Bondi

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WHITEPAPER: TOKENIZED BOND PROTOCOL FOR EMERGING MARKET CORPORATE BONDS

Abstract. Tokenization and the push for financial democratization are expanding investment access for retail investors. Bonds, which make up a major portion of global securities markets, will play a crucial role in this transformation. Despite global bond markets surpassing $100 trillion[1], emerging market bonds account for only 25%[2], underscoring their underrepresentation and limited accessibility. Tokenized bonds offer improved liquidity, lower transaction costs, and greater accessibility, benefiting investors and issuers alike. We introduce Bondi, a tokenized bond protocol designed to open access to emerging market corporate bonds for small-to-mid portfolio managers, crypto treasuries, and retail investors, thereby increasing market participation and liquidity in underdeveloped financial systems. By October 2023, 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 it by addressing the challenges of illiquid corporate bond issues in emerging markets, 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 from a willing group of investors didn't just accelerate economic development; it reshaped societies and laid the foundation for the modern world.

The first signs of modern capital markets emerged in 13th-century Europe with the rise of joint-stock companies and government debt. Before this, economic progress was stagnant, and entrepreneurial opportunities were limited to the elite. Kings and emperors expanded their power at the expense of their subjects, financing conquests through plunder or heavy taxation.

By the late 17th century, absolute monarchies were giving way to republics, and financial markets were thriving. Entrepreneurs could now raise capital more easily, and in many cases, issuing debt was preferable to selling equity—giving rise to corporate bonds. Meanwhile, states began borrowing directly from the public, offering interest in return, a far more efficient alternative to burdensome taxation.

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, capital moves more freely than ever, and access to foreign investment is a critical advantage. Yet, barriers remain. Tokenization of real-world assets, particularly securities, represents the next leap in financial innovation, expanding global market access like never before.

[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 primarily comprises instruments generally referred to as bonds. These are essentially contracts where an issuer -such as a government, municipality, corporation, or other entity- borrows funds from investors in exchange for periodic interest payments and eventual repayment of the principal at an agreed-upon maturity date. While many traditional bonds pay a fixed interest rate (the coupon) on a set schedule until maturity, there is significant variation in bond structures. Some bonds offer variable or floating interest rates, while others may pay no coupon at all (zero-coupon bonds) and instead are issued at a discount to their face value. Additionally, certain bonds can be callable, puttable, convertible into equity, or tied to inflation or other economic indicators. In general, at maturity, most bonds return the initial principal amount (often referred to as the par or face value), though the terms and conditions differ widely depending on the specific type of bond.

2. Importance of Bonds In Corporate Financing

Corporate bonds are important financial instruments 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,

in emerging markets, still relies heavily on foreign financial markets and bank financing. An established 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 emerging markets in times of stagnant or recessive global economic conditions.

Additionally, borrowing with bonds tend to give companies more desirable conditions for their loans. The covenants of bonds tend to be less restrictive for the issuers, and on average, bonds have longer maturity profiles compared to bank loans.[10]

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]

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

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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] Cortina, Juan J., Tatiana Didier, and Sergio L. Schmukler. Corporate Borrowing and Debt Maturity: Market Access and Crisis Effects. January 2018.

[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/

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

While technological advancements enabled retail investors to significantly increase their participation in global financial markets. There are still significant obstacles that prevent them from fully accessing fixed-income assets.

Unlike equities, bonds lack efficient trading venues. Most transactions are done via OTC deals, which reduce the overall desirability of bond investing. OTC deals are particularly harmful to the development of the market because they promote information asymmetry and increase transaction costs thanks to the high involvement of intermediaries in transactions.

While corporate bonds issued by companies from advanced economies with developed bond markets usually allow trading in smaller denominations of around $1000, a large majority of emerging market corporate bonds have minimum settlement values of above $100,000 which makes them extremely illiquid and inaccessible. The illiquidity issue for these bonds is so dire that even hedge funds and other asset managers consider the illiquidity risk as a considerable concern when taking investment decisions that involve these instruments. In a landscape that so heavily discourages even investors with large amounts of capital, retail investors are almost completely left out.

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

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

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]

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 robust economy. When a large 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

[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

[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

ensures efficient processes for corporate restructuring and liquidation.[23] All these 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 showed that the share of retail investors was 9% in 2010. This figure is higher than many of the advanced economies, displaying the demand for these products in emerging markets.[24]

Introducing Bondi

Tokenized bonds mark a significant advancement in financial technology, offering greater accessibility, lower costs, and more liquidity than traditional bonds.

By using tokenization, platforms like Bondi remove barriers to entry for retail investors by allowing bond purchases from as little as $100. This broader access helps diversify the

[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

[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.

