HYBRID INTELLIGENT SYSTEM FOR DEMAND FORECASTING IN DIE-CASTING INDUSTRY

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Thanks to ALLAH SWT to enable me performing this research, I would like to dedicate this dissertation to my family and parents for their continue support and encouragement

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ABSTRACT

Forecasting is one of the important elements in business nowadays. An accurate forecast of future demand is an absolute requirement for planning production without creating wasteful overages or shortages. The accurate forecast is very importance for industry especially Electronics Devices Industry. As many knows, Electronic Devices Industry is promised the fluctuate demand. To compete the forecast with the demand, many industry had to choose the hybrid Intelligent System forecast model rather than stand alone model. For this case study, long memory forecast model is hybrid with the Artificial Intelligent model are chosen to forecast the demand one of the electronic devices supplier company. Auto Regression Fractional Integrated Moving Average (ARFIMA) are chosen as the long memory process model and hybrid with Artificial Neural Network (ANN) model as the Artificial Intelligent. The hybrid Intelligent System Model improve the forecast error for the next year of demand by using the current demand with 1.4% forecast error.

ABSTRAK

Ramalan dalam permintaan adalah salah satu elemen penting dalan perniagaan pada masa kini. Kejituan ramalan dalam permintaan pelanggan pada masa akan datang merupakan satu kemestian untuk merancang perjalanan produk tanpa menghasilkan pembaziran barangan atau ketidakcukupan pengeluaran. Kejituan ramalan adalah sangat penting untuk industry terutamanya Industri Pembuatan Barangan Elektrik. Sebagaimana yang diketahui, Industri Pembuatan Barangan Elektrik menjanjikan ketidakstabilan dalam permintaan. Untuk memastikan ramalan permintaan yang tepat, kebanyakan industri telah memilih untuk menggunakan pergabungan Sistem Kecerdasan dengan model ramalan yang biasa digunakan. Untuk kajian ini, memori jangka panjang ramalan model telah digabungkan dengan Kecerdasan Buatan Model dan telah memilih untuk meramalkan permintaan pelanggan salah sebuah Industri Pembuatan Peralatan Elektrik. Auto Regression Fractional Integrated Moving Average (ARFIMA) telah dipilih sebagai model jangka panjang dan digabungkan dengan Arficial Neural Network (ANN) sebagai Sistem Kecerdasan Buatan. Penggabungan kecerdasan ini menambahbaikkan kesilapan dalam ramalan untuk tahun berikutnya bagi permintaan pelanggan dengan 1.4% kesilapan ramalan.

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ADF	-	Augmented Dickey Fuller Test
ARFIMA	-	Auto Regression Fractional Integrated Moving Average
ARMA	-	Auto Regression Moving Average
ANN	-	Artificial Neural Network
MAPE	-	Mean Absolute Percentage Error
MSE	-	Mean Square Error
MLP	-	Multi Layered Perceptron
ACF	-	Auto Correlation Function
PACF	-	Partial Auto Correlation Function

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CHAPTER 1

INTRODUCTION

1.1 Introduction

Hybrid Intelligent System is widely use in many sectors and one of the sector use this system is Forecasting. Because of the accuracy and precision of the system, it mainly used in industry nowadays. There are many intelligent system that had been developed currently to improve many application of industry including Forecasting System. For the Auto Regression Fractional Integrated Moving Average (ARFIMA) and Artificial Neural Network (ANN) are one of the hybrid forecast systems that will be discussed in this chapter.

The importance of forecast made most of the industry look into the Hybrid Intelligent System. There are several study that been discussed and investigate to increase the model accuracy and their prediction. In this chapter will focus on the objectives, scopes, methodologies and literature review of this project.

1.2 Background of the Study

In industry these days, the estimate framework is vital to run and arrangement the creation for the client request. The figure framework appear to be the a standout amongst the most imperative component particularly for Sales Department so the stock for the following requesting and client interest could be effectively satisfy.

Figure had helped the business to determined for the consumer loyalty regarding arranging, stock and so forth. The most matter that happened in estimate framework is when to foresee the client interest for the following request as precision as could be allowed so the organization could diminish the expense of stock for the stock in creating the part.

