



A Deep Learning Robo-Advisor Framework for *Shariah*-Compliant Investment into Chinese A-Shares

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Abstract

The economic growth of China has led to a growth of investment opportunities in China that has strengthened its collaboration with many Muslim countries. The One-Belt-One-Road initiative has led to growth in bilateral investment with many Muslim countries, requiring the investing Chinese companies to adopt more and more Islamic finance principles. Until recently, Muslim investors had relatively little information and options to invest into the Chinese markets, making the investment potentially impermissible according to *Shariah* Law. With the growing access provided by Islamic banks to Muslim investors, exchange traded funds incorporating *Shariah* compliant Chinese A-Share stocks have been set up. For individual investors, determining efficiently which stocks are *Shariah* compliant remains a considerable challenge and requires extensive manual analysis. Overcoming this challenge, the paper represents a deep learning Robo-advisor prescriptive framework for *Shariah* compliant investment advice in the Chinese stock market. The performance of the framework was evaluated on recent stock and company financial information, outlining the strong estimation and advisory functionality of the framework. The framework represents an important step towards making high quality *Shariah*-compliant investment advisory available to a wider audience.


Keywords: Islamic finance, Robo-Advisory, Artificial Intelligence, China, *Shariah*-compliance

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1. Introduction

Islamic finance has in the last several decades gained significant prominence in both China and beyond. While Muslims represent only a minority in China, there are several companies that provide Islamic financial products as well as ensure that their business meets the standards of Islamic finance (Irshad, 2015). With the strengthening of the Belt and Road initiative that crosses mostly Muslim countries along the former Silk Road, many Chinese companies expand in these countries, which necessarily requires them to adhere to the local regulations, which are mostly based on *Shariah* law. Financial regulations play a key role for these Chinese companies, which considerably affects the business model they use in these countries (Selmier, 2018).

Islamic finance is based on three major principles, which include *riba* (the prohibition of interest), sharing of profit between creditor and debtor, and the obligation that any financial transaction is supported by real assets (Oseni and Ali, 2019). The prohibition of charging of interest, or usury, represents a major difference compared to conventional banking and financing and requires Chinese banks and lenders as well as companies to adapt their business models to ensure that their investments are profitable. Specifically, the Belt and Road initiative has more than 65 countries that signed up for the initiative, and 27 alone are Muslim majority countries (Devonshire-Ellis, 2021). This implies that to expand into these markets, Chinese companies have to adhere to the Islamic regulations when conducting business, and with the rise of e-money services, and online payments, these companies are required to provide greater risk-sharing to their clients (Li, 2018). Lending has boomed in most of these Islamic economies, where both financial service providers and conventional banks have gained a foothold. While in the domestic market, they may charge interest, it requires them in Islamic countries to

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adapt their model and engage in greater risk-sharing. For example, buy now-pay later services must adapt in terms of that the lender purchases the item for the buyer and then sells it to the customer at a later time with a markup.

In this regard, Southwest Security established a cooperation deal with the Qatar National Bank (QNB) and the Qatar International Islamic Bank (QIIB) to develop Islamic finance compliant products in the state of Qatar (Rakhmat, 2019). This move should enable Chinese investors to invest in the Gulf markets as well as open the Chinese market up to Gulf investors. The Industrial and Commercial Bank of China (ICBC) provides *Shariah*-compliant banking products in the Gulf and China, as well as asset management in Hong Kong partnered with a UAE-based financial service provider to issue Islamic finance products in both jurisdictions. The Asian Infrastructure Investment Bank (AIIB) has become a major player in the *Sukuk* bond market, with Hong Kong taking on a crucial role. Hong Kong passed 2014 a law to enable the issuance of *Sukuk* by the Hong Kong Monetary Authority. In addition to a new taxation framework, this enabled the Hong Kong government to issue dollar-denominated *Sukuk*, which was listed both in Hong Kong, Malaysia, and Dubai (Rakhmat, 2019).

