



Analytical mind Case Championship

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Executive Summary

What is Machine learning, Artificial Intelligence and RPA ?

Machine Learning (ML) is a subfield of Artificial Intelligence (AI) that focuses on the development of algorithms and models that enable computers to learn and make predictions or decisions without being explicitly programmed. ML algorithms learn from and analyze large amounts of data to identify patterns, relationships, and insights. These algorithms are designed to improve their performance over time with experience, which is known as learning.

Artificial Intelligence (AI) is a broader field that encompasses the development of intelligent systems capable of performing tasks that typically require human intelligence. AI involves the simulation of human intelligence processes by machines, enabling them to perceive their environment, reason, learn, and make decisions. It aims to create systems that can mimic human cognitive functions such as speech recognition, problem-solving, decision-making, and visual perception.

Blockchain Technology-

How advanced analytical technology can change treasury management ?

Advanced analytical technologies like Artificial Intelligence (AI) and Machine Learning (ML) have the potential to revolutionize treasury management by enhancing efficiency, accuracy, and decision-making capabilities. These technologies are implementing in various sectors of treasury management further use cases are listed below:

- **Cash and liquidity management-** Cash forecasting, Derivative pricing, Streamlining collections, Actual reconciliation
- **Debt management-** Interest rates modeling, Loan Default probability
- **Forex risk management-** Derivative hedging, Exchange rates forecasting, Fraud detection
- **Investment management-** Building portfolio of company through reinforcement learning

With the rise in popularity of live chat software in banking and finance businesses. The combination of robo-advisors with chatbots is expected to automate the entire process in treasury management from transactions to maintaining balance sheets.

Cash and liquidity management

What is cash and liquidity management ?

Visibility into an organization's cash position, including location, currency, and liquidity position, is vital. With a timely and accurate picture of global cash across all banks and across all regions, treasury can **create more accurate forecasts and plan for expanded free cash flow**. Effective cash and liquidity management is essential for companies to maintain a **healthy balance sheet and liquidity position**. It helps ensure that a company is able to meet its short-term obligations and can take advantage of investment opportunities without needing to rely on additional financing. Proper cash and liquidity management also helps companies ensure they have enough liquidity to cover unexpected expenses and potential losses through previous investments that have been matured now.

How to implement AI-ML in cash and liquidity management ?

Cash forecasting- The old adage “cash is king” has not lost any of its relevance: a firm running out of cash will become insolvent. Meanwhile healthy, mature firms also have much to gain from accurate cash flow forecasting: they can maximize their returns by reducing the need for capital, be it in the form of loans, bonds or equity issued, and by allocating the available funds to the most promising projects.

The Weighted Moving Average, which linearly relates the current value of the time series to its earlier values. ARIMA allows the incorporation of seasonality at the expense of higher user-complexity. To take into account holidays with their significant impact on cash flows, we need multivariate methods. Here, Prophet enters the picture as a tool that promises to make forecasting easy and able to deal with holidays, thus offering two improvements on ARIMA. The plain-vanilla neural networks called multi-layer perceptrons (MLP) are our first choice. Long Short-Term Memory (LSTM) networks are specialized in sequences such as time series and will therefore complete our set of methods. The cost function yields a calculated value based on the difference between true values and those predicted by the model. Minimizing the cost function is the criterion used as a goal for estimating the model parameters, called optimization. The cost function for our type of prediction models usually is MSE—the mean of the squared values we introduce a new performance measure, Interest Opportunity Cost (IOC). IOC is a measure based on sound financial concepts that allows finance- specific comparisons of forecasting models. A method combines a model, cost function and optimization technique.

We computed IOC, MSE, mean average error (MAE) and the number of under- and overestimates for additional insights. The results are summarized in Table. It can be seen that both LSTM and MLP optimized for IOC, substantially outperform the other methods. When looking at MSE to evaluate our models, ARIMA clearly underperforms due to the squaring of the errors for the holidays, that it cannot account for. According to this measure, LSTM is the clear winner.

