioni (2000) on J.P.Morgan practice. We point out in the empirical part of the paper that a change in the recovery rate assumed in the calculation of the default probabilities implies a parallel shift in the estimated probability of default.

we use all maturities between 1 month and 12 months, whereas for the swap rates we include all maturities between 2 and 10 years and the 15, 20 and 30 years maturities. The risk-free term structure of interest rates is obtained by fitting a cubic spline to these data.

# 5. Extracting default probabilities

The implied risk-neutral default probabilities are estimated by minimizing the difference between observed and theoretical prices in equation (2) above. Table 2 contains some summary statistics on the estimated default probabilities [3], whereas figure 1 shows the time series estimates for the countries considered in the sample along with the corresponding credit spreads, calculated as the difference between the yield on the emerging market bonds and the yield on a U.S. Treasury bond with same maturity.

As expected, the dynamics of the estimated risk-neutral probabilities reflect the evolution of both the political and macroeconomic situations of the different countries over the 1997-2001 period including deep financial and economic crisis, such as the Asian financial turmoil (1997), Russia’s default (1998), the Turkish and Argentina’s crises (2001).

In the first part of the sample, the implied default probabilities are relatively low and stable. However, disruptions in the balance of payments, disequilibria in the gross domestic product growth, stock exchange bubbles and extra-ordinary overvalued real

[2] The source of the data is Thompson Financial (formerly Datastream Ltd.).

[3] In the presence of risk premiums, risk-neutral default probabilities would be larger than actual default probabilities. However, assuming that risk premia do not change significantly over time, the dynamics of actual probabilities should map into that of the risk-neutral ones.

effective exchange rates in several less developed countries culminate in the outbreak of the Asian financial crisis from mid 1997 onward.

As a result, investors all over the world re-evaluate the risk implied in keeping emerging market securities in their portfolios. This leads to a diffused panic reaction in late 1997, when the world's financial markets witnessed a panic selling of emerging market bonds and stocks in favour of safer assets in developed countries (*flight-to-quality* effect).

During this period, the estimated default probabilities for all the countries in the sample increase, even if not too dramatically according to our estimates. Argentina's implied risk-neutral probability of default grows from a semi-annual 2% to almost 4%; Brazil's, Mexico's and Venezuela's default probabilities increase, respectively, by 3%, 1% and 2.4%, while a less dramatic impact of the mentioned crisis is seen in Ecuador [4] and Colombia.

After this critical period, another period of relative calm precedes the outbreak of a more dramatic and widespread emerging markets crisis in 1998, when a general sell-off occurs first in Latin America and then spreads to other emerging markets. In particular, it affects Russia, whose banking system's fragility allows for successful speculative attacks against the Ruble, by that way forcing the subsequent default (declared in August 1998), even if limited to the domestic debt.

In this period, the estimated semi-annual risk-neutral default probabilities reach their peaks: 8.3% for Argentina, 14% for Brazil, 8.8% for Colombia, 16% for Ecuador, 6.1% for Mexico and 26.2% for Venezuela (the most dramatically hit country).

Another financial crisis affects Latin America in December 1998 - February 1999, when the Real is devalued after speculative attacks based on the financial and fiscal fragility of the Brazilian economy, and late in 1999, when Ecuador (whose implied default probability increases up to 45% in October) declares default.

The motivations leading Turkey in the severe crisis dated spring 2001 are the critical situation of the financial sector, the high level of the inflation rate, the political uncertainty and the unmatched requests formulated by the World Bank and the International Monetary Fund for critical but necessary reforms.

Argentina's troubles, instead, begin as an effect of the recession glooms involving the most important trading (and supporting) partner, the United States, as well as of the continuous political uncertainty concerning the government of the country itself. The bond markets, once again, call for higher risk premiums (and therefore higher implied default probabilities), starting from June 2001 and spreading from the domestic market to the Eurobonds and the Brady bonds markets.

Looking at the interrelation between the default probabilities estimated for the different countries, we observe a high correlation across countries belonging to the same economic region. This is particularly true for the most economically homogeneous region in our sample, Latin America, with correlations around 70-80%.

Applying a principal components analysis to the default probabilities estimated for the twelve countries in the sample, we can show that just two factors can explain almost 70% of the total variability of default probabilities.

As regards the distributional properties of implied risk-neutral default probabilities, in particular observing the distances of minimum and maximum values from the sample means and medians in table 2, we can see that the shape of such distributions looks far from being symmetric and is characterized by fat right tails. This intuition is reinforced

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4 Although we do not include Ecuador among the twelve countries in our sample, we estimate default probabilities for this country (using the 11.25% Global bond expiring in

by the estimation of a non-parametric empirical probability density function of the estimates. A normal kernel is used to obtain the probability density functions (pdf's) plotted in Figure 2.

As stated in section 3, default probabilities are estimated assuming a fixed 20% recovery rate. However, by recalculating default probabilities under different recovery rates, we observe that changes in the recovery rate imply a parallel shift in the level of default probabilities, but do not modify their dynamics. This is important from our point of view, as the portfolio allocation problem which will be addressed in the next section is mainly concerned with the changes, rather than the levels, of default probabilities [5].

Using the estimated default probabilities along with the fitted U.S. risk-free term structure, we can exploit equation (3) of the reduced-form model to recover, for each country, the implicit term structure of credit spreads, which reflects market's medium-long term expectations about bonds default probability. Table 3 contains some summary statistics on the whole sample. In general, we observe relatively flat term structures, which can become very steep during high volatility periods and downward sloping in the weeks following the end of a crisis.

Using the estimated spread curves, we can test the hypothesis that default probabilities are negatively correlated with default-free interest rates. This evidence has generally been observed for corporate bonds (see, for example, Duffee (1999) and Duffie and Singleton (1999)), as default rates tend to be higher during recessions, when risk-free rates are relatively low. We observe that, for the twelve countries considered, the average correlation between the 1-year credit spread and the 1-year U.S. risk-free rate is

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April 2002) for the period preceding the 1999 default.

[5] A different model, with simultaneous endogenous estimates of both the default probabilities and the recovery rates, would surely have been more appropriate if the

–0.31, with a peak for Turkey (–0.8) and no correlation for Russia and South Africa. Similar evidence holds for longer maturities. For example, at the 10-year maturity the average correlation is –0.33.

# 6. Predicting the dynamics of default probabilities for portfolio trading strategies

In the previous section, we have estimated historical default probabilities from market prices of emerging markets bonds. For the bonds we are considering, we can observe that to an increase (decrease) in default probability corresponds a decrease (increase) in the market price of the bond one week ahead, as the average correlation between lagged default probabilities and bond prices is –0.8.

This means that predicting default probabilities, or, at least, the direction of default probabilities, can provide useful insights about future movements in bond prices. This would obviously represent relevant information for portfolio allocation.

In this section, we develop a forecasting model for the probability of observing an increase/decrease in future default probabilities, which is based on the use of frequently observed financial variables. The forecasts are then used to implement efficient trading strategies for portfolios of emerging market bonds.

Because of the availability of data on the explanatory variables, the analysis in the following is restricted to seven countries, which are representative of different economic regions: Argentina, Brazil, Mexico, Russia, Turkey, South Korea and Philippines.

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focus of our research had been just the estimation of the implied default probabilities, and not their use in the context of a trading portfolio strategy.

