Bondi

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WHITEPAPER: TOKENIZED BOND PROTOCOL FOR EMERGING MARKET CORPORATE BONDS

Abstract. The democratization of financial markets and the advent of tokenization have significantly increased retail investors' access to investment opportunities. Bonds, which make up a major portion of global securities markets, are pivotal in this transformation. Although bond markets exceed $100 trillion in market cap[1], emerging market bonds constitute only 25% of this amount, highlighting a big gap.[2] Tokenized bonds offer improved liquidity, lower transaction costs, and greater accessibility, benefiting retail investors and firms alike. This whitepaper introduces Bondi, a tokenized bond protocol aimed at making emerging market corporate bonds available to retail investors, thereby increasing market participation and liquidity in underdeveloped financial systems. By October 2023, the value of tokenized assets on public blockchains had reached $118.57 billion[3], with projections suggesting it could grow to between $3.5 to $16 trillion by 2030.[4] As tokenization is poised for exponential growth, Bondi seeks to capitalize on this growth by addressing the challenges of illiquid corporate bond markets in developing countries, promoting financial inclusion and stability.

[1] https://www.weforum.org/agenda/2024/03/oecd-government-bonds-and-other-economic-stories-to-read/
[2] https://www.ashmoregroup.com/sites/default/files/article-docs/EV_Aug20_3_The_EM_fixed_income_universe_version_9.0.pdf
[3] https://www.21.co/research/the-state-of-tokenization
[4] https://cointelegraph.com/news/tokenized-assets-public-blockchains-ripple

Introduction

From the dawn of history until the modern era, productivity growth barely surpassed population growth until the invention of capital markets. The ability to raise funds quickly from a willing group of people changed the world in many ways. Fundamentally, this ability is the reason for the world order we know today.

The evolution of capital markets began in Europe in the late 13th century, the concepts of joint-stock companies and government debt gaining momentum. Stagnating productivity had left most people without hope for a better future and excluded most of the population from entrepreneurial ventures. Kings and emperors could only expand their land and wealth at the expense of their own subjects or other conquered peoples; conquests were financed by former plunders or heavy taxation.

By the late 17th century, absolute monarchies were weakened, republics were rising, and subjects were asserting their rights as citizens.

These developments enabled entrepreneurs to raise funds easily and establish flourishing businesses. In some cases, debt issuance was preferred instead of selling shares, giving rise to the need for corporate bonds. Additionally, states began borrowing from the public, offering interest in return, a far more advantageous arrangement than imposing burdensome taxes.

Consequently, over the course of 500 years, starting from the 1500s, global productivity per capita surged by an impressive cumulative 1600%, soaring from $550 to $8800 annually.[5]

Today, the 21st century is characterized by globalization, with the world becoming increasingly interconnected. Borders are becoming less significant, and capital is seeking new horizons to explore. Capital is plentiful on a global scale, and the significance of accessing foreign capital cannot be overstated.

The tokenization of real-world assets, particularly securities, has the potential to propel the next leap forward, increasing widespread access to financial markets around the world.

[5] Maddison, A. (2006), The World Economy: Volume 1: A Millennial Perspective and Volume 2: Historical Statistics, Development Centre Studies, OECD Publishing, Paris, https://doi.org/10.1787/9789264022621-en

Background

1. Bonds Explained

Deep capital markets are essential for a country's prosperity, distinguishing advanced
economies from emerging ones.

Most governments run budget deficits, as a result they turn to debt markets to finance public infrastructure projects and welfare programs. Similarly, corporations constantly need funding to expand their businesses or finance existing operations.

The debt securities market mainly refers to the "I owe you" papers called *bonds* issued by *sovereigns, municipalities,* or *corporates* that pay a fixed amount of interest. Investors loan their money to businesses and governments to receive a fixed amount of interest, the *coupon*, for a predetermined period of time, the *maturity* date. Most bonds pay a coupon every six months until the maturity date, at which the investor receives their initial capital, the *par value*, or the *face value*, along the last coupon of the bond. The *coupon rate* and the face value of the bonds are static and set at the *issuance*.

2. Importance of Bonds In Corporate Financing

Corporate bonds are a crucial financial instrument for both companies and investors. They provide companies with a reliable means of raising capital without diluting ownership, as would occur with equity financing. For investors, corporate bonds offer a relatively stable and predictable income stream, with the added benefit of priority over equity holders in the event of issuer default. This makes corporate bonds an attractive investment option, especially in uncertain economic times when equity markets are volatile.

In addition to providing a desirable investment venue for retail investors, a well-diversified and liquid bond market is crucial to meet the capital needs of the

corporate sector which still relies heavily on foreign financial markets and bank financing. A robust bond market expands the pool of potential investors, including sovereign wealth funds, life insurers, and pension funds, which are better equipped to provide stable, long-term financing compared to traditional banks.[6] [7] [8]

This diversification is particularly critical in times of financial distress when banks may drastically cut back on lending, as seen during the 2008 Financial Crisis when loan issuance to large borrowers dropped by 79% from peak levels.[9] A self sufficient bond market supplements the financial independence and freedom of developing markets in times of stagnant or recessive global economic conditions.