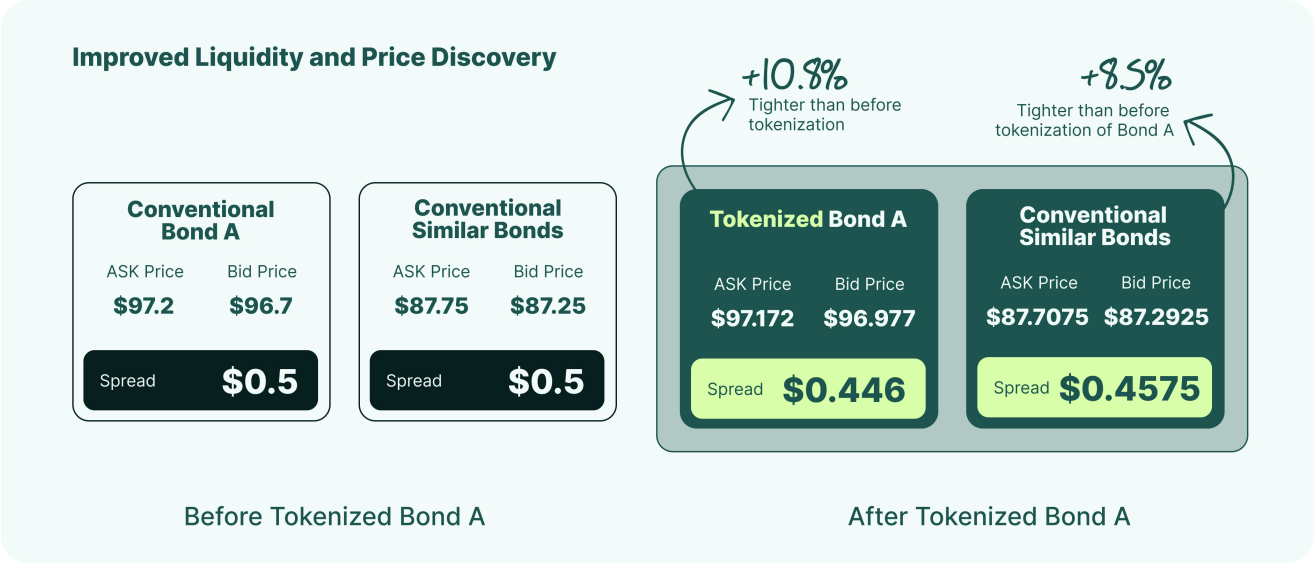
investor base and fosters greater financial inclusion. Individuals who were once deterred by high minimum investment requirements can now participate in the bond market, expanding its appeal.

Issuance and trading costs are also reduced through tokenization. In contrast to traditional bonds that involve multiple intermediaries and lengthy paperwork, tokenized bonds use smart contracts and automated processes that limit expenses. Underwriting fees, for example, decrease on average by 0.22 percentage points of the bond's par value, translating to a 25.8 percent reduction compared to conventional bonds. Issuers can also offer tokenized bonds at a yield spread that is 0.78 percentage points lower than that of similar conventional bonds, reflecting a 23.9 percent reduction at issuance. These cost savings benefit both issuers and investors.

Liquidity improves as well. Bid ask spreads for tokenized bonds decrease by an average of 0.035 percentage points, representing a 5.3 percent reduction. The benefit becomes even more pronounced when retail investors participate, reaching a 10.8 percent decrease. Furthermore, the presence of tokenized bonds can increase the liquidity of an issuer's conventional bonds, resulting in an average bid ask spread reduction of 0.049 percentage points, or 8.5 percent, after the issuance of a similar tokenized bond.[25]

Lower transaction costs also encourage more frequent trading and support better price discovery. As a result, both tokenized and conventional bonds trade under more favorable conditions, allowing a wider range of investors to participate and benefit.

[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



Institute for Monetary and Financial Research, Hong Kong, 2023

Bond Tokens

Bondi's Bond Tokens (BTs) are self-custodial, modified ERC-20 tokens fully backed by the bonds they represent. While they can be transferred permissionlessly, certain actions—such as minting, claiming coupon payments, and redeeming tokens at maturity—require identity verification to comply with regulations, as they interact with traditional finance.

Each BT corresponds to a specific bond, with a fixed face value of $100. The tokens follow a naming convention of "btXXX," where "XXX" reflects the first word of the issuer's name. BTs are designed to retain all the benefits of holding traditional corporate bonds while introducing the improved flexibility and efficiency offered by tokenization.

The most important feature of BTs is the fractionalization of the underlying asset. The majority of USD-denominated emerging market corporate bonds have a minimum settlement value exceeding $100,000. With a face value of $100 and a minimum tradable unit of 18 decimals, BTs significantly improve efficiency on the liquidity front.