We first build a logit type model for the prediction of the probability of a market downgrading or upgrading of Global bonds. From now on, we use the term *downgrading* to indicate either an increase in bonds' default probability or a decrease in bonds' price. Similarly, we use the term *upgrading* to indicate a decrease in bonds' default probability or an increase in bonds' price. In fact, as said above, an increase (decrease) in default probability is almost equivalent to a decrease (increase) in the market price of the bond.

The dependent variable in the logit model assumes either value 1 for positive weekly changes of the estimated default probability or value 0 for non-positive weekly changes. As explanatory variables, we use lagged values of some financial variables, such as short and long term interest rates in local currency, J.P.Morgan and Lehman Brothers local indexes, log changes in exchange rates and interest rate spreads with respect to U.S. rates.

The model generally provides accurate predictions both for market downgrading and upgrading of bonds. Table 4 shows the percentage of correct in-sample predictions for one week ahead default probabilities and changes in bond prices. We notice that, with the only exception of South Korea, in about 75% of the cases the model correctly predicts future movements in default probabilities. As regards future changes in bond prices, the statistics are relatively satisfactory for all countries, except for South Korea and Russia (only in the downgrading case).

The second step of our empirical investigation consists in using the logit specification to produce out-of-sample forecasts for the dynamics of default probabilities. In this case, we recursively estimate the model using windows of three years (Argentina, Mexico, Brazil) or one year (Russia, Turkey, Philippines, South Korea) of weekly data.

At each point in time, we generate *one-step-ahead* forecasts for the probability of having a bond market up/downgrading and use them to simulate trading strategies for portfolios of emerging market bonds.

The simulations are carried out for the investment period 1 September 2000 – 27 July 2001 (48 weeks) assuming a starting equally weighted portfolio of $1,000,000 Global bonds.

Portfolios of different bonds are considered and the following naive trading strategy is applied [6]:

– upgrading signal (the probability of a decreasing default probability forecasted by the model is greater than 60%): position increased by $100,000 dollars;

– downgrading signal (the probability of an increasing default probability forecasted by the model is greater than 60%): position closed;

– no clear signal (the probability of a decreasing/increasing default probability forecasted by the model is between 40% and 60%): position unchanged;

– minimum investment required to re-open a position on a bond: $100,000 dollars;

– borrowing and lending at the USD risk-free 1 week Libor rate.

We apply the strategy to 22 different portfolios: one containing all the bonds of the seven countries and 21 formed combining the seven bonds taking five at a time.

Table 5 shows that the simple active portfolio strategy, which is based on the signals derived from the out-of-sample forecasts obtained by the logit model for the probability of an upgrading/downgrading of the bond over the next week, provides quite satisfactory results, especially in comparison with the buy & hold strategy and the

6 This strategy has been implemented after several constructive discussions with numerous traders.

J.P.Morgan – Lehman Brothers benchmarks recalculated for the countries in the portfolios.

In general, along the sample period considered in the simulations, emerging market bonds have not performed particularly well, as the average returns on the benchmarks and the buy & hold portfolios are negative: –1.7% and –9.4%, respectively. Instead, the active portfolio strategy always produces positive returns, with an average value around 7.6%. Moreover, the variability of returns among the different portfolios is much lower (1.50%) than in the benchmarks (4.16%) and buy & hold (3.79%) case.

In the calculations, we do not explicitly consider transaction costs. However, we believe that these returns are not over-estimated, especially if we take the point of view of a relatively large emerging market fund. In fact, we use the mean of bid and ask quotes for bond prices, which means that, on average, transaction costs are already included in the buying and selling prices used to implement the active strategy. Table 5 shows that when we explicitly introduce transaction costs we observe a decrease of almost 200 basis points in the returns of the active portfolio strategy for a 10 basis points percentage of transaction costs. These are still relatively large returns for the active portfolio strategy with respect to the benchmark and the buy & hold strategy.

The naive portfolio strategy based on the out-of-sample forecasts for default probabilities is also flexible enough to control for the risk of the portfolio. Figure 3 shows that a VaR measure at the 95% confidence level, calculated using the J.P.Morgan RiskMetrics's methodology, satisfies the capital requirements for the 7-bond portfolio formed applying the active strategy (this is true also for all the 5-bond portfolios). We observe that the active strategy provides a more suitable VaR measure than the buy & hold portfolio. In fact, it gives rise to only two breaks along the 48 weeks considered (4.2%), whereas there are five breaks (10.4%) in the case of the buy & hold strategy.

Moreover, as it adapts to new market conditions, the VaR measure in the active strategy case is less conservative and imposes, on average, lower capital requirements than in the buy & hold case.

# 7. Conclusion

In this paper we have addressed two main issues: the computation of risk-neutral default probabilities implicit in emerging markets bond prices and the impact on portfolio risks and returns of expected changes in default probability.

First, using a reduced-form model for the pricing of defaultable bonds, we have extracted the default probabilities from Global bond prices of twelve countries. The estimated default probabilities reflect quite closely actual crisis observed in the market over the sample period comprised between February 1997 and July 2001.

Then, using logit type models, we have shown that weekly changes of the estimated probabilities could be predicted using a variety of capital markets factors (interest rates, exchange rates and credit spreads).

Finally, we have used recursive estimates of a logit model to produce out-of-sample forecasts of the appreciation/depreciation of the Global bonds.

The application of a naive portfolio strategy, based on the out-of-sample forecasts of the logit model for the probability of a weekly up/down movement in the market value of the bonds, has provided quite satisfactory results, both in terms of returns and in terms of portfolio risk management. This is particularly true when we compare them with those obtained by a buy & hold strategy and the J.P.Morgan – Lehman Brothers benchmarks recalculated for the countries in the portfolios.

# References


Bekaert, G. and C.R. Harvey, 2002, Research in emerging markets finance: looking to the future, Emerging Markets Review 3, 429-448.

Bekaert, G. and C.R. Harvey, 2003, Emerging markets finance, Journal of Empirical Finance 10, 3-55.

Black, F. and J. Cox, 1976, Valuing corporate securities: some effects of bond indenture provisions, Journal of Finance 31, 351-367.

Bulow, J. and K. Rogoff, 1989, A constant recontracting model of sovereign debt, Journal of Political Economy 97, 155-178.

Claessens, S. and G.G. Pennacchi, 1996, Estimating the likelihood of Mexican default from the Mexican prices of Brady bonds, Journal of Financial and Quantitative Analysis 31, 109-126.

Duffee, G.R., 1999, Estimating the price of default risk, Review of Financial Studies 12, 197-226.

Duffie, D., L.H. Pedersen and K.J. Singleton, 2003, Modeling sovereign yield spreads: a case study of russian debt, Journal of Finance 58, 119-159.

Duffie, D. and K. Singleton, 1999, Modeling term structures of defaultable bonds, Review of Financial Studies 12, 687-720.

Duffie, D. and K. Singleton, 2003, Credit risk for financial institutions: management and pricing (Princeton University Press, Princeton).

Eaton, J. and M. Gersovitz, 1981, Debt with potential repudiation: theoretical and empirical analysis, Review of Economic Studies 48, 288-309.

Gibson, R. and S.M. Sundaresan, 2001, A model of sovereign borrowing and sovereign yield spreads, working paper, ISB University of Zurich.

Izvorski, I., 1998, Brady bonds and default probabilities, working paper 98/16, International Monetary Fund.

Jarrow, R., D. Lando and S. Turnbull, 1997, A markov model for the term structure of credit risk spreads, Review of Financial Studies 10, 481-523.

Longstaff, F. and E. Schwartz, 1995, A simple approach to valuing risky fixed and floating debt, Journal of Finance 50, 789-819.