Moreover, banks charge a significantly higher premium on loan interest compared to the bond market. For secured term loans to non-investment-grade firms, the premium ranges from 140 to 170 basis points.[10] Additionally, the average maturity of a corporate bond is 10 years. Lower interest rates can lower the cost of borrowing to a substantial degree for a business, especially over longer durations. This cost efficiency makes bonds a more attractive financing option compared to bank loans.

3. Size and Growth

Globally, the market cap of bond markets was estimated to be between $100 trillion and $129.8 trillion in 2023, comparable in size to both global GDP and the global equities market. [11] [12]

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[6] Surti, Jay, and Rohit Goel. "CHAPTER 5 Corporate Debt Market: Evolution, Prospects, and Policy". India's Financial System. USA: International Monetary Fund, 2023. < https://doi.org/10.5089/9798400223525.071.CH005>. Web. 29 Jul. 2024

[7] World Bank. 2012. Turkey - Corporate Bond Market Development : Priorities and Challenges. © Washington, DC. http://hdl.handle.net/10986/12439 License: CC BY 3.0 IGO

[8] Attila Becsi & Gergely Bognar & Mate Loga, 2021. "The Growing Importance of the Economic Role of the Corporate Bond Market," Financial and Economic Review, Magyar Nemzeti Bank (Central Bank of Hungary), vol. 20(4), pages 5-37

[9] Victoria Ivashina, David Scharfstein, Bank lending during the financial crisis of 2008, Journal of Financial Economics, Volume 97, Issue 3, 2010, Pages 319-338, ISSN 0304-405X, https://doi.org/10.1016/j.jfineco.2009.12.001

[10] Schwert, Michael, Does Borrowing from Banks Cost More than Borrowing from the Market? (August 20, 2019). Journal of Finance, Forthcoming, Available at SSRN: https://ssrn.com/abstract=3059607 or http://dx.doi.org/10.2139/ssrn.3059607

[11] https://www.weforum.org/agenda/2024/03/oecd-government-bonds-and-other-economic-stories-to-read/

[12] https://www.sifma.org/resources/research/fact-book/

In the US, the outstanding value of bonds reached $51.9 trillion in 2023, surpassing the equity market's value of $40.3 trillion and increasing more than double by $30 trillion since 2008.[13] [14] Notably, the share of bonds, particularly corporate bonds, relative to other financing types has also increased significantly. Corporate bonds accounted for 34% of US corporate debt financing in 2023, up from 19% in 2000.[15]

Globally, the importance of corporate bond markets has also increased since 2008. Corporate bonds accounted for 19% of worldwide non-financial corporate debt in 2023, up from 10% in 2007 (Braun et al., 2008). The increase in the share of corporate bonds in corporate financing has been even more pronounced in emerging markets. In China, bond financing for corporate debt increased from 1% to 11% between 2001 and 2011. In Brazil, the increase was from 5% to 25%.[16]

These figures highlight the growing relevance of corporate bonds over the last two decades. The increasing share of corporate bonds in debt financing underscores their rising demand and importance in 2023, particularly in emerging markets.

Globally, non-financial corporations have increased their bond issuance nominally too. Corporate bonds have grown 2.7 times since 2007 to $11.7 trillion in worldwide value, tripling compared to global GDP increase. Yet, developing nations saw only a 1.92 times increase from $85 billion in 2007 to $164 billion in 2017.[17]

Although corporate bonds disproportionately increased their market share in corporate financing in emerging markets, nominal corporate bond issuance increased proportionally less than world average.

Furthermore, overall indebtedness as a percentage of GDP remains approximately twice as high for advanced economies compared to emerging markets and developing countries (EMDC)[18].

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[13] https://www.sifma.org/resources/research/fact-book/
[14] https://www.oecd.org/en/publications/2024/03/global-debt-report-2024_84b4c408.html
[15] Suresha S. (2023). Corporate bonds vis-a-vis bond market: Global economy. The Scientific Temper, 14(3):1014-1019
[16] Suresha S. (2023)
[17] Suresha S. (2023)
[18] Xiang Fang & Bryan Hardy & Karen Lewis, 2023. "Who holds sovereign debt and why it matters," BIS Working Papers 1099, Bank for International Settlements

In 2012, bond markets in the U.S. and other developed economies accounted for 222% and 109% of GDP, respectively, with bonds excluding government bonds representing 135% and 63% of GDP. Conversely, in India, other emerging Asian countries, and Africa, bond markets comprised 34%, 42%, and 39% of GDP, respectively, while bonds excluding government bonds represented a mere 8%, 13%, and 6% of GDP. Notably, by 2020, India's bond market had grown to 47% of GDP.[19]

4. Challenges in the Bond Markets

With the proliferation of tools that enable masses to more easily invest in and trade assets, retail investors have increased their presence in global financial markets. However, there are still significant obstacles that prevent them from fully participating in the debt market.

Even though electronic platforms have eased access for retail investors, a perfect market is still far from being available for bonds. Transaction costs and information asymmetry still remain high. In addition, issues like illiquid markets, inconsistent taxation and high settlement values make it prohibitive for retail investors to participate effectively.