Methods		Measures			
Name	Optimizer	IOC	MSE	MAE	Under/over
<i>Advanced statistical methods and packages</i>					
ARIMA	N/A	0.23	74.04	4.20	61/39
Prophet	N/A	0.21	30.41	3.89	52/48
<i>Neural networks</i>					
MLP	MSE	0.24	32.36	3.90	51/49
MLP	IOC	0.10	33.94	3.14	19/81
LSTM	MSE	0.23	32.97	3.58	56/44
LSTM	IOC	0.09	17.94	2.73	18/82

The neural networks were optimized using both IOC and MSE. The IOC-optimized LSTM achieved the best results

Derivative pricing- The Black-Scholes formula is probably one of the most widely cited and used models in derivative pricing. However, the model is based on several assumptions. It assumes a specific form of movement for the derivative price, namely a Geometric Brownian Motion (GBM). It also assumes a conditional payment at maturity of the option and economic constraints, such as no-arbitrage. Several other derivative pricing models have similarly impractical model assumptions. Another aspect of the many traditional derivative pricing models is model calibration, which is typically done not by historical asset prices but by means of derivative prices


Machine learning can potentially be used to tackle these drawbacks related to impractical model assumptions and inefficient model calibration. Machine learning algorithms have the ability to tackle more nuances with very few theoretical assumptions and can be effectively used for derivative pricing


We know that derivative pricing is a nonlinear problem. The ANN and the related machine learning architecture can easily be extended to pricing derivatives in the real world, with no knowledge of the theory of derivative pricing. The use of machine learning techniques can lead to much faster derivative pricing compared to traditional derivative pricing models. New technology has commoditized the use of ANN, so it might be worthwhile for treasuries to explore these models for derivative pricing.

Actual reconciliation- AI and ML have incredible potential for cash management and forecasting, particularly when reconciling prior day bank files with yesterday's expected cash position. "This is one of the first cash management processes performed each day," said Bob Stark, vice president of strategy for Kyriba. "And for some organizations, the volume of transactions is so big that it can take hours and multiple people to do that reconciliation." Machine learning will learn from the user's manual reconciliation, so next time it will reconcile faulty transactions without human intervention.

Streamlining Collections- While RPA allows AR to automate the repetitive, manual tasks, machine learning algorithms can be used for more intricate work, like identifying patterns in transactions. With a top-tier company they have to manage a massive amount of transactions, going across currencies in different regions. So you do not have a 'one-size-fits-all' solution for disputes, credits or cash application. You really have to use machine learning algorithms to identify each customer's different payment patterns and deductions behaviors that they've had in the past.

What are success stories in cash and liquidity management ?

 In the case of the Indian bank, Accenture helped the bank to develop a new AI-powered platform that could detect life cycle and macroeconomic events for small and medium businesses. The platform uses a variety of data sources, including customer data, market data, and economic data. Accenture is a multinational professional services company that provides consulting, technology, and outsourcing services. The company has been working with banks around the world to help them adopt AI.

 The Indian automobile finance company used collection analytics to streamline its collection process and trained an ML model to identify a debtor's propensity to pay using data points such as gross amount owed and contact attempts. Mahindra Finance's use of data-driven techniques has helped the company to improve its collection process and to recover more loans. The company's collection efficiency has improved by 15% in the past year.

Debt management

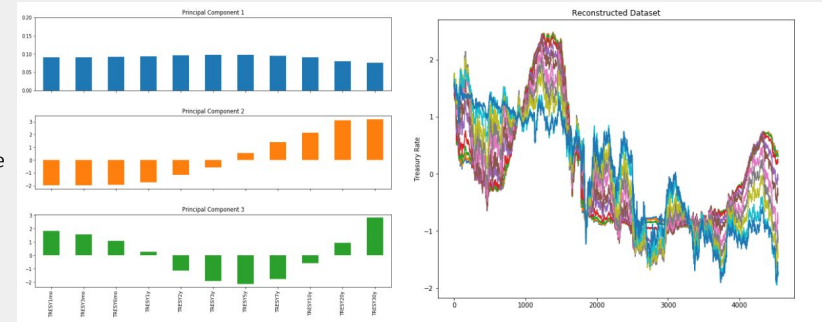
What is debt management ?