1. Verification Requirements

There are three actions that a BT holder can interact with traditional markets and require KYC:

A. Minting

Bondi issues Bond Tokens (BTs) through a process that begins with pooling user funds in smart contracts known as “funding contracts”. These contracts serve as an offering period during which users commit their funds to the funding phase. Once the target amount is reached, the pooled funds are used to purchase bonds in traditional markets, and Bond Tokens are subsequently minted and distributed to participants (see the Primary Market section for a detailed explanation). To participate in a funding phase, users must first verify their identities by completing the KYC process via Bondi’s User Dashboard. Once verified, the user’s connected wallet is whitelisted, making it eligible to participate in funding phases. Importantly, any wallet approved to join a funding phase is automatically authorized to mint its Bond Tokens during the minting phase without requiring additional verification.

B. Claiming Coupons

On the bond’s coupon dates, Bondi receives the coupon payments in its brokerage account. Once received, these payments are converted to USDC through Bondi’s partners and deposited into the coupon disbursement smart contract. Any wallet holding Bond Tokens is entitled to claim a proportional share of the coupon payment based on the amount of tokens it holds. While Bond Tokens can be freely traded on secondary markets in a permissionless manner, claiming coupon payments requires the wallet owner to complete KYC verification to ensure compliance with regulations.

C. Redeeming the Principal

At the bond’s maturity date, the final coupon payment and the face value are paid by the issuer. These funds are then converted into USDC and deposited into the burning smart contract. The burning smart contract works similar to the coupon smart contract with one difference being the condition of burning the BTs to be able to claim the principal. Once the

funds are available in the contract, BT holders who have completed KYC can burn their tokens to redeem the principal amount along with the last coupon payment.

2. Call Feature

The call function of Bond Tokens (BTs) ensures that actions taken by bond issuers in traditional markets, such as early redemptions, are reflected onchain for token holders. In bond markets, bond issuers may exercise their right to redeem bonds before maturity on specific call dates at predetermined prices. For example, a bond maturing in June 2028 might have call dates in June 2025 at $103, June 2026 at $102, and June 2027 at $101. The issuer can choose to redeem the entire outstanding amount on any of these dates or allow the bond to reach maturity.

If the issuer opts for a partial redemption, a set percentage of the outstanding amount—such as 25%—may be redeemed on a given call date. Some bonds include additional clauses limiting the percentage or specifying conditions for early redemption. Bondi ensures that these traditional market actions are mirrored onchain by executing a forced transfer of the corresponding BTs from token holders, effectively retiring the tokens that represent the redeemed bonds. Token holders are able to claim the compensation of their retired BTs from the compensation smart contract by connecting to the User Dashboard.

3. Document Append Feature

The document append feature for Bond Tokens ensures that all critical bond-related documents, such as prospectuses and brokerage statements for purchasing and holding the underlying bonds, are accessible and verifiable. This feature also supports updates, enabling new documents to be appended while preserving a record of previous versions.

Actors

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

1. Bondi

Bondi serves as the platform where the primary and secondary markets for Bond Tokens (BTs) operate. During Phase 1, the protocol facilitates the funding and minting processes, enabling users to pool funds through smart contracts until a target investment amount is reached. Once funded, Bond Tokens are minted and distributed to investors. In Phase 2, the protocol will introduce steadyAMMs, which will allow users to trade BTs on a secondary market, ensuring liquidity and market accessibility. To maintain compliance, the protocol only allows verified users to mint tokens, claim coupons, or redeem bond principal.

Key functionalities include:

- **Onboarding:** Users complete identity verification to gain access to the primary market, ensuring that all participants meet compliance requirements.

- **User Dashboard:** Investors can manage their holdings, access live data, and claim their coupon payments or bond principal when due.

- **Offboarding**: At maturity, verified users can redeem their tokens in exchange for the bond's face value and final coupon payment.

2. Custodian Broker

The custodian broker acts as the link between traditional markets and the Bondi. It is responsible for acquiring the bonds once a funding phase is complete, holding them on behalf of the protocol, and ensuring accurate disbursement of coupon and principal payments. The broker also delivers regular audit reports to maintain transparency and trust.

3. Primary Market Investor

Primary market investors are participants in the funding phases, where they commit funds to mint Bond Tokens. Once minted, these investors hold the rights to the bond's coupon

payments and principal value at maturity. If they decide to exit their positions before maturity, they can sell their tokens on the secondary market. Investors who partially sell retain the right to earnings on their remaining holdings.

4. Secondary Market Investor

Secondary market investors engage with Bond Tokens after they have been minted and made available for trading on the protocol's exchange, powered by the steadyAMM. The steadyAMM provides a decentralized and efficient trading mechanism, allowing investors to buy and sell Bond Tokens freely. Unlike primary market participants, secondary market investors are not required to complete identity verification, provided their wallets are not blacklisted. The steadyAMM also enables price stability and seamless transactions, making it easier for new investors to enter the market and for existing holders to exit their positions as needed.

