Analysis of Macroeconomic Indicators That Affect Electric Vehicle Stock Market

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Abstract. The performance of an individual stock is exposed to both systematic and unsystematic risks based on economic indicators. Such indicators may directly or indirectly have drastic effects on the performance of an individual stock or the overall market. The stock market is an integral part of the financial system. Therefore, publicly trading companies are large entity that is part of the economic environment. Thus, any fluctuations in the macroeconomic environment would also affect the performance of stocks. For example, the Consumer Price Index measures the price of the average market basket of products. The CPI is crucial to the stock market as it also serves as a key economic metric for tracking the rate of inflation. This paper collected CPI, U.S.-China exchange rates, and other data sourced from FRED (Federal Reserve Economic Data) and Yahoo Finance. These indexes were part of the data selected to perform multivariate regression through SPSS Statistics and MATLAB to determine its relationship with the performance of three EV stocks including Tesla, BYD, and Nio. Results suggest that BYD and Nio's stock performance is likely affected by its PE ratio. For Nio, there is also an inverse relationship between its stocks and CPI. Tesla's stocks and CPI, on the other hand, have a positive correlation. However, there is an inverse relationship with U.S.-China's exchange rates.

Keywords: EV, Renewable energy, Indexes, Stocks fluctuation, Policies

1 Introduction

Electric vehicles, the fastest-growing segment of the automotive market, are taking over the industry. The New York Times reported a 70 percent jump in EV sales in the U.S. during the first nine months of 2022. In its subsequent poll with 3,000 participants regarding motives of EV purchases, the most common incentive that led to the purchase of an EV is, among environmental concerns, affordability in the long run. The rapid growth in the sector is supported by technological advancement that improves efficiency, affordability, and supportive policies. This growth is further propelled by volatilities in the crude oil market. Consumers find that even though EVs have a higher base cost, it is still the more economical option for unnecessary

P. Dou and K. Zhang (eds.), *Proceedings of the 2023 International Conference on Economic Management, Financial Innovation and Public Service (EMFIPS 2023)*, Advances in Economics, Business and Management Research 287,
https://doi.org/10.2991/978-94-6463-441-9_13

spending capital required for gasoline. Advancement in battery technology also contributes to more affordable EV models. Firms compete with different strategies and business models to efficiently implement their battery and subsequent charging services. This is crucial as it not only concerns affordability but also availability.

In terms of the outlook for the global EV market, several major financial entities provided near and long-term forecasts. The consensus is that EV sales will continue to break records. The year of 2021 saw a record 6.6 million vehicles sold, double the amount from the previous year. This is largely due to the continued support from world governments' dedication to transitioning into a more carbon-friendly economy. The majority of countries pledged to reduce carbon emissions and implemented policies to regulate carbon usage while promoting renewable resources. Governments have spent a collective of 30 billion US dollars on subsidies supporting the EV market. In addition, major automotive manufacturers have all pledged to transition to producing fully electric vehicles. The number of options and performance of EVs have all subsequently grown, further incentivizing sales. China is responsible for half of the growth recorded in 2021, which doubled in the first quarter compared to the previous year's data[1]. This was achieved through relatively low manufacturing costs that were able to drive down prices that allow EVs to compete with fossil fuel cars in price. However, developing countries have yet to see mass adoption of EVs. Brazil, India, and Indonesia all have less than 0.5% of EV sales.

A key bottleneck for greater EV adoption is the availability of charging stations, which reflects the overall strength of a region's charging infrastructure. The current predicament for developing a greater charging network is that businesses are only incentivized to build more charging stations if there were more EV sales. However, the quantity will only be improved with an already established charging network. The Biden Administration established a goal that half of all vehicles sold in 2030 will be zero-emission. At the current pace of EV adoption, there will not be enough charging stations for all drivers. McKinsey estimates the U.S would need to expand its current charging network 20 times to satisfy charging demands in 2030 if half of the active vehicles are EVs [2]. Along with availability, charging speed will also need to greatly improve to satisfy future demand. Current commercial chargers fall between Level 2 and 3, which offers a range of 25-200 miles for 30 minutes to an hour of charging. As EV firms keep developing new models with higher ranges, charging technology must keep up with vehicles with higher capabilities.