The treasurer is usually called upon to either manage a company's existing debt or procure new debt. In either case, this calls for a knowledge of the broad variety of debt instruments available, as well as dealing with credit rating agencies. It may also be necessary to have a working knowledge of the accounting, controls, policies, and procedures used to manage debt.

How to implement AI-ML in Debt management ?

Interest rates modelling- A yield curve represents interest rates, or yields, across a range of maturities, usually depicted in a line graph. The movement of various U.S.Treasury bond yields are captured by three factors, which are often referred to as level, slope, and curvature. The names describe how each influences the yield curve shape in response to a shock. The main effects of the shock to the curvature factor focuses on medium-term interest rates, leading to hump, twist, or U shaped characteristics. Dimensionality reduction breaks down the movement of the yield curve into these three factors.

We use PCA to generate typical movements of a yield curve. The first three principal components account for 84.4%, 14.08%, and 1.09% of variance, respectively. Cumulatively, they describe over 99.5% of all movement in the data. This is an incredibly efficient reduction in dimensions. We saw that the principal components are quite intuitive for this case study. The first three principal components explain more than 99.5% of the variation and represent directional movements, slope movements, and curvature movements, respectively. We use the data of 11 tenors (or maturities), from 1-month to 30-years, of Treasury curves. These are of daily frequency and are available from 1960 onwards.



Debt recovery/Loan default probability- Default prediction could be described as a perfect job for machine learning, as the algorithms can be trained on millions of examples of company data. Algorithms can perform automated tasks such as matching data records, identifying exceptions, and whether company can default the taken loan or wether in a position of taking a loan. This debt recovery analysis helps in creating a debt management plan (DMP) tailored to company's situation. DMPs roll unsecured debts into a single monthly payment, simplifying the repayment process. A debt attracts interest. Hence, higher debt and/or longer tenure imply more money lost towards interest payments. This affects the profitability and growth of the company, thus efficient debt management plan is essential. The gradient boosting method (GBM) model performs best in evaluating loan default probability measurement through various factors in a company.

What are success stories in debt management ?

HDFC BANK The leading private Indian bank that has implemented predictive analytics through regression and decision tree models to identify borrowers with a high tendency to default across segments. HDFC Bank is the largest private bank in India in terms of market capitalization. The bank has been using predictive analytics for several years to improve its lending decisions. HDFC Bank's predictive analytics models have been shown to be very accurate in identifying borrowers with a high tendency to default. This has helped the bank to reduce its loan defaults by as much as 20%.

LENDINGKART The non-deposit taking NBFC in India that uses non-traditional data points such as GST data, mobile data, product interaction data and social data in combination with ML techniques to evaluate the creditworthiness of applicants. Lendingkart's use of ML techniques allows the company to analyze large amounts of data quickly and efficiently. This helps the company to make more informed lending decisions and to reduce the risk of lending to borrowers who are not creditworthy. Lendingkart's use of non-traditional data and ML techniques has helped the company to grow rapidly. The company has disbursed over \$1 billion in loans to over 1 million borrowers.

Forex-Risk management

What is forex risk management ?

When a company accepts foreign currency in payment for its goods or services, it accepts some level of foreign exchange risk, since the value of that currency in comparison to the company's home currency may fluctuate enough between the beginning of the contract and receipt of funds to seriously erode the underlying profit on the sale. When dealing in foreign currencies, a company must determine its level of exposure, create a plan for how to mitigate that risk, engage in daily activities to implement the plan, and properly account for each transaction.