The growing importance of these foreign markets for these companies has also become a critical business model change driver for several Chinese companies. Specifically, the growing interest of Islamic countries to invest in the Chinese market and the demand of investors to ensure that these companies are compliant have led to a greater focus of these companies to have an Islamic finance compliant business model.

While businesses that invest in Casinos, military industry, and other sectors forbidden by *Shariah* law are excluded from obtaining investment based on *Shariah* principles, several other businesses have benefited from this new investor class (Saad et al., 2020). This necessarily poses the question to what extent the adherence of these companies to Islamic finance principles has on their stock price and performance, and to what extent the correlation between investments into Islamic funds and the stocks arises.

This article presents a prescriptive innovative artificial intelligence Robo-advisor framework for investment recommendation in *Shariah*-compliant stocks in the Chinese stock market, as well as classify the impact of Islamic finance investment products on the performance. The latter classification enables investors to determine the degree of importance of investments according to Islamic principles on the performance of the company, potentially affecting the business model strategy as well as financing of the company to align stronger with *Shariah* principles.

2. Literature Review

Artificial intelligence has gained prominence in a variety of different sectors to enable data-driven decision making, obtain a more profound overview of the processes and dynamics in societies, organizations and automatize processes. Artificial intelligence has also penetrated the field of finance and is utilized in a variety of different use cases, from investment advice to automatic trading.

Gazali et al. (2020) provided an overview of how artificial intelligence can be applied in Islamic investments. The authors outlined the evolution of digital banking, starting from the introduction of emails and internet banking in the 1990s over to the introduction of digital banking 4.0 starting from the late 2010s (Gazali et al., 2020). While the authors provided an overview of the applications of artificial intelligence being primarily in detecting and deterring security intrusions and gauging internal compliance, there have been growing applications in the field of finance.

When it comes to applications in the Islamic financial system, then Robo-advisors have become of crucial interest. The Robo Islamic Advisor (RIA) is the first step and promises to be able to provide 2 billion Muslims with easy access to portfolio management that is based on Islamic principles. There are several other Robo advisors that build automatic portfolios based on Islamic principles. While these portfolios are of importance, the selection is primarily based on whether a particular company qualifies for the master portfolio list. Factors such as its future performance as well as whether the company's action makes it suitable for Islamic investment are only marginally considered.

Lin (2019) presented an overview of artificial intelligence in law and finance and outlined the potential challenges blind trust and belief in the system may affect both financial decisions and challenges law enforcement (Lin, 2019). A crucial component is that data bias, virtual threats, and systemic risks may pose a challenge to these algorithms if they are not properly able to adapt to the environments in which they operate. This relates especially to financial decision-making that may provide inadequate recommendations and may

lead to shortfalls when related to Islamic finance.

Khan et al. (2020) demonstrated a new chatbot system related to Islamic finance investment decisions for individuals. The chatbot provides general information about Islamic finance terms and allows the users to interact with it. However, it does not provide any investment advice or is able to provide portfolio recommendations (Khan and Rabbani, 2020). Therefore, the chatbot system is solely a knowledge system that provides terminology information and allows the users to interact with it.

Dahlan (2018) provided an overview of whether robots that can perform tasks of humans shall be considered as human and whether the matter of *fiqh* (Islamic jurisprudence) is relevant to these robots (Dahlan, 2018). Given that more and more artificial intelligence solutions are also employed in the Islamic finance space, this may pose the question of whether the recommendations or advice provided by these AI robots has to adhere to *Shariah* principles and to what extent it affects the decision making and recommendation process.

When it comes to artificial intelligence and the acquisition of funds based on Islamic principles, crowdfunding has become a key component to attract investment (Hassan, 2017). Specifically, investment funding and crowdfunding of new companies have become a crucial interest in the Islamic finance community. Challenges arise in this context, specifically when applying artificial intelligence to provide *Shariah*-compliant investment decisions.