2 Literature Review

2.1 Global Renewable Energy Policies

As of 2022, at least 145 countries have made efforts to implement renewable energy policies that would promote the production of renewable energy sources while diminishing carbon emissions from the use of fossil fuels. Mechanisms for renewable energy production that countries use are commonly seen in regulations in favor of using renewable sources and banning certain use of fossil fuel, and financial investments to aid supply and research and development for renewable energy.

Research conducted by Ross Cullen at Lincoln University New Zealand argues in favor of renewable energy policies and elaborates on the challenges and opportunities policymakers confront when implementing such policies. Cullen points out that energy price signals are skewed due to unseen external costs and government subsidies. Specifically, through the price-gap approach, IEA and IMF both estimate worldwide fossil fuel consumption subsidies to be $548 billion in 2022 [3]. Cullen argues that the most cost-effective method to reduce fossil fuel consumption and internalize its external costs, such as health and climate change, is the removal of fossil fuel pre-tax subsidies. This has been described as the lowest economic cost method to increase competitiveness for renewable energy subsidies for its positive effect on reducing carbon emissions, increasing fuel efficiency, and the fiscal balance of the government. This is a more cost-efficient solution compared to an increased subsidy for renewable energy, where costs will be high and fewer goals met. However, increasing subsidies for renewable energy is the second-best approach to meet the criteria set by renewable energy policies. Fossil fuel prices are operating below the efficient price level and their negative externalities are not internalized. The producers and users of fossil fuels are not directly affected by the monetary externalities, thus increasing fossil fuel's competitiveness. Meanwhile, renewable energy has smaller externalities and is less competitive. Therefore, increasing subsidies for renewable energy would greatly benefit its competitiveness over fossil fuels [3].

The global context is also crucial when designing such policies. Nations must evaluate the location and endowment of resources, along with their regional economic and energy context when designing renewable energy policies. These factors should also be evaluated against the nation's current available infrastructure and resources. For example, the allocation of resources must meet the demand for energy, which ranges depending on the region and its location to energy resources.

Cullen's guidelines for policymakers are shown in China's Rural Marsh Gas Construction State Program Management Method's "One pool three reform" policy. As part of the financial user subsidy, the policy refers to the harmless treatment and remodeling of methane-releasing household amenities in rural areas such as bathrooms, kitchens, and farming equipment. Notably, the principles behind this policy outline the important factors mentioned above, which influence policymakers. The overall planning of this remodeling emphasizes the restructuring of resources based on regional conditions. Mainly, this depends on the local region's natural climate, ground resources, resident status, and agricultural industry structure [4]. As these factors range between regions, the subsidies related to the policy also adjust accordingly. Other than user subsidies, investment subsidies and product subsidies are all part of China's financial policies to promote renewable energy. China in recent years made efforts on refining its renewable energy policies based on energy threats and other pressures. Around three-quarters of China's consumed energy is imported, which makes China highly reliant on other countries for resources such as oil and coal [5]. Heavy reliance on coal usage also caused environmental, trade, and health concerns both from internally within the country and externally by the international community. Along with pressures from U.N's environmental agreements, these incentives resulted in China being the leading country in renewable energy resources investments in the world. However, China is not performing at the highest level due to policy limitations in coordination and consistency as many separate state departments have their own renewable energy sectors [5].

Norway is exemplary for having the most successful and effective policies. Historically, the Norwegian political sphere has identified priorities in policies focusing on the quality of future energy supply services, environment, and public efforts. Thus, such policies improved the cost-effectiveness of energy supplies [6]. After the UN conference in Kyoto, Norway quickly drafted the "Norwegian implementation of the Kyoto Protocol". Through long periods of effort, Norway also accumulated enough data to serve as a prime example for assessing the impacts of public policies in the rest of the world. China and Norway's policies both intended to or have allowed them to monopolize a certain field, which in the future would greatly increase production, exports, and advancements in the electric vehicle industry.