How to implement AI-ML in forex management ?

Derivative Hedging- Much of traditional finance theory for handling risk management is based on the idealized complete markets assumption of perfect hedgability, without trading restrictions, transaction costs, market impact, or liquidity constraints.. As a consequence, practical risk management using derivatives requires human oversight and maintenance; the models themselves are insufficient. Reinforcement learning algorithms, with their ability to tackle more nuances and parameters within the operational environment, are inherently aligned with the objective of hedging. This allows for automation of hedging without requiring frequent human intervention, making the overall hedging process significantly faster. The RL-based approach is model independent and scalable, and it offers efficiency boosts for many classical problems.




Exchange rate forecasting - AI algorithms can analyze vast amounts of historical data, market trends, economic indicators, and news sentiment to generate accurate exchange rate forecasts. By leveraging machine learning techniques, AI models can adapt and improve over time, aiding treasury teams in making informed decisions about hedging strategies and optimizing currency exposure. AI technologies can automate the execution of forex trades based on predefined rules and parameters. AI algorithms can analyze real-time market data, liquidity conditions, and transaction costs to execute trades at the most favorable rates and minimize slippage. This helps treasury departments optimize trade execution and reduce transaction costs.

Fraud Detection - Fraud is one of the most significant issues the finance sector faces. It is incredibly costly. According to one study, it is estimated that the typical organization loses 5% of its annual revenue to fraud each year. When applied to the 2017 estimated Gross World Product of \$79.6 trillion, this translates to potential global losses of up to \$4 trillion. Fraud detection is a task inherently suitable for machine learning, as machine learning-based models can scan through huge transactional datasets, detect unusual activity, and identify all cases that might be prone to fraud. Also, the computations of these models are faster compared to traditional rule-based approaches. By collecting data from various sources and then mapping them to trigger points, machine learning solutions are able to discover the rate of defaulting or fraud propensity for each potential customer and transaction, providing key alerts and insights for the financial institutions. We can use various classification-based models to detect whether a transaction is a normal payment or a fraud. A couple of models, including random forest (RF) and logistic regression (LR), perform well, GBM slightly edges out the other models.

What are success stories in forex-risk management ?

 **MANTRA LABS** Indian InsurTech company that provides AI-powered solutions for insurance companies after integration with an insurer's systems and can undertake claim analysis and fraud detection using a highly accurate AI decision engine. Mantra Labs' AI-powered solutions are used by some of the leading insurance companies in India, including ICICI Lombard, Bajaj Allianz, and HDFC Ergo. The use of AI by Mantra Labs is helping the insurance industry to improve the customer experience, reduce costs, and combat fraud.

There are many quant hedge funds and mutual funds that are using AI to enhance the way they analyze securities and make investment choices. Here are a few examples:

-  **TWO SIGMA** Two Sigma is a quantitative hedge fund that uses AI to analyze large amounts of data and make investment decisions. The company has been using AI for over 20 years and has seen significant success.
-  **AQR** CAPITAL MANAGEMENT AQR Capital Management is another quantitative hedge fund that uses AI. The company was founded in 1998 and has over \$100 billion in assets under management. AQR uses AI to analyze data from a variety of sources, including financial markets, economic data, and social media.
-  **Dimensional** Dimensional Fund Advisors is a mutual fund company that uses AI to build its investment portfolios. The company was founded in 1981 and has over \$600 billion in assets under management. Dimensional uses AI to analyze data from a variety of sources, including financial markets, economic data, and customer behavior.

Investment management

What is investment management ?

Surplus funds not needed for either operating purposes or compensating bank balances are available for investment. Prudent use of these funds can add to income, though the treasurer must consider a range of investment criteria, types of investments, and investment strategies before selecting the appropriate investment vehicle. The accounting, controls, policies, and procedures required for an ongoing investment program are essential part of investment management.