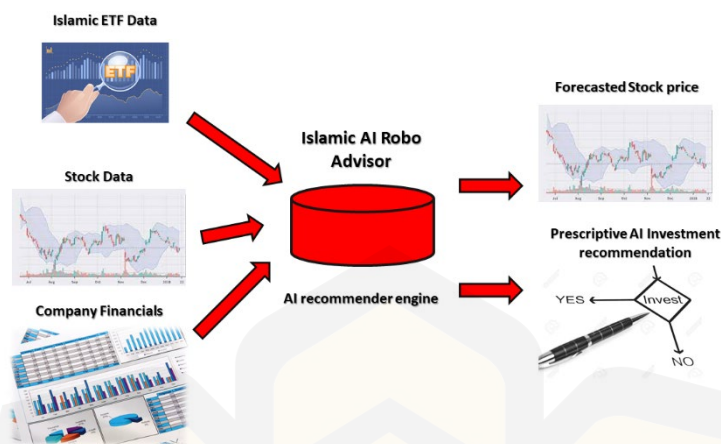
While there have been review articles and research on the application of artificial intelligence in Islamic finance, relatively little research has been conducted on providing specific solutions to optimize the performance of artificial intelligence frameworks in an Islamic finance setting. This research article aims to provide an important contribution to the field of Islamic finance via providing an artificial intelligence Robo-adviser framework for investment recommendation in *Shariah*-compliant stocks in the Chinese stock market, building upon prior research.

3. Conceptual Framework

We have developed a new prescriptive Robo-adviser framework for forecasting of stock prices of Chinese stocks qualifying under *Shariah* law. The framework integrates both the stock data, such as closing, opening, and volume data of the stocks, in addition to critical data regarding the Islamic exchange-traded fund (ETF) performance that invests into these Chinese stocks. The data consist both of time series and general volume and size of the exchange-traded fund. Additionally, the sector classification is utilized as a distinguishing factor for enhancing stock price forecasting and provide better recommendations towards *Shariah* compliance of investments.

Specifically, the incorporation of financial statements and information in connection with the investment sector allows improving forecasting and recommendations given that company valuations are considerably for various sectors. While new technology companies, such as Tencent or BYD, are primarily valued based on their future market potential and growth, more mature companies such as banks are primarily valued at their current market potential (Mohammed and Ali, 2018). Furthermore, price-to-earnings ratios for technology companies are considerably higher as compared to more mature companies (Tahat et al., 2018). WeWork was a prime example of inflation in valuation, which was primarily driven by a false narrative that it was a tech company instead of a real-estate firm (Meredith, 2019). Given the fictitious valuations, this may render some of these companies not permissible for Muslim investors as there are not any real assets that are backing the stock valuations (Ramazan et al., 2018). *Shariah* explicitly forbids *maysir* or gambling (*Qur'an* 5:90), and such investments into companies whose value is not backed by real assets or reasonable valuation, is considered forbidden in *Shariah* Law (Ramazan et al., 2018). The framework considers the financials of the companies for the valuation of the framework and outlines whether the investments adhere to Islamic principles and whether an investment is advisable. A graphical illustration of the framework is provided in Figure 1.