2.2 Global Ev Policies

The electric vehicle policies are closely affected and are continuously adjusting to renewable energy policies as the two industries have a high causal relationship. While looking at the EV market, it is imperative to discuss Norway. Norway is the world's leading EV market. Norway has offered its citizen incentive packages in order for them to lean towards EV and PHEV vehicles. The impact of Norway's incentive packages for EV owners seems to be significant; research highlights that only 4% of Norwegian EV owners want to switch to a diesel/petrol car if they were to replace their EVs immediately [7]. Overall, the paper highlights that economic incentives are above all, the most important reason to convince people to try out new technology.

Outside of Norway, most countries are avid in developing policies promoting electric vehicles. These policies commonly target the downstream segment of the EV value chain [8]. The impacts are largely dependent on which direction of growth the government intervenes. In a study that evaluated China, France, Germany, the rest of the EU, California state, and the rest of the United States. The study found that the EU's policies mostly target risk management, while Germany, the U.S, and China's policies lean towards industrial. The state of California and France have a mixture of industrial policy and risk management [8].

The majority of the world, including certain countries rich in natural resources such as oil, is working towards electric mobilization. As explained by the resource curse theory; natural resources may greatly advance a country's initial development and may stall technological innovation. However, other research suggests other economic or political factors may drive toward electric mobilization [9]. Political priorities motivated by climate targets serve as a large incentive to achieve those targets, as seen in the policy push by China for air pollution concerns and highly funded incentives from oil wealth to drive technological innovation in the Middle East.

3 Current Situation Of New Energy Vehicles

3.1 Ev Technologies

Successful EV manufacturers that distinguish themselves are largely dependent on technological innovation, particularly on the advancement of battery technology. As consumers worry about the availability of charging stations, companies are actively competing for solutions to lower the production cost of charging methods to increase accessibility.

In the U.S, prominent EV maker Tesla was able to take advantage of its multiple mega factories to achieve economies of scale and produce 6000 supercharging stations for $100,000 per station. As a comparison, the building cost of a charging station previously attempted by other firms was $500,000. Over years, Tesla had developed a mature supercharging network covering most areas in the United States. On Battery Day in 2020, Tesla announced its development of 4680, a revolutionary battery cell type. Most prominently, this new battery cell is promised to reduce production cost by nearly 50% and extend both range and power drastically [10]. However, Tesla is not immune to the global supply shortage of essential raw materials required to produce batteries that affect all EV firms, such as nickel. This has stagnated wider application of the 4680 cells and production for Tesla's new vehicles, including the Cyber truck, Semi, and yet-to-be-unveiled "Model 2".

In China, the Battery-as-a-Service (BaaS) model has been increasingly adopted by prominent firms. The battery swapping model is a subscription service where car batteries are leased and delivered to homes as a separate component of the car instead of purchasing new or maintaining current batteries. Battery cost is a significant portion of the cost of EVs. Leasing on a monthly or one-time subscription can reduce the base cost of a new EV by a third to 50% of the initial cost, which greatly lowers the barrier of entry and is an efficient incentive for consumers to purchase EVs. Battery swapping has higher efficiency and lower infrastructure cost than charging stations. In addition, the BaaS model addresses consumer concerns about the depreciation of car batteries and provides a more sustainable solution. Automobile manufacturer Nio has been leading the expansion of the BaaS model in China. For instance, refer to the graph below for price differences with BaaS options. Though Tesla has a battery swapping service, it serves more to complete Tesla's renewable energy ecosystem. Tesla attempted the Baas model previously and the demand was deemed unnecessary for further business development[11].