Additionally, there are other persistent issues that prevent better integration of retail investors. The current public issue requirements are often perceived as too onerous, counter-productive, and time-consuming. As a result, in many emerging and underdeveloped economies, the private placement route is still preferred by most corporate bond issuers. Private placements lack the transparency and statutory disclosure obligations associated with public offerings. Since a significant share of the market is dominated by a select group of institutional repeat players, market dynamics are influenced more by mutual trust and reputational factors than by regulatory oversight. The lack of standardization and overall opacity in private placements can be attributed to these dynamics. Furthermore, since privately placed bonds are typically held by investors until maturity, they fail to provide the necessary liquidity in the secondary market, significantly affecting the growth of corporate debt markets in emerging and underdeveloped countries.[20]

[19] ASIFMA Paper: India Bond Market Roadmap - October 2013

[20] Schou-Zibell, Lotte & Wells, Stephen, 2008. "India's Bond Market-Developments and Challenges Ahead," Working Papers on Regional Economic Integration 22, Asian Development Bank

Corporate bond markets in most developing countries tend to be illiquid due to current offerings being offered in very high denominations for the average non-professional investor, coupled with infrequent, and often private issuing of the bonds.

The common practice in advanced economies is to proceed with public issues wheres private placements play a major part in emerging markets. In Vietnam and India, approximately 90% to 99% of the existing bonds are issued through private placements. However, private placements accounted for only 12% in the USA, 10% in Germany, and 0.4% - 15% in South Korea. [21] [22]

5. Financial Inclusion and Bond Markets

According to the United Nations Capital Development Fund (UNCDF), financial inclusion involves providing individuals and enterprises with access to a range of appropriate and responsibly offered financial services within a regulated framework. Financial inclusion is a key driver of economic development. By providing broader access to financial products and services, it improves the overall stability and growth of financial systems.

A strong debt market, with a balanced distribution between bank loans and bonds, is crucial for a cohesive and strong financial system. When a robust corporate bond market is established, it allows market dynamics to play a larger role in the economy, which helps in lowering systemic risk and preventing financial crises. This environment promotes better accounting transparency, a strong network of financial analysts, credible rating agencies, and a variety of corporate debt instruments and derivatives that require advanced credit analysis. It also ensures efficient processes for corporate restructuring and liquidation.[23] All these

[21] MB Securities Joint Stock Company, Vietnam Bond Market In the Readiness for Further Growth

[22] https://www.livemint.com/money/personal-finance/increasing-retail-investor-participation-in-corporate-bonds-the-case-for-a-smaller-ticket-size-11696785149518.html

[23] Hakansson, Nils H., The Role of a Corporate Bond Market in an Economy--And in Avoiding Crises (June 1999). IBER RPF-287, Available at SSRN: https://ssrn.com/abstract=171405 or http://dx.doi.org/10.2139/ssrn.171405

mechanisms, born out of necessity for the efficient working of bond markets, naturally result in the growth of the financial system, therefore improving financial inclusion.

In the US, households hold 19% of all corporate bonds and the remaining 81% is held by institutional investors, banks and other legal entities.

In Japan, for instance, only 5% of the total outstanding amount of corporate bonds was held by households at the end of 2013. In Japan, the largest investors by far were the banks and other financial institutions, including the financial institutions for small businesses, with 53% of the total amount.

Direct holdings of bonds by individual investors nevertheless vary a lot between European countries. In Italy, individual investor holdings of bonds comprise 20% or more of total financial holdings. In Germany, the equivalent percentage is between 10- 15%, and in other countries it will be typically lower than 5% the lowest figure being that for the UK (just 1.5%).

A survey by IOSCO (2011) on corporate bond markets in 36 emerging market economies
shows that the share of retail investors was 9% in 2010., displaying the demand for these products in emerging markets.[24] This figure is even higher than many of the advanced economies.

Introducing Bondi

Tokenized bonds represent a significant leap forward in promoting financial inclusion, particularly in emerging markets.

Bondi lowers the entry barriers for retail investors with tokenization, allowing them to participate in bond markets with investments as low as $100. The democratization of access is crucial for diversifying the investor base and promoting financial inclusion. By enabling smaller investments, Bondi opens up the bond market to a wider audience, including those who may not have previously considered bond investments due to high minimum investment requirements.

[24] Çelik, S., G. Demirtaş and M. Isaksson (2015), "Corporate Bonds, Bondholders and Corporate Governance", OECD Corporate Governance Working Papers, No. 16, OECD Publishing, Paris, https://doi.org/10.1787/5js69lj4hvnw-en.

Tokenized bonds provide lower costs and increased liquidity compared to their traditional counterparts. The transaction costs associated with bond issuance and trading can be significantly reduced. Traditionally, these processes involve multiple intermediaries and extensive paperwork, which are costly and time-consuming. Tokenized bonds eliminate many of the intermediaries, and processes are automated through smart contracts. This reduces costs and accelerates both issuance and transactions, improving market efficiency and appeal for issuers and investors alike.

Underwriting fees for issuing tokenized bonds are notably lower than those for conventional bonds, with a reduction of an average 0.22 percentage points of the bond's par value, representing a 25.8% decrease. Also, issuers can offer tokenized bonds at a lower yield spread, averaging 0.78 percentage points less than similar conventional bonds, translating to a 23.9% reduction in the yield spread at issuance. These cost savings make tokenized bonds a more attractive option for both issuers and investors.[25]

Moreover, tokenized bonds exhibit lower bid-ask spreads compared to conventional bonds. On average, the bid-ask spread for tokenized bonds is 0.035 percentage points lower, representing a 5.3% reduction. This difference becomes more pronounced when bonds are accessible to retail investors, potentially doubling to a 10.8% decrease. Furthermore, issuing tokenized bonds can positively impact the liquidity of conventional bonds from the same issuer, with an average bid-ask spread decrease of 0.049 percentage points, or 8.5%, following the issuance of a similar tokenized bond.[26]

Lower transaction costs also encourage more frequent trading, contributing to market liquidity and more effective price discovery, facilitating better trading conditions for both tokenized and conventional bonds.