Figure 1: AI Robo-Advisor Framework



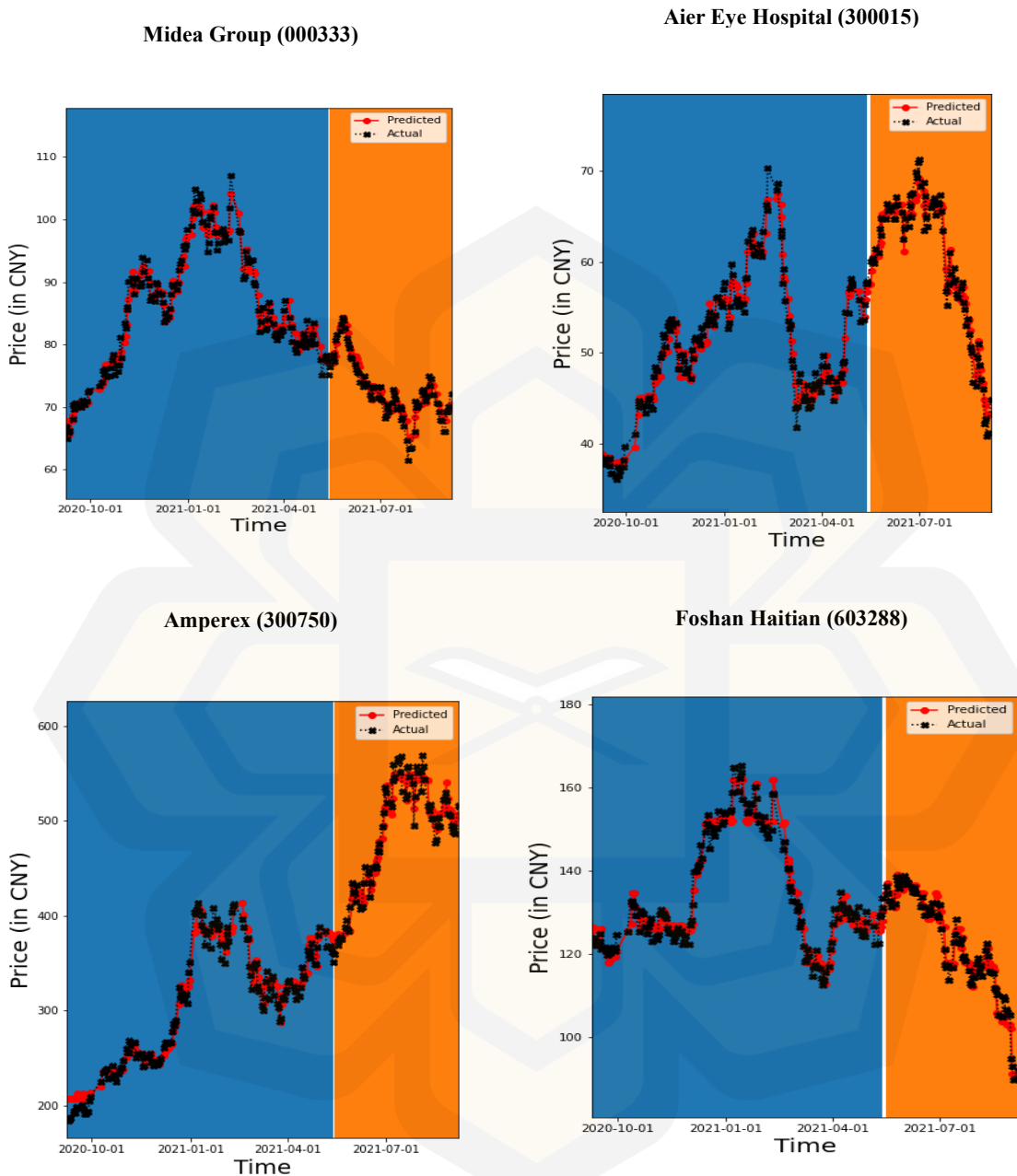
4. Results and Discussion

We evaluated the framework on the stocks in the VP-DJ *Shariah* China A-Shares 100 ETF (exchange-traded fund), which is a major Islamic ETF focusing on the investment into Chinese A-shares that adhere to Islamic principles. The ETF enables easy access to A-Shares for foreigners willing to invest in *Shariah*-compliant A-Shares. A core component of the ETF is that the ETF performs a quarterly readjustment of its composition, which may lead to some A-shares being dropped. The dropping may be either due to a change in market value or the companies not being *Shariah* compliant. Furthermore, stock data from the *Shariah*-compliant stocks are utilized for the Robo advisor estimation and the prescriptive investment recommendation. *Shariah* compliance of a stock requires that the stock fulfills six key criteria as required by the *Shariah* advisor Amanie Advisors Sdn Bhd for the issuer of the ETF Value Partners Asset Management Malaysia (Value Partners Asset Management Malaysia Sdn. Bhd., 2021).