How to implement AI-ML in investment management ?

Building portfolio of Company- The most commonly used technique for portfolio allocation, mean-variance portfolio optimization, suffers from several weaknesses, including:

- Estimation errors in the expected returns and covariance matrix caused by the erratic nature of financial returns.
- Unstable quadratic optimization that greatly jeopardizes the optimality of the resulting portfolios

Reinforcement learning algorithms, with the ability to decide the policy on their own, are strong models for performing portfolio allocation in an automated manner, without the need for continuous supervision. Automation of the manual steps involved in portfolio allocation can prove to be immensely useful, specifically for robo-advisors. RL algorithms can be leveraged to solve complex and dynamic portfolio allocation problems. The trained RL-based model outperformed an equal-weight benchmark in the test set. The performance of the RL-based model can be further improved by optimizing the hyperparameters or using a longer time series for training. However, given the high complexity and low interpretability of an RL-based model, testing should occur across different time periods and market cycles before deploying the model. We should carefully select the RL components, such as the reward function and state, and ensure we understand their impact on the overall model results. The RL based model can perform portfolio allocation and rebalancing with a very flexible and automated approach.

What are success stories in investment management ?



Upside AI is a technology-driven asset management company that uses machine learning to identify undervalued stocks. The company's AI model is trained on a massive dataset of historical stock market data, and it uses this data to identify patterns and trends that can help predict future stock price movements. Upside AI's use of AI in investing has helped the company to achieve strong performance. The company's flagship fund, the Upside AI Top 250 Fund, has outperformed the Nifty 50 index by an average of 5% per year since its inception in 2016.



Happiest Minds is a digital transformation IT consulting and services company that uses AI in a variety of ways, including in investing. The company has a team of experts in AI and machine learning who are working to develop new ways to use AI to improve investment strategies. This company uses reinforcement learning to develop trading algorithms that can learn from historical data and make decisions in real time.

ChatGPT in Treasury

What is ChatGPT ?

The name ChatGPT contains a reference to the "Generative Pre-trained Transformer" technology that powers the chatbot. Transformers are a type of neural network that are particularly well-suited for natural language processing tasks. ChatGPT is trained on a massive dataset of text and code, which allows it to generate human-like conversational dialogue.

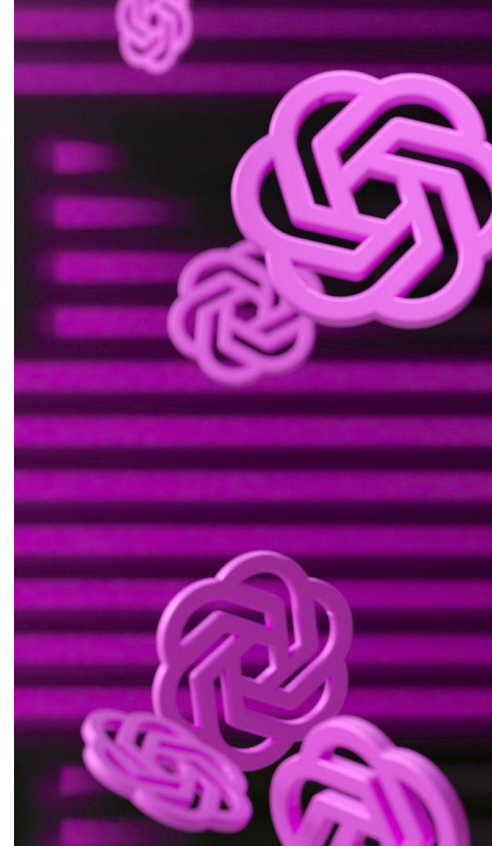
Uses of ChatGPT in Treasury management ?

Anomaly Detection- In the financial landscape, one of the earliest applications of NLP was implemented by the US Securities and Exchange Commission (SEC). The group used text mining and natural language processing to detect accounting fraud. The ability of NLP algorithms to scan and analyze legal and other documents at a high speed provides banks and other financial institutions with enormous efficiency gains to help them meet compliance regulations and combat fraud.