Table 1. The price of different NIO cars

	ES8	ES6	EC6
Base Price	¥468,000	¥358,000	¥368,000

BaaS Base Price	¥380,000	¥273,600	¥280,000
Down payment	¥70,200	¥53,700	¥55,200
BaaS down payment	¥57,000	¥41,040	¥42,000
Monthly payment	¥11,578	¥8,841	¥9,005
Baas monthly payment	¥10,372	¥7,742	¥7,900

3.2 Market Analysis

Greater market capitalization requires competitive EV technologies, market strategies, and product cost-effectiveness. With the mission statement "To accelerate the world's transition to sustainable energy" and a market cap of nearly 1 Trillion USD, Tesla employs a unique branding strategy closely tying the brand image with its well-known CEO Elon Musk. Unlike most business owners, Musk is more open and interactive with customers, which has shown to be a successful approach by amassing large online followers. Furthermore, Tesla does not spend resources on marketing. Musk expressed emphasis on allocating resources towards improving customer experience rather than marketing. This effort proved to be contributing to Tesla's effective design elements and overall customer experience.

The cost efficiency of an EV is a crucial indicator determining sales. Cost efficiency is calculated by the number of kilowatt-hours of electricity consumed per 100 miles. Vehicles that have lower kWh/100 miles require less capital spent on recharging and thus leading to higher sales volume. The 2022 Tesla Model 3 is a prime model for cost efficiency with 25kWh/100 miles [12]. Meanwhile, the 2020 BYD e6 has 0.47kWh/mi. At Bjørn's 1,000 Km Challenge, Nio's ES8 outperformed Model 3 by 15 minutes. The 1000Km Challenge was designed to test long-distance traveling abilities for EVs, such as range and efficiency in the context of a region with pre-established fast charging infrastructure. Interestingly, the ES8 model beat Model 3 because it was able to drastically cut time from its battery-swapping technology. Nio's battery-swapping technology creates more competitively cost-efficient vehicles. Cost-efficient vehicles are more popular amongst users as they consume less electricity and have lower long-term costs. Furthermore, cost-efficient vehicles are also more environmentally friendly as they consume less energy.

EV firms increase competitiveness through information technology. Developments from artificial intelligence to big data provide additional opportunities to improve their products for bigger market capitalization. Predictive modeling can analyze the behavior of drivers and the vehicle for feedback in order to adjust any errors and self-improve. This is greatly beneficial for the industry because terabytes of data collected from a drive can give insight into key statistical data such as battery usage or charging data which is valuable feedback that is then applied to new designs to improve the product. This data can also be further monetized and shared to build a collective information system that pushes the overall growth in the sector. Advancements in in-car artificial intelligence also increase the strength of a product in the market. Nio after it first launched its ES8 model in 2017 along with NOMI, the first mass-produced in-car artificial intelligence system [13]. NOMI received positive feedback for creating a more personable and immersive driving experience. As an AI digital assistant, NOMI can perform tasks outside of basic voice recognition such as detecting movements or expressions. Furthermore, NOMI also has a face-like interface that has expressions and limited movements that allow drivers to create emotional engagements.

In price competition, Nio attempts to use the BaaS model to catch up to Tesla's price efficiency and market dominance. Currently, by the end of the third quarter of 2022; Tesla sold over 318,000 units of vehicles. The favorite models Y, 3, and S - sold at $41,312, $37,990, and $74,990 respectively. Domestic rivals such as Xpeng and Nio each sold 98,500 and 31,600 units, whereas the favorite Nio models ES8, ES6, and EC6 were sold for $67,000, $56,000, and $57,000 respectively.

Even though Tesla has the most expensive model, it also has cheaper options than Nio and maintains market dominance. Notably, BYD - China's biggest EV maker and backed by Warren Buffett's Berkshire Hathaway, reported a 250% increase in sales. With 1.2 million units being sold in the same timeframe, BYD had taken over the sales of Tesla by a large measure. The most popular BYD models Seal, Yuan Plus, and Han EV sold at $29,050, $18,357, and $37,350 respectively. Through strong sales and a wider product range than competitors, BYD can drastically reduce production costs. Furthermore, BYD also alleviated supply chain shortage issues and costs associated with increased inflation by internally producing batteries and some microchips [14].