The quandary that many industry encountered is when the quantity forecast as erroneous as quantity demand. The industry had previsedmany method to merge with the forecast system to ascertain the system is given the most precise quantity for the authoritative ordinance and one of the system that gaining nowadays is Keenly intellective System.

Inserting the keenly intellective system into the forecast had been one of the amelioration to ascertain the forecast system would give the precision of quantity demand. Astute system for Forecasting industry would be the challenge since the method of the perspicacious system was very intricate and varies. By implement the perspicacious system would withal give the conception of amelioration for industry to maintain the customer contentment and reduce the inventory of raw material at industry.

Nowadays, forecasting plays the consequential role in drive the company to prosperity orchestrating for operation and inventory. Forecasting commences with several prognostications which is it is predicated on the management's experience or adeptness, cognizance, and judgment.

On the other word, along with the enlargement of markets, an incrementing in the number of investors, authoritative ordinance of customers and complications involved in the analysis of the effect of different variables on the stock index due to the close relationship of the markets with macroeconomic variables during the last two decades, forecasting had become most importantly in terms of the pricing comportment of the financial properties in the dynamic field of economy and capital market has turned into one of the most paramount issues discussed in financial

sciences leading to a growing increase in the consequentiality and value of forecasting-cognate issues. The reason is that it guides policy-makers, planners, researchers and investors in exact and efficient evaluation, pricing the properties, and felicitous allocation of resources (Stekler, 2007).

In the present world, all industries need to be adaptable to a changing business environment and mindset in the context of a competitive global market. Manufacturers must rely on efficient and accurate forecasting systems in order to make decisions related to the conception and the driving of any logistic structures, (Sun et al., 2008).

An accurate forecasting system is essential for avoiding problems such as inventory shortages and excesses, miss delivery or missed due dates, plant shutdowns, lost sales, lost customers, expensive expediting, and missed strategic opportunities. By increasing the effectiveness of forecasting models is considered a vital part in the overall supply chain process (Sayed et al., 2009).

Users of electronic devices are raising the comfort levels and living standards of the growing population with rapidly growth of electronic devices. This industry is shaken by the economic downturn but with the world economy becoming more stable the electronics user are making their way back into the market because of to fulfill the high level standard of living.

Currently, the consumer of electronics industry is undergoing modest growth with modest living, but it is expected to grow tremendously in the coming years as for now which is people are laying more stress on comfort and better living standard rather than the prices of products. Forecasting is also used in Customer Demand Planning in everyday business for manufacturing and distribution companies to ensure it can fulfill the demand of high living standard consumer.

Forecasting has also been used to predict the development of conflict situations such as in political issue or others. Almost every years, the forecasters had

perform research that uses empirical results to gauge the effectiveness of certain forecasting models to suite with certain and desired situation. However research has shown that there is always had difference between the accuracy of the forecasts of experts knowledgeable and technique in the conflict situation and those by individuals who knew much less about the forecast concept.

There are many issues of forecasting in the electronics industry which is indirectly giving the impact to electronics component suppliers, which including Die Casting manufacturer for HDD. With the proper planning of business strategy, by developing the Intelligent system into the industry would as much as possible guide the company to gain more profit and getting trust by other customer. Intelligent system also might help the industry to use as less as possible the resources with the efficient input and effective output. Forecasting is very useful for industry or manufacturer, as it allows them to plan production, inventory, manpower, financing and so on.

Forecasting can be a dangerous art in certain situation, because when the forecasts become a focus for companies and governments, mentally limiting their range of actions or mindset, by presenting the short to long-term future as already being determined or applied. Moreover, forecasts can easily breakdown or unreliable due to random elements or prediction that can't be incorporated into a forecast model, or they can be just plain wrong from the beginning. It had occurred at most industry including Die Casting Industry. The negatives aside, business forecasting isn't going anywhere if it is used wrongly.

Used properly and effectively, forecasting allows businesses or manufacturer to plan ahead of their needs or desired, raising their chances of keeping healthy competition through all markets. That's one function of business or manufacturer of forecasting that all investors can appreciate and build trust. To make forecasting more valuable and can be trust as one of the business strategy tools, practitioners, engineer and industrial management had improve the forecasting system by develop the intelligent system into the forecasting. There are many research had been done by

merging the intelligent system not only at industry but also for the environment forecast.