Merrick, J.J., 2001, Crisis dynamics of implied default recovery ratios: evidence from Russia and Argentina, Journal of Banking and Finance 25, 1921-1939.

Merton, R., 1974, On the pricing of corporate debt: the risk structure of interest rates, Journal of Finance 29, 449-470.

Pages, H., 2001, Can liquidity risk be subsumed in credit risk? A case study from Brady bond prices, working paper, Bank of France.

Xu, D. and F. Nencioni, 2000, Introducing the J.P.Morgan implied default probability model: a powerful tool for bond valuation, working paper, JPMorgan, New York.

## Table 1

### Main features of Global bonds

This table shows the main features of the U.S. Dollar denominated Global bonds included in the sample. The sample contains weekly market values of prices ranging from 14 February 1997 to 27 July 2001. All bonds pay the coupon semi-annually and are not collateralized. Bid-ask spreads are expressed as a percentage of the ask price.

| Issuer | Maturity | Coupon | Bid-ask spreads | |
|---|---|---|---|---|
| | | | Mean | St. Dev. |
| Argentina | 19 Sept. 2027 | 9.75 | 1.25 | 1.33 |
| Brazil | 15 May 2027 | 10.125 | 1.25 | 1.71 |
| Colombia | 15 Feb. 2027 | 8.375 | 1.86 | 1.60 |
| Mexico | 15 May 2026 | 11.50 | 0.64 | 0.49 |
| Panama | 30 Sept. 2027 | 8.875 | 1.16 | 0.69 |
| Venezuela | 15 Sept. 2027 | 9.25 | 0.99 | 1.00 |
| Russia | 24 July 2018 | 11.00 | 1.63 | 0.96 |
| South Africa | 19 May 2009 | 9.125 | 0.91 | 0.29 |
| Turkey | 15 June 2009 | 12.375 | 0.81 | 0.52 |
| China | 22 Oct. 2027 | 7.30 | 1.09 | 0.29 |
| Philippines | 15 Jan. 2019 | 9.875 | 1.37 | 0.88 |
| South Korea | 15 Apr. 2008 | 8.875 | 0.62 | 0.32 |

## Table 2

**Summary statistics on estimated default probabilities**

This table shows summary statistics on estimated default probabilities. These are weekly estimates from equation (2), where we consider long-term U.S. Dollar denominated Global bonds (see table 1) for a sample period ranging between 14 February 1997 and 27 July 2001. USD Libor (all maturities between 1 month and 12 months) and swap rates (all maturities between 2 and 10 years and the 15, 20 and 30 years maturities) are used to fit the risk-free term structure in correspondence of the payments dates. The risk-free term structure of interest rates is obtained by fitting a cubic spline to these data. Values are expressed in percentage terms.

| Country | No. Obs. | Mean | Median | St. Dev. | Max | Min |
|---|---|---|---|---|---|---|
| Argentina | 203 | 3.54 | 3.34 | 1.13 | 9.42 | 2.04 |
| Brazil | 217 | 4.35 | 3.73 | 2.05 | 15.18 | 2.24 |
| Colombia | 233 | 2.88 | 2.95 | 1.20 | 8.40 | 0.88 |
| Mexico | 233 | 2.04 | 1.98 | 0.84 | 5.74 | 0.70 |
| Panama | 202 | 2.21 | 2.11 | 0.56 | 5.06 | 1.25 |
| Venezuela | 203 | 5.64 | 4.43 | 4.53 | 45.13 | 2.03 |
| Russia | 120 | 11.26 | 5.70 | 13.04 | 76.00 | 3.83 |
| South Africa | 116 | 1.41 | 1.44 | 0.31 | 2.25 | 0.85 |
| Turkey | 110 | 3.54 | 3.55 | 1.07 | 6.22 | 2.02 |
| China | 197 | 1.13 | 1.07 | 0.40 | 2.39 | 0.27 |
| Philippines | 134 | 2.90 | 2.85 | 0.81 | 4.67 | 1.51 |
| South Korea | 173 | 1.31 | 0.79 | 1.20 | 6.71 | 0.35 |

## Table 3

**Estimated term structures of credit spreads**

This table shows average estimated credit spreads for different maturities. These are implicitly derived from estimated default probabilities and U.S. risk-free term structure. The sample period varies for each country and ranges between 14 February 1997 and 27 July 2001. Values are expressed in percentage terms. Standard deviation in parentheses.

| Country | No. Obs. | 1 year | 5 years | 10 years |
|---|---|---|---|---|
| Argentina | 203 | 3.09 | 3.05 | 2.98 |
| | | (1.02) | (0.98) | (0.92) |
| Brazil | 217 | 3.85 | 3.76 | 3.64 |
| | | (1.92) | (1.79) | (1.61) |
| Colombia | 233 | 2.51 | 2.48 | 2.43 |
| | | (1.07) | (1.04) | (0.99) |
| Mexico | 233 | 1.76 | 1.75 | 1.73 |
| | | (0.74) | (0.72) | (0.70) |
| Panama | 202 | 1.90 | 1.89 | 1.87 |
| | | (0.49) | (0.48) | (0.46) |
| Venezuela | 203 | 5.20 | 4.87 | 4.50 |
| | | (5.43) | (3.75) | (2.47) |
| Russia | 120 | 8.05 | 7.50 | 6.68 |
| | | (5.99) | (5.08) | (3.80) |
| South Africa | 116 | 1.21 | 1.21 | 1.20 |
| | | (0.27) | (0.27) | (0.26) |
| Turkey | 110 | 3.09 | 3.06 | 2.99 |
| | | (0.94) | (0.92) | (0.88) |
| China | 197 | 0.97 | 0.96 | 0.96 |
| | | (0.34) | (0.34) | (0.34) |
| Philippines | 134 | 2.52 | 2.50 | 2.46 |
| | | (0.72) | (0.70) | (0.68) |
| South Korea | 173 | 1.13 | 1.12 | 1.10 |
| | | (1.06) | (1.03) | (1.00) |

## Table 4

### Percentage of correct in-sample predictions

This table shows the percentage of correct in-sample predictions of a market *downgrading* (weekly increase in default probability or decrease in bond price) or *upgrading* (weekly decrease in default probability or increase in bond price) in the underlying bonds. These are obtained estimating a logit model, where the dependent variable assumes either value 1 for positive weekly changes of default probability or value 0 for non-positive weekly changes. As explanatory variables, short and long term interest rates in local currencies, J.P. Morgan and Lehman Brothers local indexes, log changes in exchange rates and interest rate spreads calculated with respect to U.S. rates are used. The sample period varies for each country and ranges between 14 February 1997 and 27 July 2001. Values are expressed in percentage terms.

| | | Change in default prob. | | Change in bond price | |
|---|---|---|---|---|---|
| Country | No. Obs. | Downgrading | Upgrading | Downgrading | Upgrading |
| Argentina | 203 | 75 | 75 | 79 | 70 |
| Brazil | 217 | 78 | 74 | 76 | 67 |
| Mexico | 233 | 76 | 75 | 62 | 69 |
| Russia | 120 | 80 | 80 | 53 | 75 |
| Turkey | 110 | 78 | 79 | 67 | 71 |
| Philippines | 134 | 77 | 72 | 70 | 65 |
| South Korea | 173 | 61 | 79 | 58 | 56 |