Project Roadmap

[25] Institute for Monetary and Financial Research, Hong Kong, An Assessment on the Benefits of Bond Tokenisation (November 2023). Hong Kong Institute for Monetary and Financial Research (HKIMR) Research Paper 17/2023, Available at SSRN: https://ssrn.com/abstract=4624156 or http://dx.doi.org/10.2139/ssrn.4624156
[26] Institute for Monetary and Financial Research, Hong Kong, An Assessment on the Benefits of Bond Tokenisation (November 2023). Hong Kong Institute for Monetary and Financial Research (HKIMR) Research Paper 17/2023, Available at SSRN: https://ssrn.com/abstract=4624156 or http://dx.doi.org/10.2139/ssrn.4624156

The first stage of Bondi's roadmap is divided into two phases, spread to two quarters.

Actors

The ecosystem consists of four main actors: the protocol, the custodian broker, primary market investors, and secondary market investors.

1. The Protocol

The protocol is a Web3 application featuring both primary and secondary markets. For the first the website provides smart contracts for the funding and minting processes. In Phase 2, *steadyAMM*s that facilitate the secondary trading of bond tokens will be made available. Only registered users can mint the bond tokens, claim coupons, or receive the face value of the bonds on the protocol.

Basic Functions of the Protocol

A. Onboarding

Primary market investors are required to complete identity verification upon connecting their wallets to access the primary market. This process allows the protocol to ensure regulatory compliance by whitelisting investors.

Having users' personal information on record also enables the protocol to contact those who consent to receive notifications about updates, such as upcoming commitment deadlines and coupon dates.

B. User Dashboard

The user dashboard is where the users connect their whitelisted wallets to see and manage their investments. It features information about the tokenized bonds they hold such as prospectuses, credit ratings, and live market data. In addition, it allows them to claim their earnings at coupon dates and maturity.

C. Offboarding

The final holders of the bond tokens may be the original minters, or other investors who bought them on the protocol's secondary market or different DeFi markets. Nevertheless, account registration and identity verification is required to claim coupons or the face value of the tokens at maturity.

2. Custodian Broker

The custodian broker is a partner brokerage firm from which the protocol buys the bonds. It acts as the custodian and the fiduciary. After a funding phase is successfully completed, it receives the funds that are converted into fiat and credits the bonds to the protocol's account.

A. Responsibilities of the Custodian Broker

- **A.** Locating and selling the selected bonds to the protocol.
- **B.** Transferring the coupon payments to the protocol's account.
- **C.** Transferring the face value of the bonds to the protocol's account at maturity.
- **D.** Providing live market price data of the bonds for the steadyAMM oracles.
- **E.** Providing audit reports for the protocol's account holdings.

3. Primary Market Investor

Primary market investors are those who participate in the funding phase and the minting of the bond tokens. As long as the primary market investors hold on to their bond tokens, they hold the right to claim coupon earnings from the user dashboard. Users who wish to exit their positions partially or completely can sell their tokens on the protocol's exchange, effectively becoming secondary market investors. Those who sell a fraction of their original tokens are eligible to receive the coupon payments on the rest of their token holdings, the same goes for secondary market investors who buy fractions of tokens.

4. Secondary Market Investor

Once the bonds are minted, they can be traded on the protocol's exchange that features the steadyAMM. The users who wish to buy the tokens on the secondary markets are not required to go through an identity verification process and can simply connect with their wallets as long as their wallets aren't on any blacklists.

Mechanisms

1. The Primary Market

The primary market is where the smart contracts for the funding phase are listed. It has a permissioned structure, allowing only registered users who complete identity verification to participate. The target investment amount for each contract is $200,000. To gauge market demand and reward early adopters, Bondi employs a two-step funding phase for Phase 1. Initially, investors commit 10% of their intended investment amount to the smart contract. Once the total commitments reach 10% of the target amount, investors are expected to fulfill their remaining commitments to receive *OG* NFTs, the only way to guarantee highest allocation in the future Bondi token generation event. If the target investment amount is not reached by the end of the the three-month funding phase period, the smart contracts refund the initial commitments back to the investors.

A. The Funding Phase

$T = \$200,000$, where T is the target amount.

C_i is the total commitment of the i-th investor and the initial commitment of C_i is $C_{i,initial}$, calculated as follows:

$$C_{i,initial} = 0.1 \times C_i$$

The total initial commitments $C_{total,initial}$ must reach at least 10% of the target amount:

$$C_{total,initial} = \sum_{i=1}^{n} C_{i,initial} \geq 0.1 \times T$$

where n is the number of investors.

If 10% of the target investment amount T is collected, investors have until the end of the funding phase to fulfill their remaining commitments $C_{i,remaining}$:

$$C_i - C_{i,initial} = 0.9 \times C_i$$

The total remaining commitments $C_{total,remaining}$ must be paid until the end of the funding phase:

$$C_{total,remaining} = \sum_{i=1}^{n} C_{i,remaining}$$

If the total commitments do not reach 10% by the end of the 90-day funding period, the smart contract refunds the initial investments to the investors.