1.3 Problem Statement

Figure 1.0 is the 6 challenges of electronic industry nowadays. The study will focus on challenge no 5 which is ***Uncertain Demand***. With the rapid growth of the electronics devices and various consumer behavior, the demand for the electronics part is very unpredictable.

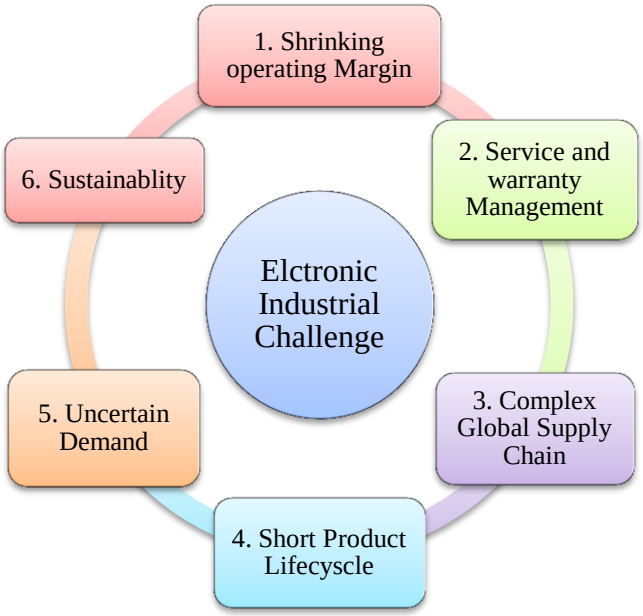

Figure 1.1: 6 Challenges of electronics industry

The competition amongst the electronics part supplier also make the demand fluctuate since the price of the part will be the importance issue. For the fluctuate demand situation, to plan the financial for the next quarter is very complex. With the current system forecast to predict the customer demand for the next quarter, sometime put the industry in the financial crisis when inventory is more that customer demand.

For the certain situation, when the forecast was not accurate as customer demand will cause the industry had to increase in transportation cost. There is situation when the demand higher than forecast value, the industry need to reproduce which is the manufacturing cost increase (for overtime) and the transportation cost also increase (for using the freight or other special transportation).

This is always happened in the electronic industry when most of the industry will used the short term planning or forecast to predict the demand. For most company, especially electronic devices component supplier, the product were running based on customer forecast. This also happened in company B, the production run by followed the customer forecast. Normally, the customer will give quarterly forecast and the company B will do the weekly basis forecast based on quantity forecast for three month for planning the raw part and machine availability.

Sometime there is incident when the customer would increase the quantity demand suddenly and it will make the Company B in bottleneck situation which is to plan to increase the raw part and also time for production running. It will have the cost increase especially for the special arrangement of raw part transportation and also overtime for production. It is good to have 1 year internal forecast as a safety net to Company B. To have the internal forecast, it should have the forecast model with the very minimum of percentage forecast-demand error.

For most study of forecasting, to have the minimum forecast error is to hybrid the forecast model with the Artificial Intelligent System. The forecast model also had to have the long memory process so that the forecast quantity would not create a significant different with the demand. This study is to use the long memory process to predict the long term rather than short term planning.

ARFIMA, and ARFIMA – ANN hybrid model, had been research in different cases, with multiple outcomes and various expectations. ARFIMA model is choose in this case study because of its behaviour to decay more slowly than ARIMA

model. This factor is important to ensure that for the next year of forecast would not give the significant different compared to current year demand.

There are many factors that influencing the result outcome with the different method applied. Based on the model application, the model is needed to test them again in different situation and cases. The study will focused on the long term forecast rather than short term forecast.

1.4 Objectives of the Study

The objectives of this study are:

i. To develop the hybrid intelligent system with the long memory process in Die Casting industry.
ii. Implement the ARFIMA, the hybrid of ARFIMA-ANN model on the manufacturing to check with the accuracy of current Forecasting System.
iii. Improve the accuracy of Forecasting System
iv. Evaluate the develop system forecast for the percentage error.