## Table 5

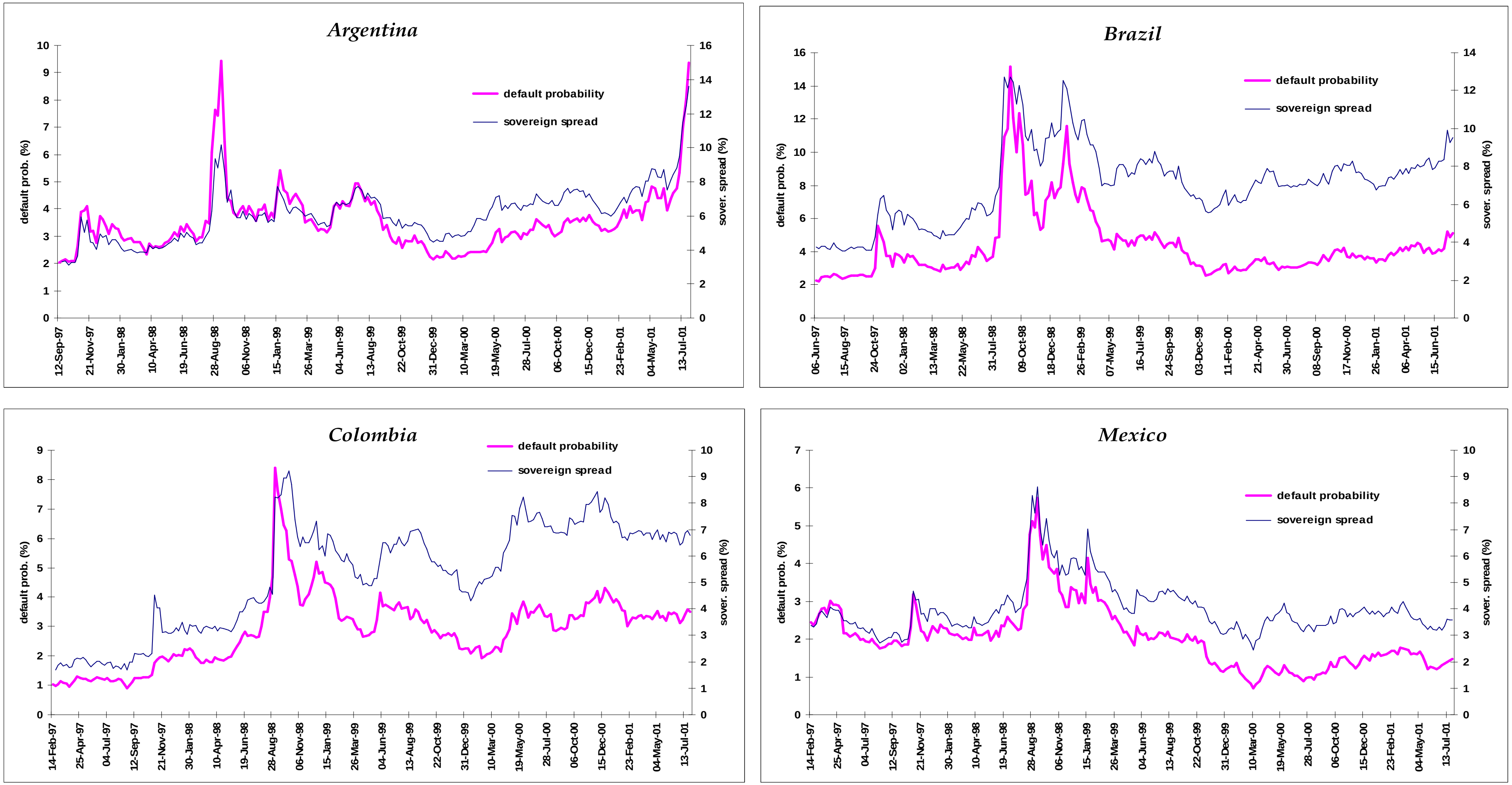
**Return on different investment strategies**

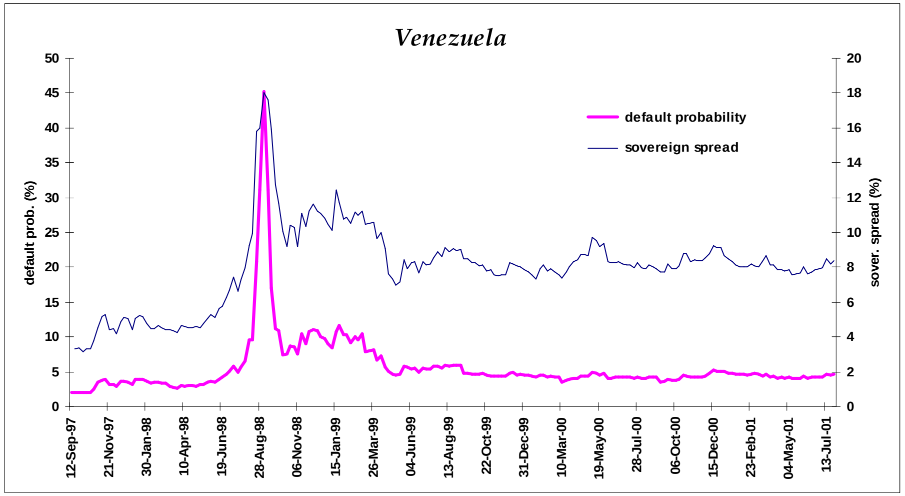
This table shows the returns given by different investment strategies on portfolios of Global bonds. Simulations are carried out for the period 1 September 2000 - 27 July 2001 (48 weeks) assuming that the portfolios are initially equally weighted. An initial investment of $1,000,000 is assumed. On the active strategy, a minimum investment requirement of $100,000 is imposed to re-open a position. No constraints on borrowing/lending at the USD 1 week risk-free Libor rate are imposed. All values are in percentage terms. Bonds used to form portfolios are those of table 1 for Argentina (A), Brazil (B), South Korea (K), Mexico (M), Philippines (P), Russia (R) and Turkey (T).