3.3 Market Movers

A firm's business and its stock price are affected by multiple economic indicators. The U.S currently faces increasing CPI growth and inflationary pressure where the supply of dollars exceeds the supply of goods. In response, the Federal Reserve sells Treasury securities into the open market and increases bank reserve requirements to raise interest rates. When a bank's lending is affected by rising interest rates, businesses require higher operation costs and borrowing becomes difficult. The stock price falls once the growth of a firm is halted and demand for its goods and services reduces. The CPI provides insightful data on consumer behavior, such as how collective groups respond to price changes in average items and where expenses are spent, which also affects the stock market. The stock market responds to shifting CPI; high CPI usually indicates lower spending power by the average household, which could lead to a recession that is reflected in companies' stock prices. Currently, the CPI in the U.S climbed 8.2% on a yearly basis, furthering diminishment for consumer confidence, which dropped from 132.6 in February to 102.5 this month in October. Furthermore, the stock price is the estimation of the firm's future value and growth. Stock prices are calculated on earnings per share. When the Fed plans to temporarily halt growth to adjust the economy, earnings per share decrease as revenue and sales would also be affected [15].

Volatilities in the Forex, another major financial market, may also impact the stock market. In theory, when the stock market has a strong performance, it attracts foreign investors and thus demands for its local currency. When a country's currency is exchanged at a lower rate, its exported goods become more attractive internationally as they can be purchased at a lower value. The portfolio balance approach suggests that this effect can increase sales and growth of domestic firms, thus the correlation between the value of firms and the state of their national currency. Due to the impacts of capital flight and reliance on dollar-based exports, the stock prices in emerging markets, such as China amongst many others, are closely associated with the movements of the U.S dollar. When the dollar is strong, currencies and exports in emerging markets become cheaper, as is their stock price. This is not always the case – a strong dollar may drive up the price of imports for U.S firms which could affect their stock price [16]. The impacts of exchange rates on imported goods can be seen in the EV market in the U.S. For example, the U.S is impacted by its reliance on importing key minerals used to manufacture electric vehicles. U.S EV manufacturers have 100% net import reliance on graphite and manganese, which are imported mainly from China, Gabon, and South Africa. Along with over 50% imports the reliance on nickel, cobalt, and lithium, which are mainly imported from Russia, Norway, and Argentina [17]. As these minerals trade at a higher exchange rate when the dollar is strong, U.S firms suffer from higher import prices.

4 Data Analysis

4.1 Data Collection

SPSS Statistics was used to perform a multivariate regression analysis to determine the relationship between CPI, U.S-China exchange rate, and PE ratio on EV ETFs. Stock price and P/E data are collected from Yahoo Finance. CPI and exchange rate collected from FRED (Federal Reserve Economic Data). The data selected ranges from August 2018 to July 2022. Following are results table based on data gathered from previously mentioned sources.

Table 2. The SPSS result of BYD

Variables	BETA
CPI	0.052
U.S-China Exchange Rate	0.069
PE Ratio	0.658

The beta for CPI differs across the firms. For BYD, the 0.052 does not reflect a strong correlation between the CPI index and the performance of BYD's stock price. Exchange rate for BYD also has a high beta of 0.658. However, Tesla does not; indicating less relevance.

Table 3. The SPSS result of Nio

Variables	BETA
CPI	-0.005
U.S-China Exchange Rate	0.032
PE Ratio	0.947

The price-to-earnings ratio (P/E) is a popular metric used to evaluate stock price. As reflected under table 4.2.2b the performance of Nio's P/E ratio is closely tied to the performance of its stock as the beta is 0.947, closely followed by BYD.