1.5 Scope of the Study

This project is consist of below scope;

i. The Company B Sdn Bhd manufacture the Die Casting Part had been chosen as the case study representing the manufacturing industry.
ii. STATA/SE12.0 software is used to simulate the data for ARFIMA model
iii. MATLAB software is used to simulate the data for the ANN.

1.6 Summary of Literature

Demand forecasting or prediction plays a crucial role in advanced systems especially for supply chain management. A reliable estimation for a product's future demand is the basis for the respective systems which is desired most by all manufacturer. With various forecasting techniques have been develop nowadays, each one will have particular advantages and disadvantages compare to other approaches for various industry and situation. This motivated the development of hybrid systems combining different techniques and their respective advantages especially with the Artificial Intelligent System (Luis Aburto, etl, 2007)

The ARFIMA model is designed to represent these series. According to Beran (1994), stochastic processes may be utilized to model the behavior of observed time series solely by the statistical approach without a physical interpretation of the process parameters. Long-range memory models, ARFIMA processes in particular, have been used extensively in different fields such as astronomy, economics, geosciences, hydrology and mathematics (Beran 1994). Early applications of the ARFIMA model were performed by Granger and Joyeux (1980), Hosking (1981) and Geweke and Porter-Hudak (1983).

The ARFIMA models are generalization of the linear stationary ARMA and linear nonstationary ARIMA models. The autoregressive (AR) model of first order emerged as the dominant model for background climate variability for over three decades; however, some aspects of the climate variability are best described by the long memory models (Vyushin and Kushner 2009. Box and Jenkins (1976) provide the details on the forecasting, confidence band estimation and forecast updating for ARIMA models. The governing equations, provided in Box and Jenkins (1976), are utilized and extended for ARFIMA models that use the non-integer differencing parameter d.

The most used in most research or literature review for AI technique is probably artificial neural networks (ANN). The human brain function concept is

apply in the ANN such a way of learning algorithm been develop in ANN. The model play a way by interconnected neurons (series) in a similar manner to the working of the brain. However even with the largest modern computers it is estimated that an ANN with 10 million interconnections would have a neuron structure somewhat smaller than a cockroach. (De Lurgio, 1998).

These two techniques are very often compared in the research over century, the process or method of using the ANN for forecasting is largely the same as for other artificial forecasting methods such as multiple regression will be develop. They each use a series of coefficients in the modelling process and each attempt to minimize error terms in a similar manner which is in each case or studies there is input data which is used to model output data.

The standard methods of holdout samples are also commonly or usually used in both as a measurement of the forecasting ability. The internal process of the ANN model is however more complex and complicated also less easy to reproduce and explain. It is functions as the "black box" to a much bigger extent than for traditional statistical methods that commonly known.

This sets a dangerous precedent and it is probable the use of ANN's will be over-sold and on the other hand, the people with no background in the method or no skill seem to be able to make better predictions using ANN's also they will be used in situations where more conventional methods are probably superior (Peter Rossini, 2000). As a result, not with standing this ANN's have been well researched in business fields in recent years the dangerous conclusions and recommendations will be made by people who use ANN's wrongly.

For a basic time series situation Kuo et al. (1996) found that neural networks produced lower errors than Box-Jenkins and regression procedures. These include forecasting of electricity consumption (Nizami et al., 1995), airline passengers (Man et al 1995), company audits (Lanard et al (1995), bank failures (Tam, 1992), bankruptcies (Fletcher, 1993), stocks and bonds (Desai, 1998, Li,

1994), futures and financial markets (Meade, 1995, Kaastra et al, 1995, Mangasarian, 1995, Kuan et al, 1995, Grudnitski et al, 1993). In most cases researchers have found that ANN's can produce forecasts with lower overall errors than with conventional methods such as regression.

Forecast of exchange rates has been regarded as one of the most challenging applications of modern time series forecasting. Thus, numerous models have been depicted to provide the investors with more precise predictions. Hybrid forecast is a well-established and well-tested approach for improving the forecasting accuracy. Therefore, the importance of hybrid forecast methods has steadily increased and it acts still on time series forecasting.