First, the business of the company must be halal and must be in line with *Shariah* requirements. This implies that an investment in conventional banking, conventional insurance, alcoholic drinks, tobacco, pork production, arms manufacturing, pornography, or related activities are not permissible. The second test is whether the debt to total assets is less than 37%. While this threshold is negotiable, it is an adequate measure. Debt is classified as any interest-bearing debts, which also involve zero-coupon bonds and preference shares. Another test the investment has to fulfill is that non-compliant investments shall make up at most 33% of the total assets based on the accounted book value. This shall incorporate the non-compliant security investments. A fourth test is that the non-compliant income as a percentage of the total revenue must be less than 5%. Specifically, the income should be provided to charity as a pro-rate ratio of the issued dividends. The fifth test is whether the ratio of assets that are illiquid to total assets is 25% at least. An illiquid asset is defined as an asset that is permitted to be traded at a value other than par, according to *Shariah* Law. Finally, the net liquid assets per share to share price shall be less than one. The net liquid asset is calculated as the difference between total assets, illiquid assets, and total liabilities.

These constraints represent an important part of determining whether an investment into a company is permitted or not. While these ratios may be adapted depending on the sector the company operates in, excessive valuations may represent a situation where the value of the company is disconnected from the real assets and performance of the company. Excessive valuations are currently not taken into consideration when classifying stocks in terms of their *Shariah* compliance. Hence, more extensive research is needed in this regard. As outlined previously, we evaluated the forecasting performance on the constituents of the *Shariah* China A-Shares 100 ETF. An AI based system requires a training and testing period to train the AI routines and evaluate its performance on a separate dataset. The results for selected stocks for both the training and testing period are outlined in Figure 2 and Figure 3. The performance of the framework was observed over a total time horizon of one year, with the eight months being utilized for the training period and the remaining four for the testing period. The time period ranges from September 8th, 2020 until September 8th, 2021, and stock prices were recorded daily. The framework utilized an adaptive boosting ensemble learning approach implemented in python in order predict the stock prices. Comparing predicted versus to actual stock prices for some *Shariah*-compliant stocks demonstrates the high accuracy of the framework for the forecasting of the stock prices and subsequent performance determination. The stocks were randomly selected ensuring that they represent different market capitalizations.