Table 4. The SPSS result of Tesla

Variables	BETA
CPI	0.369
U.S-China Exchange Rate	-0.628

PE Ratio	0.035

Interestingly, the beta for currency exchange rate between China and the U.S. against Tesla's stocks is -0.628. This indicates an inverse relationship where the stock would rise if the exchange rate fell. This would tie Tesla's profits with appreciation in Yuan. As Tesla's earnings report indicates, half of their profit comes from China. Naturally, growing strength of a domestic currency nurtures its domestic businesses, which now embeds Tesla. In addition, Tesla stocks have a higher correlation with CPI, with its beta at 0.369. For BYD, the correlation is not necessarily demonstrated in international business operations. As a popular financial product in China, its performance is due to be tied to the strength of the Yuan and has a medium to long-term attraction for domestic investors. Therefore, movements in Yuan will to a degree affect asset allocation and purchase level for the average investors. Recently, both Nio and BYD publicly announced plans to export their vehicles to the overseas markets. This will no doubt strengthen the correlation between their stock prices and its domestic currency. It is likely the beta will increase through time as BYD and Nio ambitiously expands to the global market, going above 0.05. However, it will not raise to a significant level past 0.2 in the near future due to Biden's new law which eliminates federal tax credits for EVS made outside of North America.

4.2 Bp Neural Network

Qualitative and quantitative analysis were conducted on economic indicators that affect stock price of EV firms. Part of this report consists of future and potential development of these firms. This is done through predictions of its future stock movements. The method for such prediction is processed through BP neural network. Through the predictive properties of BP neural network, CPI data, U.S-China exchange rate, and CSI New Energy Vehicle Index were collected to through the properties of the coefficients to perform analysis on dependent variables which is the stock price of BYD, Tesla, and Nio. Neural network's self-learning mechanism for coefficient has higher accuracy for prediction when compared to SPSS's linear model based on fixed mode. One of neural networks' distinct properties is its ability to adjust the weight of independent variables, allowing for higher accuracy in the model. Whereas SPSS analytics cannot weigh its variables and its subsequent models are based only on historic data. Therefore, BP neural network is often the preferred method to predict the development of data.

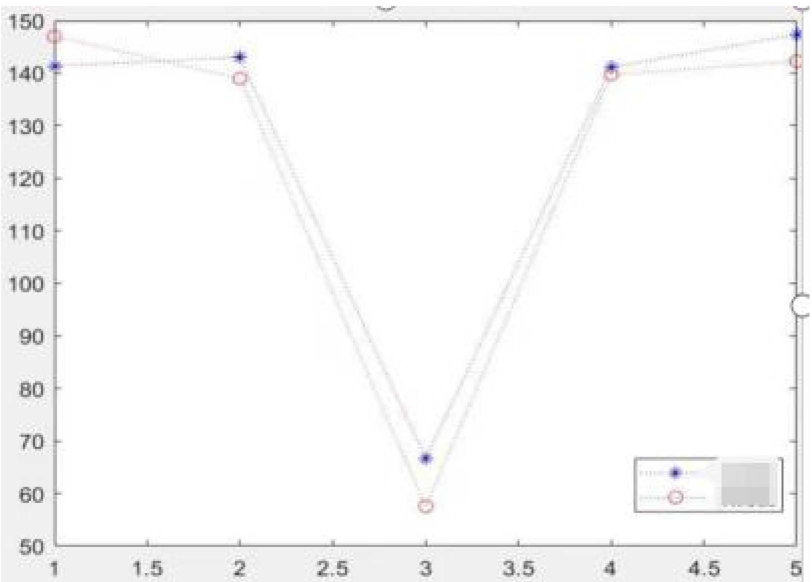

Fig. 1. The BP neural network results of NIO

Table 5. True value and predicted value of NIO

141.4100	147.0164	5.6064
143.0033	138.9896	-4.0138
66.7267	57.5534	-9.1733
141.1433	139.7215	-1.4218
147.3833	142.2760	-5.1073