After the funding phase is successfully completed, the funds are converted to fiat, and the custodian broker completes the bond purchases.

2. The Secondary Market, steadyAMM

The steadyAMM serves as an exchange that enables the trading of bond tokens. Since the bond tokens cannot be redeemed before maturity, primary market investors who want to exit their positions have to use the secondary market to sell their tokens. It has a permissionless structure, providing a DeFi-like experience where prospective investors may simply connect their wallets (as long as they are not blacklisted) and conduct trades.

The constant product formula of Automated Market Makers (AMMs) is used to determine the price of two assets in relation to each other mathematically. The formula ensures that the product of the quantities of two tokens in the liquidity pool remains constant. This formula is represented as:

$$x \cdot y = k$$

where:
- x is the quantity of token X (e.g., bond token) in the liquidity pool.
- y is the quantity of token Y (e.g., a stablecoin) in the liquidity pool.
- k is a constant that remains unchanged.

Although the well-known constant product function dictates the price changes, we propose two key modifications to the standard constant product function for the purpose of trading bond tokens:

A. Price Boundaries

We recognize that bond tokens may exhibit limited liquidity at the beginning, potentially leading to significant price discrepancies between the protocol's secondary market prices and the real-world market prices. To ensure price stability, we integrate circuit breakers when prices reach $\pm 5\%$ of the oracle price, only allowing trades on the opposite direction. The oracle price is fetched from live market data.

To maintain the price of the Bond Tokens within $\pm 5\%$ of the oracle price, the following boundaries are defined:

Oracle Price P_o: The price of the bond tokens provided by the oracle.

Upper Bound P_{max}: $P_{max} = 1.05 \cdot P_o$

Lower Bound P_{min}: $P_{min} = 0.95 \cdot P_o$

Mechanism for Maintaining Price Range

1. Initialization

Users provide liquidity with initial quantities $x_{bondtoken}$ and y_{usd} such that the initial price of X equals the oracle price P_o:

$$P_o = \frac{y_{usd}}{x_{bondtoken}} \text{ in terms of } Y$$

2. Regular Supply and Price Calculation

Supply Dynamics

$$\Delta x_{bondtoken} = amount\ bought\ (-),\ or\ sold\ (+)$$

$$\Delta y_{usd} = \frac{k}{x_{bondtoken} + \Delta x_{bondtoken}} - y_{usd}$$

Price Calculation

$$X = \frac{y_{usd} + \Delta y_{usd}}{x_{bondtoken} + \Delta x_{bondtoken}} Y$$

3. Trade Execution and Price Bound Adjustments

When Buying Bond Tokens

Calculate P_{new} to ensure that it remains within the upper bound:

$$P_{new} = \frac{y_{usd} + \Delta y_{usd}}{x_{bondtoken} + \Delta x_{bondtoken}} \leq P_{max}$$

When Selling Bond Tokens

Calculate P_{new} to ensure that it remains within the lower bound:

$$P_{new} = \frac{y_{usd} + \Delta y_{usd}}{x_{bondtoken} + \Delta x_{bondtoken}} \geq P_{min}$$

The circuit breaker will be activated if P_{new} does not satisfy the conditions.

Note that the above calculations of price and supply do not account for the accrued coupon interest to which each bond is entitled. The modified calculation will not change the formula of P_{new} but will change its numerical outcome. This is discussed in the following section.

B. Accrued Interest

Accrued interest refers to the interest earned on a bond but not yet collected. Interest accumulates from the bond's issuance or coupon date until the next coupon date or maturity date. When buying or selling a bond through a broker, accrued interest is either credited to or debited from your account automatically. The steadyAMM model incorporates accrued interest into the supply and price calculations by integrating it into the pool, similar to traditional market practices.

Bond Token Sale

When an investor sells their bond tokens on the secondary market between two coupon dates, the pool pays the the accrued interest they earned during the period they held the tokens in addition to the market price.

Bond Token Purchase

When an investor buys tokens on the secondary market between two coupon dates, they pay the the accrued interest to the pool, accounting for the accrued interest of the liquidity provider's tokens.

$$Accrued\ Interest = \left(\frac{Coupon\ Rate}{Number\ of\ Coupons\ per\ Year}\right) \times \left(\frac{Days\ Since\ Last\ Coupon}{Days\ in\ Coupon\ Period}\right)$$

Adjusted Supply Dynamics of the AMM

Δc = accrued coupon: paid to the pool (+), paid from the pool (-)

$$\Delta x_{bondtoken} = amount\ bought\ (-),\ or\ sold\ (+)$$

$$\Delta y_{usd} = \frac{k}{x_{bondtoken} + \Delta x_{bondtoken}} - y_{usd} + \Delta c$$

As P_{new} is calculated using the Δy and Δx values determined by this adjustment, this does not alter the P_{new} formula above.

3. Coupon Disbursements

The bond tokens allow their holders to redeem coupon payments from the user dashboard when the date comes. A token holder does not have to hold a full token to redeem a coupon payment, a fractional owner can redeem coupon payments that correspond to their portion of a bond.

To qualify for coupon redemption, investors must meet the following requirements:

- The coupon an investor can claim corresponds to the amount of tokens they hold at the time of the coupon date.
- Only token holders who have a registered account are eligible.