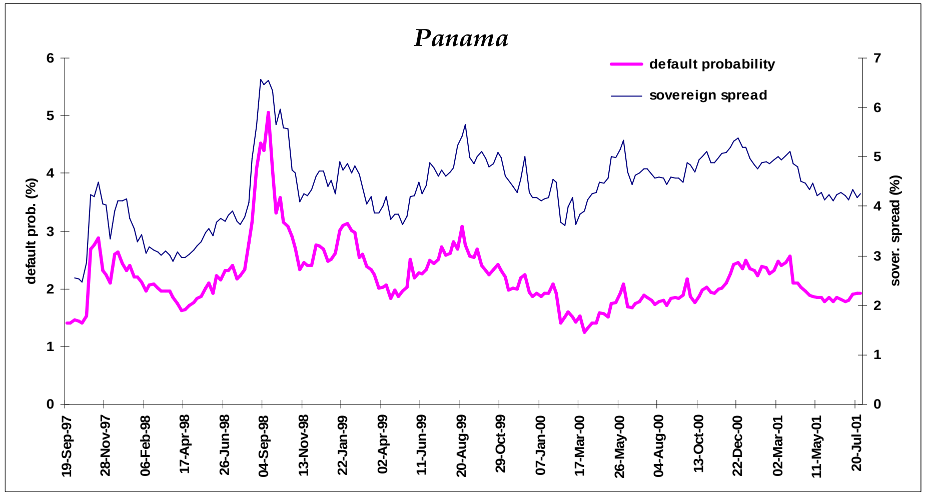
| Portfolios | Active portfolio No trans. costs | Active portfolio 10% b.p. trans. costs | Benchmark | Buy & hold |
|---|---|---|---|---|
| A B K M P | 4.58 | 2.80 | 0.24 | – 9.45 |
| A B K M R | 6.75 | 5.07 | 0.85 | – 7.41 |
| A B K M T | 7.98 | 6.00 | – 6.37 | – 13.73 |
| A B K P R | 5.81 | 4.12 | 0.59 | – 8.21 |
| A B K P T | 7.05 | 5.05 | – 6.61 | – 14.53 |
| A B K R T | 9.22 | 7.32 | – 6.08 | – 12.48 |
| A B P R T | 8.29 | 6.28 | – 6.77 | – 14.34 |
| A B M P R | 5.82 | 4.04 | 0.11 | – 9.26 |
| A B M P T | 7.05 | 4.97 | – 7.05 | – 15.58 |
| A B M R T | 9.22 | 7.23 | – 6.53 | – 13.54 |
| A K M P R | 6.73 | 5.11 | 3.22 | – 5.19 |
| A K M P T | 7.96 | 6.04 | – 4.18 | – 11.51 |
| A M P R T | 9.20 | 7.28 | – 4.32 | – 11.32 |
| A K P R T | 9.20 | 7.36 | – 3.87 | – 10.27 |
| A K M R T | 10.13 | 8.31 | – 3.61 | – 9.47 |
| B K M P R | 5.06 | 3.48 | 8.43 | – 1.24 |
| B K M P T | 6.29 | 4.41 | 0.64 | – 7.56 |
| B M P R T | 8.44 | 5.65 | 0.54 | – 7.37 |
| B K P R T | 7.53 | 5.73 | 1.00 | – 6.32 |
| B K M R T | 7.53 | 6.68 | 1.26 | – 5.52 |
| K M P R T | 8.46 | 6.72 | 3.58 | – 3.30 |
| A B K M P R T | 9.09 | 6.55 | – 1.70 | – 9.41 |
| Average | 7.61 | 5.74 | – 1.67 | – 9.41 |
| Standard deviation | 1.50 | 1.42 | 4.16 | 3.79 |

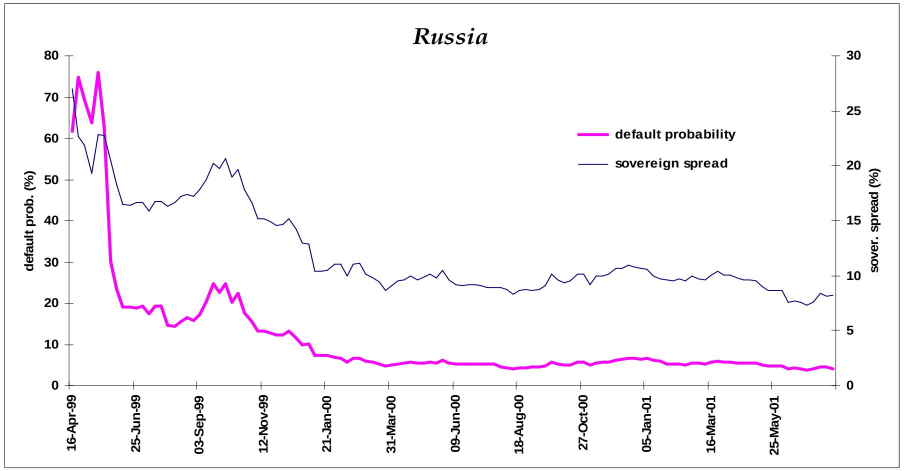
# Figure 1

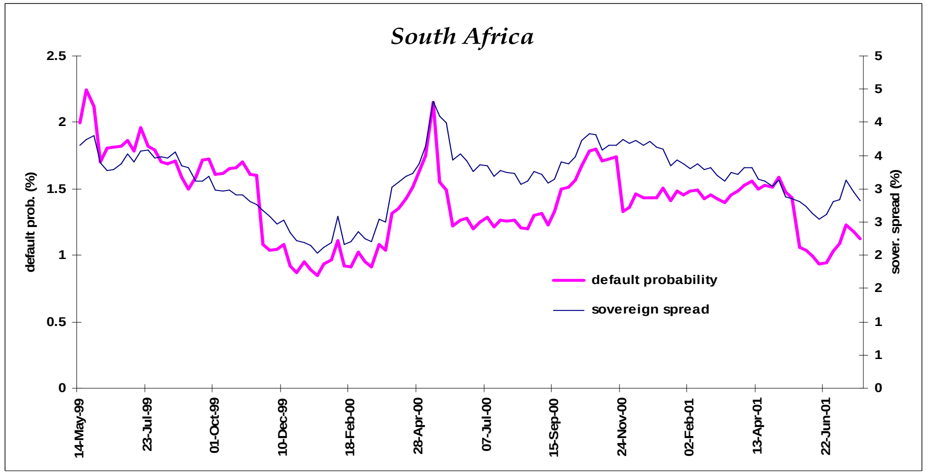
## Estimated default probabilities and sovereign spreads

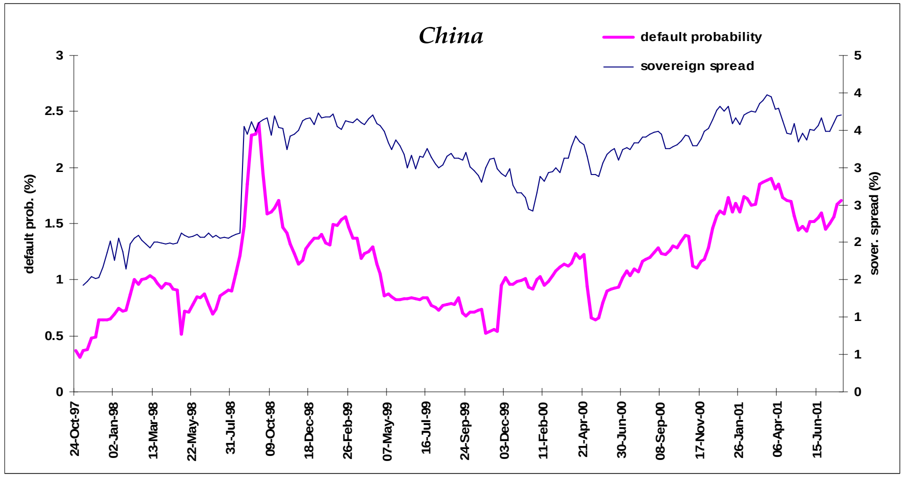


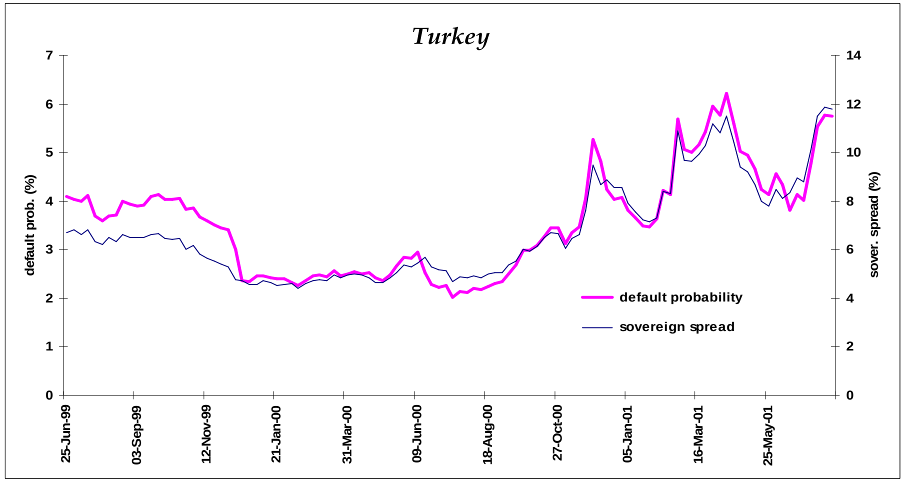

Venezuela
default prob. (%)
sover. spread (%)
default probability
sovereign spread