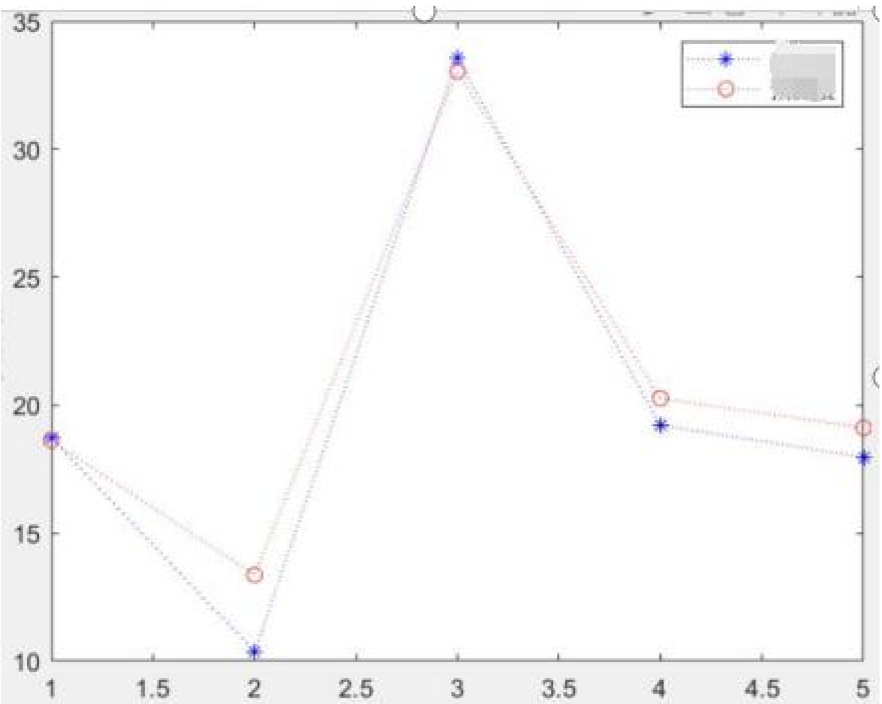

Fig. 2. The BP neural network results of BYD

Table 6. True value and predicted value of BYD

18.7256	18.6245	-0.1010
10.3750	13.3666	2.9916
33.5562	33.0462	-0.5100
19.2149	20.2763	1.0614
17.9765	19.1206	1.1441

5 Conclusion

There are several factors that can affect the movement of a stock. For example, if sales increase for a company, their revenue would also grow. This can be positively reflected in growing stock prices as investors consider it to be a valuable company. Similarly, CPI is a metric that is a reflection for the overall consumer purchasing power. The rate that CPI moves in is also the primary indicator to measure rate of inflation, which is a systematic risk that affects the stock market. In the case of BYD, the beta for CPI is 0.052. This means there is a positive correlation between the growth of CPI and BYD stocks; for every unit of growth for CPI, BYD stock would grow by 0.052 per share. Thus, shifts in CPI can also indicate movements in the stock market. The primary reason for this is that when CPI increases, the wealth of consumers and their purchasing power also increases. Including the likelihood of inflation when this occurs, it would also allow more capital to flow into the market. Compared to its rivalries, BYD focuses on more economic models with high efficiency. In an unsaturated market like China, this provides plenty of room for stock growth as CPI increases. BYD's stock is also an investment product, which means its assets and equities will grow with naturally occurring inflation. This is also an indicator that investors consider BYD to be a worthwhile investment.

Exchange rate between China and the U.S. and performance of Tesla stocks has a strong negative correlation. The gigafactory in Shanghai is one of the main organs in Tesla, responsible for producing 800,000 units a year and Tesla's strong performance in 2021. In the short span since the factory began operating, it has surpassed one million units of production, which accounts for a third of all total Teslas made. Depreciation in Yuan allows its exports to become more attractive internationally and thus sales for domestic products would also soar. As a U.S. firm operating in China, lower exchange rate for Yuan allows its U.S. entity to see greater returns for their investments as it requires less capital to achieve the same effects.

Policy-makers should establish short-term and long-term focus. Where using tax incentives and awareness campaigns to refuel infrastructure is the near-term focus. Long-term goal planning should emphasize forcing vehicle retirements if they are not up to specific emission standards. Currently, most EV policies still rely on financial incentives. Even though downstream financial subsidies have supported the development of the EV market, this is not a sustainable approach. Policies must shift along with the fast-paced growth in the industry.

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