4. Credit Rating System

Traditional credit rating systems may fall short due to biases and inadequacies in assessing the unique conditions of emerging markets. Furthermore, traditional credit ratings tend to constrain the rating with "sovereign-ceiling", which limits the highest credit rating a corporate issuer can receive to the sovereign rating of the country in which it is located.[27]

To evaluate the potential yield and credit risks posed by emerging market corporate bonds more accurately, we have developed the *Bond Spectrum Model*, a revised version of the modified Z-Score model developed by NYU Stern Finance Professor Edward Altman. The original Z-score model, which was also invented by Altman, incorporates certain financial metrics with corresponding coefficients depending on how much each affects the bankruptcy probability of US manufacturing companies. Altman later proposed a modified Z-Score, named Emerging Market Score (EMS), applicable to emerging market corporations from all industries. The EMS equation involves different financial metrics and coefficients, tailored to the bankruptcy risk factors relevant to these markets.

$$EMS = 6.56 \times X_1 + 3.26 \times X_2 + 6.72 \times X_3 + 1.05 \times X_4 + 3.25$$

where $X_1 = \frac{Working\ capital}{Total\ assets}$, $X_2 = \frac{Retained\ earnings}{Total\ assets}$, $X_3 = \frac{Operating\ income}{Total\ assets}$, and $X_4 = \frac{Book\ value\ of\ equity}{Total\ liabilities}$

[27] Altman, Edward. (2005). An emerging market credit scoring system for corporate bonds. Emerging Markets Review. 6. 311-323. 10.1016/j.ememar.2005.09.007

In the EMS model, a US equivalent firm must have been rated with the same methodology to establish a rating for an emerging market firm. To establish this, a roster of US debt issuers are first scored according to EMS (*Table 2*). After that, the EMS scores of the companies are matched with the original credit ratings they received from big credit rating agencies to establish a benchmark for each score. To letter-rate an emerging market firm, its EMS score is calculated, and the firm is given the corresponding letter grade of a US firm with the same EMS score.

Consequently, the final credit rating reached by the EMS model (Modified Rating Column on *Table 1*) is the letter grade obtained above, adjusted by notches based on company and emerging market specific criteria proposed by Altman.

Company	Industry	EM SCORE	Bond-Rating Equivalent	Modified Rating	Ratings M/S&P/D&P
Aeromexico	Airlines	-4.42	D	D	NR/NR/NR
Apasco	Cement	8.48	AAA	A	Ba2/NR/NR
CCM	Supermarkets	4.78	BB-	B+	NR/NR/NR
Cemex	Cement	5.67	BBB-	BBB-	BA3/BB/BB
Cyndsa	Chemicals	4.67	BB-	B+	NR/NR/NR
DESC	Conlomerate	4.23	B	BB+	NR/NR/NR
Empresas ICA	Construction	5.96	BBB	BB	B1/BB-/B+
Femsa	Bottling	6.37	A-	BBB+	NR/NR/NR
Gemex	Bottling	5.40	BB+	BB+	BA3/NR/NR
GIDUSA (Durango)	Paper and Forest Products	4.61	B+	BB	B1/BB-/NR
GMD	Construction	4.85	BB	B-	B1/BB-/NR
Gruma	Food Processing	5.56	BBB-	BBB+	NR/NR/NR
Grupa Dina	Auto Manufacturing	5.54	BBB-	BB+	NR/NR/B
Hylsamex	Steel	5.51	BBB-	BB	NR/NR/NR
IMSA	Steel	5.45	BBB-	BB-	NR/NR/NR
Kimberly-Clark de	Paper and Forest Products	8.96	AAA	AA	NR/NR/NR
Liverpool	Retail	9.85	AAA	A+	NR/NR/NR
Moderna	Conglomerate	5.28	BB+	BB+	NR/NR/NR
Ponderosa	Paper and Forest Products	6.64	A	BB	NR/NR/NR
San Luis	Autoparts	2.69	CCC	CCC-	NR/NR/NR
Sidek	Congromerate	4.68	BB-	B	NR/NR/CCC
Simec	Steel	4.42	B+	B-	NR/NR/CCC
Situr	Hotel and Tourism	5.17	BB+	B	NR/NR/CCC
Synkro	Textile / Apparel	1.59	CCC-	CCC	NR/NR/NR
TAMSA	Steel Pipes	3.34	CCC+	B	NR/NR/NR
TELMEX	Telecommunications	957	AAA	AA	NR/NR/NR
Televisa	Cable and Media	7.29	AA	BBB+	BA2/BB-/NR
TMM	Shipping	5.34	BB+	BB+	BA2/BB-/NR
Vitro	Glass	5.18	BB+	BB	BA2/BB-/NR

M = Moody's Investor Services
S&P = Standard & Poor's
D&P = Duff & Phelps (now FITCH)

Table 1

Table 1 exhibits the letter grades which the evaluated firms received under Altman's EMS model compared to the ratings they received from the "big three"

credit rating agencies. The “Modified Rating” column displays the rating results from Altman’s model. Meanwhile, The “Ratings M/S&P/D&P” column displays the ratings given by the credit rating agencies. The effects of credit rating agency bias is clear, as Altman’s model rated the firms significantly higher.