Mechanisms

1. The Primary Market

The primary market is where the initial funding for each bond issue takes place. Participation is open only to investors who have completed the required identity verification through the User Dashboard. Once verified, these investors can contribute a minimum of $100 during a predetermined funding window—e.g., 30 days—to help meet a specified target amount. If, for example, the target is set at $200,000, participants have until the deadline to collectively reach or surpass this total.

If the target amount is achieved in time, the pooled funds are then used to purchase the bonds from a regulated custodian broker. Should the target not be met by the deadline, the smart contracts automatically return all contributed funds to investors, ensuring that no participant is penalized for an unsuccessful funding round.

A. Clean and Dirty Prices

Bond purchases are executed at their dirty price, which includes both the clean price and accrued interest from the last coupon payment date up to the settlement date. However, the dirty price is only determined at the moment of purchase, meaning it is not used to set the target amount during the funding phase.

Instead, the target amount is calculated to ensure full funding by incorporating:

- The base amount (bond price multiplied by the number of bonds purchased)
- One full coupon payment collected upfront from all participants
- Service fees charged by third-party providers and minting fees collected by Bondi as commission
- Rounding up to the nearest $1,000 to account for price fluctuations and ensure sufficient funds

Once the bond purchase is completed, any excess accrued interest collected beyond what was required for the transaction is distributed back to token holders with the first upcoming coupon payment. This ensures fairness while streamlining fund management.

B. The Funding Phase

Users participate in Bondi's funding phases by depositing USDC into a smart contract. Once the target amount is reached, the funds are converted into USD and used to purchase bonds in traditional markets.

To ensure fairness:

- Everyone pays the same amount of accrued interest during the funding phase, preventing discrepancies in pricing.

- Early participants do not suffer from capital inefficiency. Bondi mitigates early commitment disadvantages by:
    - Deploying idle funds into tokenized treasury bills, which are considered riskless assets.
    - Loyalty NFT allocations that increase based on the time held before investment, ensuring greater rewards for early backers.

Once the bonds are acquired, Bond Tokens (BTs) are minted and distributed to participants in proportion to their contributions.

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 ±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 ±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

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

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

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 investors' accounts 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 wallet 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.[26]

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.

[26]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

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

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

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. For 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 credit ratings they received from

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. 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.

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	Conglomerate	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 Mexico	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
AAA	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.

To calculate the normalized EMS, EMS_n, we use the following formula:

$$\text{EMS}_n = \frac{\text{EMS}_{corporate} - \text{EMS}_{min}}{\text{EMS}_{max} - \text{EMS}_{min}} \times 100, \text{ where}$$

$$\text{EMS}_{min} = 1.75 \quad \text{and} \quad \text{EMS}_{max} = 8.15$$

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 $100/22 \approx 4.54$ 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.

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.

Sector	Average Sector Credit Safety
Telecommunication	High A
Independent Finance	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.

≤ 3 notch difference: ± One notch = 4.54 points

3 to 6 notch difference: ± Two notches = 4.54 × 2 points

3. ADJUST FOR COMPETITIVE POSITION

A corporate's rating can be adjusted by a maximum of one notch (± 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.

- **Senior Secured: +6.08 points**
- **Secured: +4.56 points**
- **Subordinated Secured: +3.04 points**
- **Senior Unsecured: +1.52 points**
- **Senior Preferred: 0 points**
- **Senior Non-Preferred: -1.52 points**
- **Senior Subordinated Unsecured: -3.04 points**
- **Subordinated Unsecured: -4.56 points**
- **Junior Subordinated Unsecured: -6.08 points**

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 10 Year sovereign bond − 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 1000 bps difference between EM corporate's yield and $(a + b + 10\ \ Year\ US\ Treasury)$, modify the score by ± 1.52 points in the appropriate direction.

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.[27]

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.[28]

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.

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

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

Conclusion

Bondi Finance aims to open up a part of the financial world that's often closed off to everyday investors. By using tokenization and a clearer way of measuring credit quality, we're making emerging market corporate bonds easier to understand and more straightforward to access. Instead of navigating opaque pricing, high minimums, and limited transparency, investors can now tap into opportunities that offer higher yields and more global diversification. Both investment-grade and high-yield segments have consistently delivered stronger returns, all while maintaining a lower default rate over an extended period compared to US counterparts. Taken together, these factors present emerging market corporate bonds as a favorable opportunity for investors.

Ultimately, Bondi Finance is part of a larger shift toward more inclusive, efficient markets. By lowering barriers, we hope to channel funds toward places that need them most, helping to foster growth and development in emerging economies. Over time, we believe these changes can bring more stability, opportunity, and fairness to the bond market.