Sentiment Analysis- It can be used to help treasury managers make better decisions about things like investment strategies, risk management, and financing. For example, if sentiment towards a particular currency is becoming more negative, this could be a sign that the currency is becoming more risky and that treasury managers should consider hedging their exposure.

Chatbot digital assistant- The chatbot can facilitate bank account reconciliation by retrieving bank statements, categorizing transactions, and matching them with internal records, thereby improving efficiency and accuracy in the reconciliation process. Chatbot assistants can streamline bank account management processes. Chatbot assistants can improve communication between treasury teams and stakeholders, such as internal departments, senior management, and external partners. Users can interact with the chatbot to inquire about treasury policies, procedures, and guidelines, and receive instant responses. The chatbot can also provide updates on ongoing treasury initiatives, answer frequently asked questions, and direct users to relevant resources or documents, promoting self-service and reducing the need for manual interventions. Treasury professionals can interact with the chatbot to obtain up-to-date information quickly and conveniently, aiding in decision-making and analysis.

Document Summarization- Document summarization refers to the selection of the most important points and topics in a document and arranging them in a comprehensive manner. Document summarization using NLP can provide in-depth support in this analyzing and interpretation. When tailored to financial documents, such as earning reports and financial news, it can help analysts quickly derive key topics and market signals from content. Document summarization can also be used to improve reporting efforts and can provide timely updates on key matters. It can be used to analyze legal and regulatory documents, ensuring that organizations are complying with laws and regulations.



Blockchain in Treasury

How Decentralized Finance (DeFi) can improve Treasury Management ?

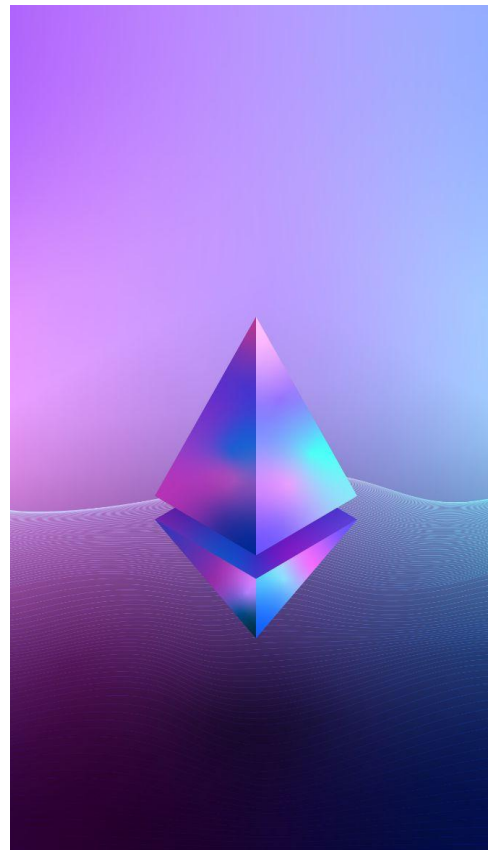
Decentralized finance (DeFi), enabled by blockchain, could bring about a new financial system, where peers will **interact directly**, with little or no place for traditional intermediation. However, some crucial tasks cannot be left solely to an algorithm and, consequently, most DeFi applications still require human decisions. The aim of this research is to assess the role of intermediation in the light of DeFi, analysing how humans and algorithms will interact.

How Decentralized Finance (DeFi) solves the problem of intermediaries ?