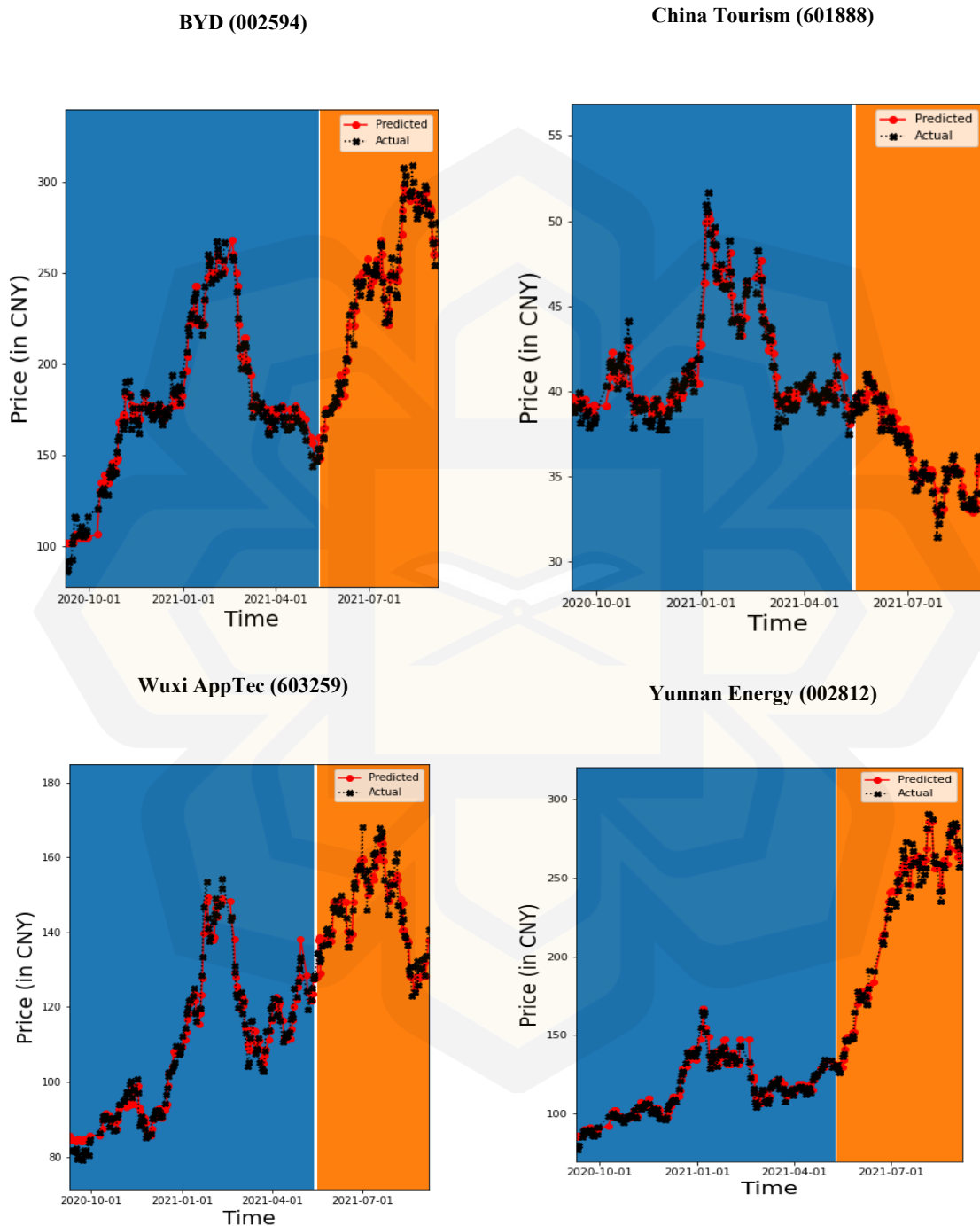
Figure 2: Comparison of Stock Price Forecasts for Four Different Stocks



Analyzing the various stocks in greater detail, one observes potential challenges that some of these stocks may not fulfill the requirements for being *Shariah*-compliant anymore. For example, Amperex almost tripled its stock price within less than a year while revenue and income increased considerably less than 300 %. Specifically, BYD experienced a considerable increase in its stock price that has not been matched a similar increase in its revenues and income. Specifically, electric car makers have been heavily affected by the global chip shortage, leading them to reduce their overall car production. A similar situation is experienced by Tesla, which is in terms of market capitalization, the largest car manufacturer in the world, but in terms of actual units delivered and sold far behind other companies. This lack of a real asset-supported business environment necessarily leads Tesla not to be *Shariah*-compliant and be considered rather speculative. This stands in contrast to Yunnan Energy that has observed an increase in its revenue and overall assets due to strong demand for packaging and e-commerce. While the stock price increased considerably, the percentage increase is similar to the overall increase of the assets of the company and revenue. Sales revenue growth was 119% alone in 2021,

which supports the increase in the stock price (The Wall Street Journal, 2021). This leads to the stock remaining *Shariah*-compliant.