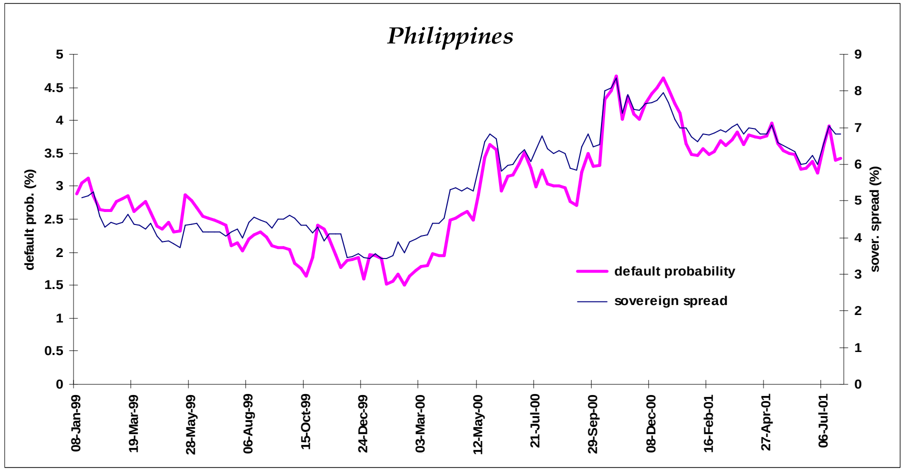

Panama
default prob. (%)
sover. spread (%)
default probability
sovereign spread

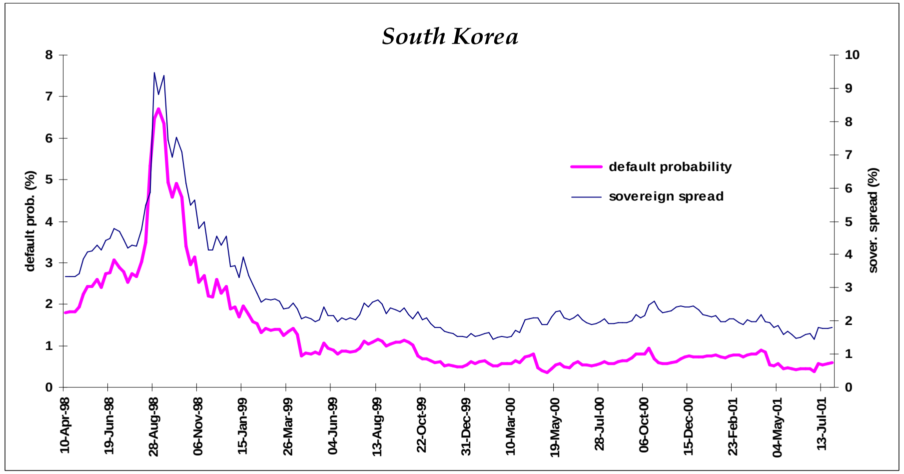

Russia
default prob. (%)
sover. spread (%)
default probability
sovereign spread


South Africa
default prob. (%)
sover. spread (%)
default probability
sovereign spread


China
default probability
sovereign spread
default prob. (%)
sover. spread (%)

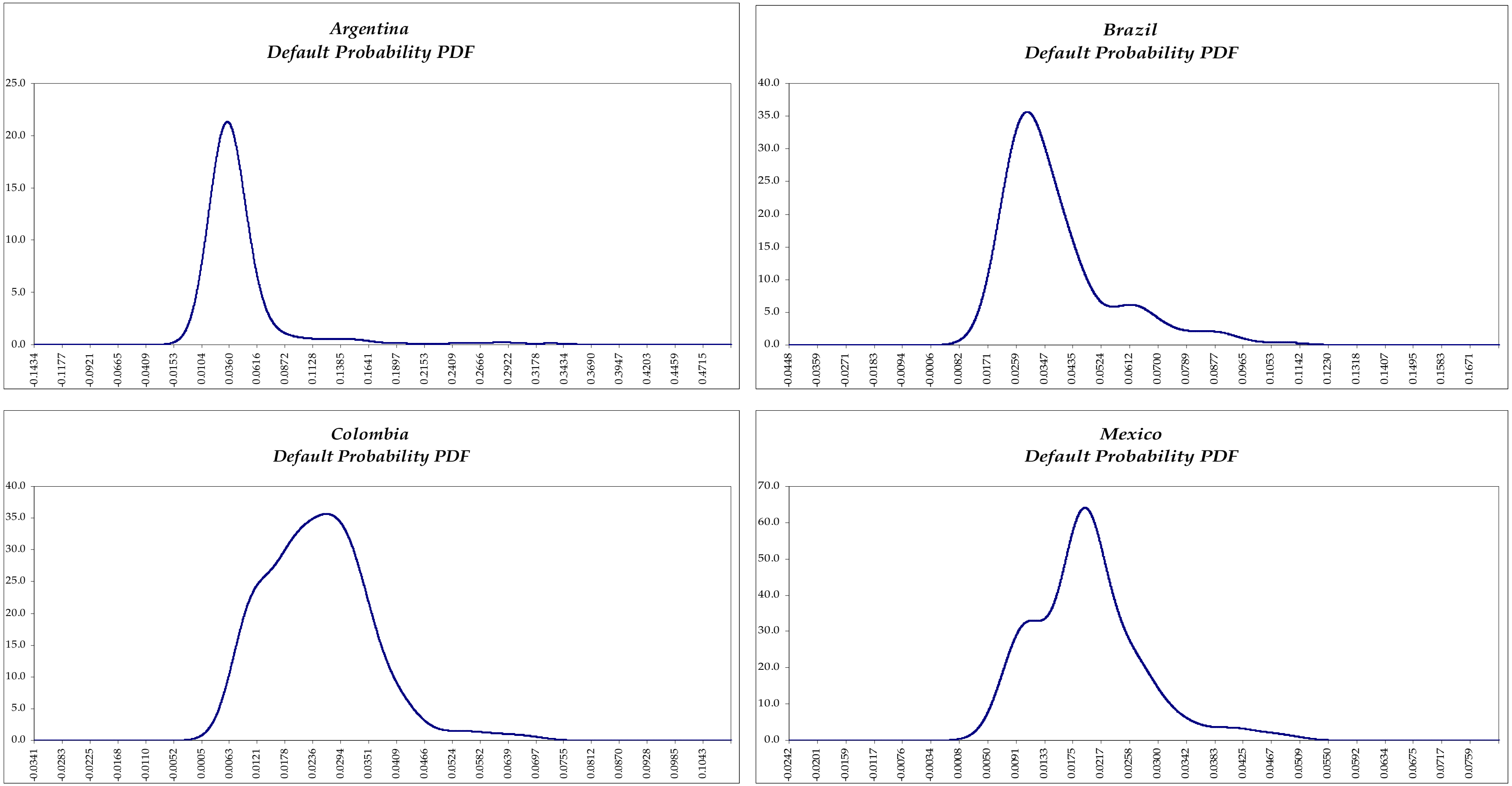

Turkey
default probability
sovereign spread
default prob. (%)
sover. spread (%)