In addition to notch adjustments according to company-specific circumstances, we propose one new adjustment criterion and modify the use of the existing but unquantifiable US corporate -EM sovereign yield differential.

US Equivalent rating	Average EM Score	Sample Size
A A A	8.15	8
AA+	7.60	-
AA	7.30	18
AA-	7.00	15
A+	6.85	24
A	6.65	42
A-	6.40	38
BBB+	6.25	38
BBB	5.85	59
BBB-	5.65	52
BB+	5.25	34
BB	4.95	25
BB-	4.75	65
B+	4.50	78
B	4.15	115
B-	3.75	95
CCC+	3.20	23
CCC	2.50	10
CCC-	1.75	6
D	0.00	14

Source In-Depth Data Corp. Average based on over 750 US industrial corporates with rated debt outstanding; 1994 Data.

Table 2

A. The Bond Spectrum Model

We offer an innovative approach to credit ratings by establishing a color-rated system. This system is designed to be more user-friendly by simplifying complex letter-rated systems.

The color spectrum corresponds to numbers between 0-100. In order to achieve this using the EMS model, we need to normalize the EMS as well as the modification parameters, which are notches.

Our system also includes a community-driven *Investor Feedback Score* as the final parameter, allowing investors to share feedback through color ratings for a more intuitive and consistent experience.
To calculate the normalized EMS, EMS_n,we use the following formula:

$$EMS_n = \frac{EMS_{corporate} - EMS_{min}}{EMS_{max} - EMS_{min}} \times 100, \text{ where}$$
$$EMS_{min} = 1.75 and EMS_{max} = 8.15$$

Using the EMS ranges in *Table* 2, we bound the EMS pragmatically between the maximum and minimum EMS that could be practically received by the companies of which bonds would be offered on the our bond protocol. As a result, the Bond Spectrum Model directly eliminates any bonds from issuers that fall outside these bounds.

In order to normalize the “notch” modification parameter used by Altman, we determine the number of notches available in the letter-grading scheme used by him. The scheme has 22 notches between AAA and D. This means that each notch corresponds to a change of $100/22 \approxeq 4.54$ points in our normalized EMS score between 0-100. After normalizing the EMS and integrating our additional criteria, the result is rounded to the closest integer and matched to a color as follows:

$$\begin{cases} \text{Blue} & \text{if } EMS_n \geq 80 \\ \text{Green} & \text{if } 60 \leq EMS_n < 80 \\ \text{Yellow} & \text{if } 40 \leq EMS_n < 60 \\ \text{Orange} & \text{if } 20 \leq EMS_n < 40 \\ \text{Red} & \text{if } EMS_n < 20 \end{cases}$$

B. The Modification Criteria

It is important to note that the EMS model allows analysts to further adjust the existing modification criteria as they see fit. However, we adhere to the limits set by Altman regarding the extent to which each criterion can impact the final EMS.

1. Adjust for Foreign Currency Devaluation Vulnerability

The adjustment according to this modifier is made by assigning a high, neutral, or low currency devaluation vulnerability depending on:

FX revenue / FX interest cost
FX revenue / FX debt
FX holdings / FX debt due next year

Rate modification according to FX vulnerability is:

High = 3 Notches
Neutral = 1 Notch
Low = No change

Since each notch corresponds to 4.54 points in our numeric rating system between 0-100, this modifier may reduce the EMS between 3×4.54 and 1×4.54 . a

2. Adjust for Industry Risk

The firm's industry is determined and the industry's corresponding "Average Sector Credit Safety" rating is compared with the firm's letter rating.

Company	Average Sector Credit Safety
Telecommunication	High A
Independent Fiannce	High A
Natural Has Utilities	High A
Beverages	High A
High Quality Electric Utilities	High A
Railroads	High A
Food Processing	Mid A
Bottling	Mid A
Domestic Bank Holding	Low A
Tobacco	Low A
Medium-Quality Electric Utilities	Low A
Consumer Products Industry	Low A
High Grade Diversified Mfg./Conglomerates	Low A
Leasing	Low A
Auto Manufacturers	Low A
Chemicals	Low A
Energy	Low A
Natural Gas Pipelines	High BBB
Paper/Forest Products	Mid BBB
Retails	Mid BBB
Property & Casualty Insurance	Mid BBB
Aerospace / Defense	Mid BBB
Information / Data Technology	Mid BBB
Supermarkets	High BB
Cable and Media	High BB
Vehicle Parts	High BB
Textile / Apparel	High BB
Low-Quality Electric Utilities	Mid BB
Gaming	Mid BB
Restaurants	Mid BB
Constructions	Mid BB
Hotel / Leisure	Mid BB
Low-Quality Manufacturing	Mid BB
Airlines	Low BB
Metals	High B

Table 3

For every three notch difference between the firm's rating and the sector rating, the firm's rating is adjusted by one notch, corresponding to 4.54 points in our normalized EMS.
For example:

≤ 3 notch difference

$\pm$ One notch = 4.54 points

3 to 6 notch difference

$\pm$ Two notches = 4.54 $\times$ 2 points

3. Adjust for Competitive Position

A corporate's rating can be adjusted by a maximum of one notch ($\pm$ 4.54 points) in either direction according to the following parameters:

Industry dominance
Domestic power in terms of size
Political influence
Quality management

4. Adjust for Special Debt Issue Features

Unique features of the issued bond are taken into consideration such has collateral or high-quality guarantors to further modify the rating. There are no predetermined "notch" amounts, therefore the modification amount is up to the analyst.