Intermediaries can be a problem in finance management because they may risk depositors' money on ill-judged investment schemes due to **poor management**. They also pursue their own interests and may recommend products that they either offer themselves or **receive a commission** from other providers. However, intermediaries can help create efficient markets and lower the cost of financial transactions. So far, there was no possibility to trace performing financial markets without relying on financial intermediation. Recently, the emergence of blockchain and DeFi show that “for the first time in human history, two or more parties, be they businesses or individuals who may not even know each other, can forge agreements, make transactions and build value without relying on intermediaries”

DeFi Protocols

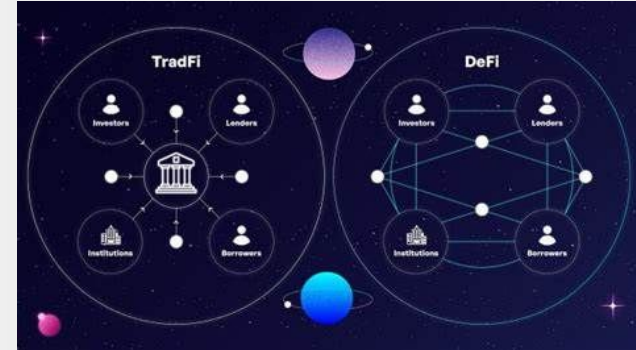
1. **Asset Pooling:** Protocols allow users to pool their crypto assets using smart contracts, which act as custodians. These pooled assets can be used for various purposes such as providing liquidity on decentralized exchanges (DEXs) or collateral in lending platforms (PLFs)
2. **Peer-to-Pool Model:** DeFi services are automated and deterministic, relying on the logic embedded in smart contracts. They don't require matching mechanisms or interactions with specific counterparties.
3. **Service Customers:** Users who actively demand liquidity through services like borrowing or swapping crypto assets pay fees or interest rates.



4. **Capital Providers:** Users who passively earn revenues by supplying liquidity and participate in **liquidity mining programs**. They take on risks, such as price fluctuations for liquidity providers (LPs), and their claims over locked assets are represented by tokenized assets.

5. **Incentive Mechanisms:** Protocols incorporate mechanisms like keepers, who initiate transactions for a fee that cannot be triggered automatically. Arbitrageurs conduct profitable trading activities to ensure price convergence. Oracles provide **off-chain data** and collect fees for their services. Governance members, holding protocol tokens, have decision-making power and voting rights.

6. **Pricing Mechanisms:** Token supplies are adjusted through burning and minting to manage scarcity. Stablecoins maintain price stability using collateral reserves or algorithmic methods. DEXs use bonding curves and conservation pricing functions to price assets relative to each other, and oracles incorporate external information.



Blockchain **Startups** disrupting Financial Market-

Synaps – A joint initiative by **Symbiont** and **Ipreo**, which focuses on **automating and improving the global loan syndicate market** using blockchain-based smart contracts.

Bitpay – An American payment service that allows businesses to **accept and transact with Bitcoin and Bitcoin Cash** as well as invest and exchange between cryptocurrencies and fiat currency.

Request Network – A decentralized Ethereum-based network **allowing users to perform transactions between each other**, send or request payments, issue invoices, pay and receive money for online purchases and more.

Ripple – A payment solution which represents a distributed payment settlement system built on the blockchain and a shared public ledger called XRP ledger. The system serves both private users and organizations and banks, allowing them to **settle money transfers and payments faster and cheaper**.

Appendix

Proof of concept for Machine Learning models discussed earlier:

- **Interest Rates modelling through Principal Component Analysis (PCA)**
<https://github.com/krishnarathore12/Machine-Learning-models-in-Treasury-Management/blob/main/Interest%20Rates%20Modelling.ipynb>
- **Portfolio building through Reinforcement Learning**
<https://github.com/krishnarathore12/Machine-Learning-models-in-Treasury-Management/blob/main/Building%20Portfolio.ipynb>

References:

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- <https://www.oreilly.com/library/view/treasury-management-the/9780470497081/>
- <https://www.oreilly.com/library/view/artificial-intelligence-in/9781492055426/>
- <https://www.oreilly.com/library/view/machine-learning-and/9781492073048/>

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