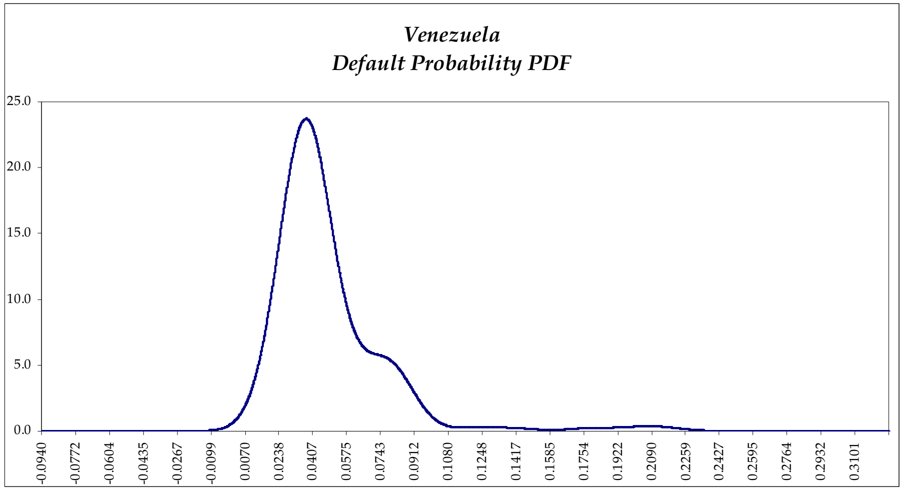

Philippines
default probability
sovereign spread
default prob. (%)
sover. spread (%)


South Korea
default probability
sovereign spread
default prob. (%)
sover. spread (%)

# Figure 2

## Non-parametric estimates of default probabilities pdf's




Venezuela
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20.0
15.0
10.0
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-0.0772
-0.0604
-0.0435
-0.0267
-0.0099
0.0070
0.0238
0.0407
0.0575
0.0743
0.0912
0.1080
0.1248
0.1417
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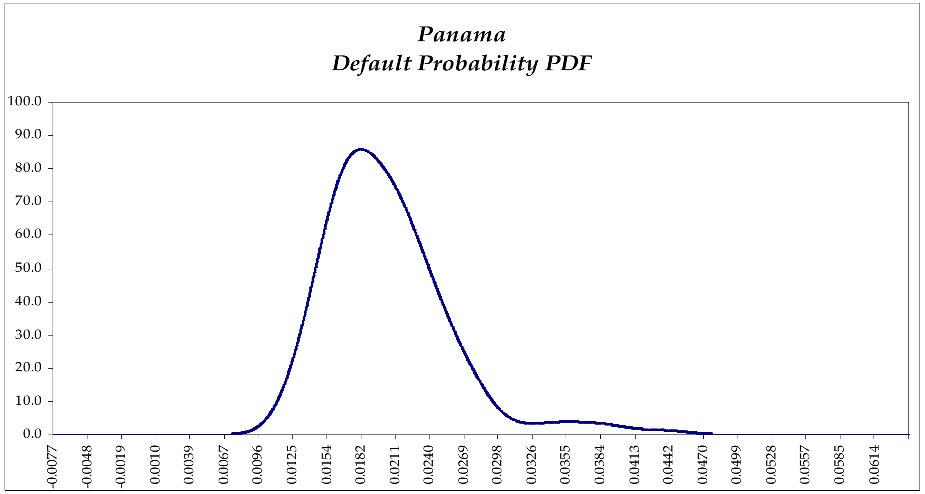
0.2932
0.3101


Panama
Default Probability PDF
100.0
90.0
80.0
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
-0.0077
-0.0048
-0.0019
0.0010
0.0039
0.0067
0.0096
0.0125
0.0154
0.0182
0.0211
0.0240
0.0269
0.0298
0.0326
0.0355
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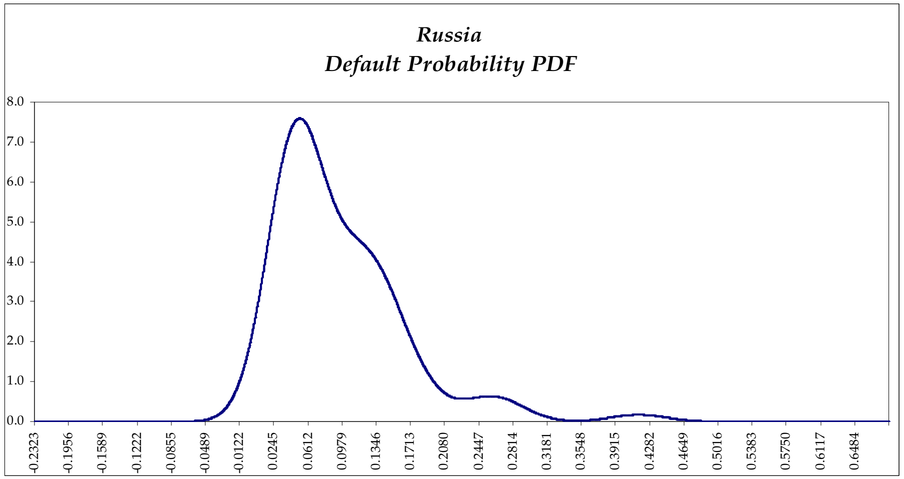
0.0528
0.0557
0.0585
0.0614


Russia
Default Probability PDF
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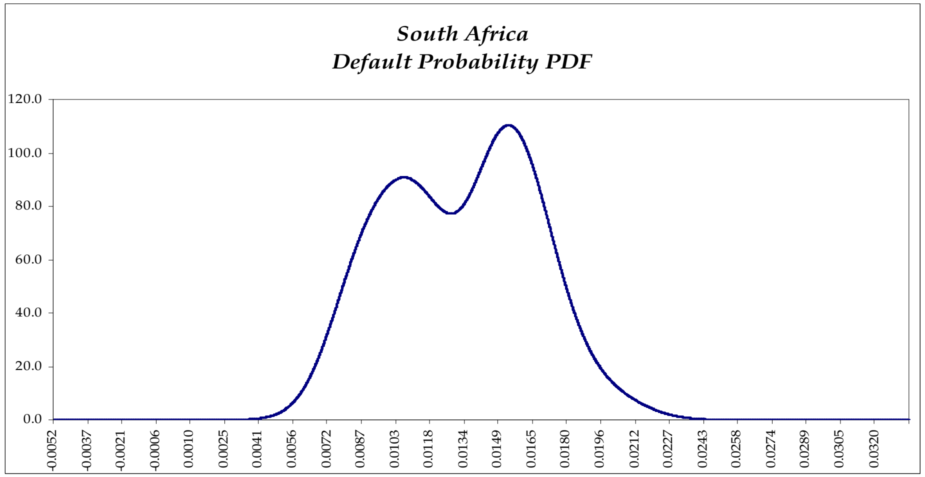
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
-0.2323
-0.1956
-0.1589
-0.1222
-0.0855
-0.0489
-0.0122
0.0245
0.0612
0.0979
0.1346
0.1713
0.2080
0.2447
0.2814
0.3181
0.3548
0.3915
0.4282
0.4649
0.5016
0.5383
0.5750
0.6117
0.6484