There are two additional modification criteria in the *Bond Spectrum Model*.

5. Adjust by Comparing to US corporate spread and sovereign spread

In the original EMS, this is actually proposed as an absolute parameter that decides if a corporate bond is worth investing or not. To calculate:

a = US corporation of equal rating with the EM corporate – 10-Year US Treasury
b = EM corporate's 10y sovereign – 10-Year US Treasury

$If\ EM\ corporate's\ yield > (a + b + 10 - Year\ US\ Treasury)$, then the bond is a good investment according to the EMS model.

Instead, we propose a modifier:

For each 10% difference between EM corporate's yield and ($a + b$), modify the score by $\pm$1.52 points in the appropriate direction.

6. Adjust by Investor Feedback SCORE

Investors assign a rating, R, to each corporate based on a five-color scheme. Each color represents the mean of 5 portions of our 0-100 numeric range.

$$R = \{Blue\ 90\ Green\ 70\ Yellow\ 50\ Orange\ 30\ Red\ 10$$

Average Investor Feedback is then calculated as the mean of all investors' ratings.

If modified EMS − Average Investor Feedback results in:

-90 to -40 points difference, adjust by +10 points
-40 to +40 points difference, adjust by ±5 points
+40 to +90 points difference, adjust by -10 points

Case for Emerging Market Corporate Bonds

There is a strong case to make for emerging market corporate bonds based on historical evidence. Since the year 2000, emerging market corporate bonds have yielded higher returns compared to their U.S. counterparts. Moreover, these bonds have exhibited lower default rates than their U.S. counterparts over the last four decades.

1. Comparing Investment Grade Bonds

Emerging market corporate bonds offer higher yields compared to their counterparts in U.S. markets. Investment-grade emerging market corporate bonds, as reported by the ICE BofA High Grade Emerging Markets Corporate Plus Index, had an average yield of 4.86% between 2000 and 2024. In comparison, the average yield of investment-grade U.S. corporate bonds, taken from 5-Year High Quality Market (HQM) Corporate Bond data provided by the U.S. Treasury, and the ICE BofA BBB US Corporate Index, was 4.41% over the same period. The average yield on "risk-free" 5-year U.S. Treasuries during this time was 2.71% per year. Consequently, investment-grade emerging market corporate bonds offered a 10.20% risk premium over investment-grade U.S. corporate bonds and a 79.34% premium over U.S. government debt.

Between 1981 and 2023, the default rate for investment-grade emerging market corporate bonds averaged 0.07% annually and 1.5% over a cumulative 10-year period. In comparison, investment-grade U.S. corporate bonds had a default rate of 0.11% annually and 2.37% over a cumulative 10-year period during the same period. This indicates that the default risk for investment-grade U.S. corporates

over emerging market corporates has been on average 58% higher for a cumulative 10-year period over the last four decades. Notably, there were no defaults in 2022 and 2023 for investment-grade emerging market corporate bonds.[28]

2. Comparing High-Yield Bonds

High-yield emerging market bonds provided even greater returns with an average yield of 9.46% over the same period, according to the ICE BofA High Yield Emerging Markets Corporate Plus Index. In comparison, high-yield U.S. corporate bonds yielded only 8.32%, according to the ICE BofA High Yield Index. Thus, high-yield emerging market bonds had a 13.70% risk premium over their U.S. counterparts and a 94.65% premium over investment-grade emerging market bonds.

For high-yield emerging market corporate bonds, the default rate averaged 2.58% annually and 12.7% over a cumulative 10-year period from 1981 to 2023. In contrast, high-yield U.S. corporates had a default rate of 3.95% annually and 22.22% over a cumulative 10-year period during the same timeframe. Therefore, the average default risk for a cumulative 10-year period for high-yield U.S. corporate bonds has been 74.96% higher than that for high-yield emerging market bonds over the last four decades. Additionally, the annual default rates of high-yield emerging market corporate bonds for 2022 and 2023 were lower than the average, at 2.38% and 2.1% respectively.[29]

Despite offering higher yields, emerging market corporate bonds are also less risky than their U.S. counterparts. This combination of higher returns and lower risk makes emerging market corporate bonds an attractive option for investors seeking better yields without significantly increasing their risk exposure.

Conclusion

[28] https://www.spglobal.com/ratings/en/research/articles/240328-default-transition-and-recovery-2023-annual-global-corporate-default-and-rating-transition-study-13047827

[29] https://www.spglobal.com/ratings/en/research/articles/240328-default-transition-and-recovery-2023-annual-global-corporate-default-and-rating-transition-study-13047827

Bondi Finance addresses challenges in the emerging market corporate bond sector by using tokenization to make high-yield investments more accessible. This approach improves liquidity, lowers transaction costs, and supports financial inclusion.

Emerging market corporate bonds provide higher yields and lower default rates compared to their U.S. counterparts. The Bond Spectrum Model offers precise and easy-to-understand credit ratings tailored to these markets, incorporating investor feedback for a more adaptive investment process.

By enabling smaller investments and simplifying processes with smart contracts, Bondi increases efficiency and accessibility in bond investing. This protocol offers better returns, lower risks, and broadens access to the financial market for all investors.