Figure 3: Stock Price Comparison for Four Different China A-Shares Listed Satisfying the *Shariah* Requirements



A general comparison of the framework is outlined by the root-mean-squared error (RMSE). The RMSE represents an important measurement criterion for the accuracy of the estimates and has to be considered relative to the stock price. The overall one-year observation period was divided into the first 2/3 period as the training timeframe and the remaining period to be for testing. With an average stock price of around 250 CNY, the average error rate is less than 3 % for the stock BYD. Furthermore, the framework does not seem to be overfit, given that the RMSE for both the testing and training dataset is rather similar. Overfitting would typically imply that the testing dataset has a considerably higher RMSE as compared to the training dataset.

Table 1: Comparison of Root-Mean-Squared Estimation Error for Selected *Shariah*-Compliant Stocks of the *Shariah* China 100 ETF

Ticker	Company	Training RMSE	Test RMSE
002594	BYD Co Ltd	7.218871	7.928522
000333	Midea Group Co Ltd A SHARES (SZHK)	1.684763	1.44759
300750	Contemporary Amperex Technology Co Ltd A SHARES (SZHK)	12.00713	12.75635
601012	LONGi Green Energy Technology Co Ltd A SHARES (SHHK)	2.201218	2.271409
600900	China Yangtze Power Co Ltd A SHARES (SHHK)	0.225631	0.211866
601888	China Tourism Group Duty Free Corp Ltd A SHARES (SHHK)	8.311843	8.26593
603288	Foshan Haitian Flavouring & Food Co Ltd A SHARES (SHHK)	2.806185	2.708975
603259	WuXi AppTec Co Ltd	3.293607	3.97375
600276	Jiangsu Hengrui Medicine Co Ltd A SHARES (SHHK)	1.527193	1.190468
600438	Tongwei Co Ltd A SHARES (SHHK)	1.257737	1.269348
002352	SF Holding Co Ltd A SHARES (SZHK)	2.024137	1.564844
300122	Chongqing Zhifei Biological Products Co Ltd	5.796864	5.783156
002475	Luxshare Precision Industry Co Ltd A SHARES (SZHK)	1.233121	1.062239
600031	Sany Heavy Industry Co Ltd A SHARES (SHHK)	0.901653	0.849431
002812	Yunnan Energy New Material Co Ltd	4.164092	6.892617
300015	Aier Eye Hospital Group Co Ltd A SHARES (SZHK)	1.448022	1.641037
300274	Sungrow Power Supply Co Ltd	3.243822	4.888028
600887	Inner Mongolia Yili Industrial Group Co Ltd A SHARES (SHHK)	0.821711	0.685575

Finally, the framework determines whether the stock remains compliant based on financial and stock price development, via comparing the actual stock price with the valuation based on the financial statement. As outlined above, the framework accurately determines that the stock BYD is non *Shariah*-compliant anymore and has to be excluded from the ETF, while Yunnan New Energy may still be retained given its *Shariah* compliance. Nevertheless, actual fund decisions may depend on the cost of excluding a particular stock and may solely exclude the stock if the valuations are consistently not complying with *Shariah* regulations. The framework represents an important step towards data-driven forecasting and determination of *Shariah*-compliant stocks.

6. Conclusion and Recommendation

We presented a novel Robo prescriptive advisor framework for investment recommendation into *Shariah* compliant Chinese stocks. With the growth of Islamic finance and the One-Belt One Road initiative, the collaboration between China and most Muslims countries has considerably increased. While the initiative focuses primarily on strengthening infrastructure investments in the countries along the road, bilateral investment has been a cornerstone. Specifically, foreign investment into Chinese corporations has multiplied considerably, and this has been accompanied by a growing interest of Muslim investors to invest in these corporations based on *Shariah* compliance.

The framework enables to forecast stock price development, as well as provide recommendations on the *Shariah* compliance of these stocks based on market backed valuations. Evaluation of the framework on *Shariah*-compliant Chinese A-shares outlined the strong performance and quality of the Robo advisor framework to recommend *Shariah*-compliant shares and determine their expected performance. This framework represents an important part of utilizing artificial intelligence within Islamic finance to provide advisory services for Muslim investors in China.

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