South Africa
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100.0
80.0
60.0
40.0
20.0
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-0.0052
-0.0037
-0.0021
-0.0006
0.0010
0.0025
0.0041
0.0056
0.0072
0.0087
0.0103
0.0118
0.0134
0.0149
0.0165
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0.0212
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0.0243
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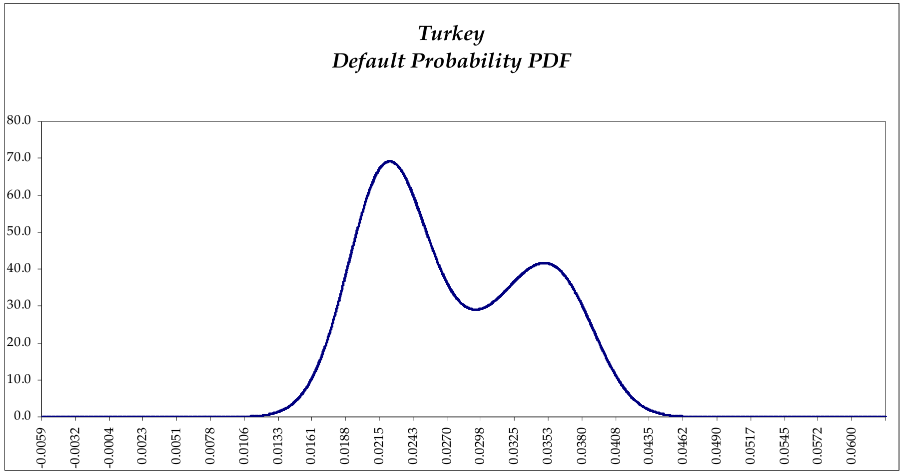
0.0274
0.0289
0.0305
0.0320


Turkey
Default Probability PDF
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70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
-0.0059
-0.0032
-0.0004
0.0023
0.0051
0.0078
0.0106
0.0133
0.0161
0.0188
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0.0243
0.0270
0.0298
0.0325
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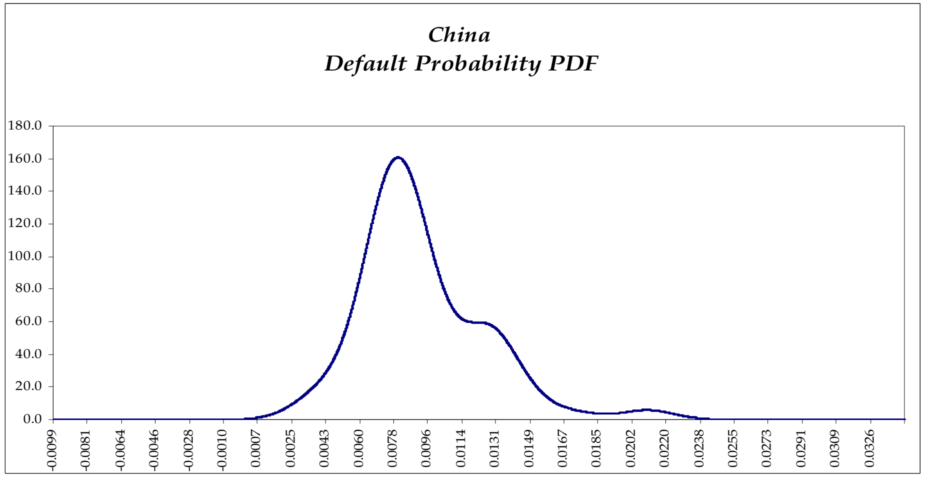
0.0572
0.0600


China
Default Probability PDF
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160.0
140.0
120.0
100.0
80.0
60.0
40.0
20.0
0.0
-0.0099
-0.0081
-0.0064
-0.0046
-0.0028
-0.0010
0.0007
0.0025
0.0043
0.0060
0.0078
0.0096
0.0114
0.0131
0.0149
0.0167
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0.0202
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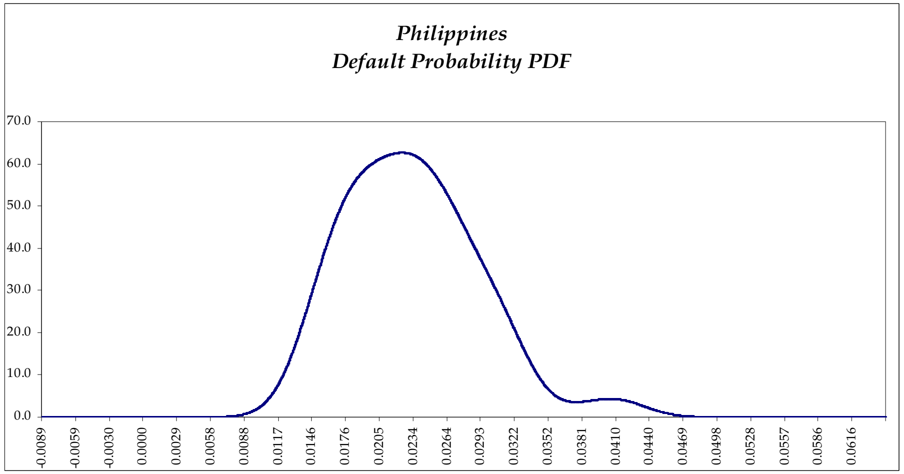
0.0238
0.0255
0.0273
0.0291
0.0309
0.0326


Philippines
Default Probability PDF
70.0
60.0
50.0
40.0
30.0
20.0
10.0
0.0
-0.0089
-0.0059
-0.0030
0.0000
0.0029
0.0058
0.0088
0.0117
0.0146
0.0176
0.0205
0.0234
0.0264
0.0293
0.0322
0.0352
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0.0469
0.0498
0.0528
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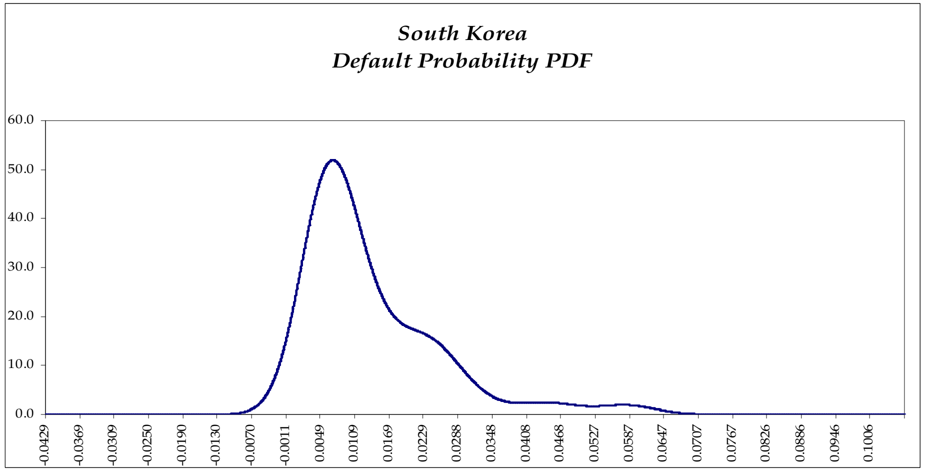
0.0586
0.0616


South Korea
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40.0
30.0
20.0
10.0
0.0
-0.0429
-0.0369
-0.0309
-0.0250
-0.0190
-0.0130
-0.0070
-0.0011
0.0049
0.0109
0.0169
0.0229
0.0288
0.0348
0.0408
0.0468
0.0527
0.0587
0.0647
0.0707
0.0767
0.0826
0.0886
0.0946
0.1006

# Figure 3

## Value at Risk at the 95% confidence level for the 7-bond portfolio