Since it is difficult to completely know the characteristics of data in a real problem, applications of hybrid methods in the literature show that combining different methods can be an effective and efficient way to improve forecasts, hybrid methodology which has both linear and non-linear modelling capabilities can be a good approach for practical purposes (Cagdas Hakan, etl 2012). Therefore, to model time series having both linear and non-linear structures, to model long memory time series, any hybrid approach has not been proposed in the literature hybrid approaches are proposed..

1.7 Significance of the Study

Development of the intelligent system in the current system is not the new things nowadays. Many type of the intelligent system that have been develop in order to improve the current system to suite the current requirement. Forecast system also had been part of this improvement whereas, many study had been done by implement the intelligent system.

The most research been done so far is develop the hybrid forecast which is by merge the forecast system with the intelligent system. The table below is some example of the few intelligent system of forecast that been done previously:

Table 1.1 : Summarize of the implementation of the intelligent system in forecast system

Forecast Method	**Agriculture**	**Manufacture**	**Oil and Gas**	**Tourism**	**General**
Hybrid Forecast	Benyamin Khoshnevisan, etl (2013). -Prediction of potato yield based on energy inputs using multi-layer adaptive neuro-fuzzy inference system	Jamal Shahrabi, etl (2013) - Developing a hybrid intelligent model for constructing a size recommendation expert system in textile industries S.O. Olatunji, *etl* (2010) - A Hybrid Model Through The Fusion of Type-2 Fuzzy Logic Systems and Extreme Learning Machines for Modelling Permeability Prediction	Mohsen Mehrara, etl (2013) - A hybrid intelligent system for forecasting crude oil price		Attarius Hicham etl (2012) -Hybrid Intelligent System for Sale Forecasting using Delphi and adaptive Fuzzy Back-Propagation Neural Network Shuliang Li, etl (1999) -A framework for a hybrid intelligent system in support of marketing strategy development by Shih-Hung Yang etl (2009) -Intelligent Forecasting System Based on Grey Model and Neural Network J.P.S Catalão, etl, (2011) - New Hybrid Intelligent Approach to Forecast Wind Power and Electricity Prices in the Short Term Shahrokh Asadi *etl* (2012) - New Hybrid Artificial Neural Networks for Rainfall–runoff Process Modeling. Abbas Ali

					Abounoori *etl* (2013) -Hybrid Intelligent System for Financial Time Series Forecasting
Delphi Forecast	Claudia Bazzani etl (2013) - Forecasting a scenario of the fresh tomato market in Italy and in Germany using the Delphi method			Yeong Wee Yong, etl (1989) -A Delphi Forecast for the Singapore Tourism Industry; Future Scenario and Marketing Implication	
AI Forecast					Peter Rossini (2000) - Using Expert Systems and Artificial Intelligence For Real Estate Forecasting

This study will be a significant endeavor in industrial forecasting especially in electronic industry and in promoting of using long term forecast rather than short term forecast. Generally, the forecast for industry is given by customer, and for the supplier to forecast by weekly basis to run the production. By using this methodology, the industry importantly for electronic devices component supplier should have the initiative to forecast long term as easy to plan rather than short term forecast.

This study will also be beneficial to the students in strategic management especially for forecasting methodology, by applying a different concept of forecast with the Artificial Intelligent System, to find an effective way to reduce the forecast error in industry. By understanding the needs of the industry and benefits of strategic management to student, these industry and students be assured of a competitive advantage. Moreover, this research will provide recommendations on how to upgrade the forecast performance accordance to industry needed.

Moreover, this study will be helpful to the electronic devices component in term of to have the strategic planning of raw part and time management of production in order to achieve its objectives in reducing cost. It will also serve as a future reference for researchers on the subject of Hybrid Forecasting model with Artificial Intelligent and corporate companies.

This study will focus on the develop of the intelligent system in the current forecast system to:

i) To improve the current system
ii) To develop the new system that will predict the demand of the customer as accurate as possible

1.8 Expected Outcomes

Based on literature, it is expected that the error of forecast would be reduce comparing with the customer demand. The level of accuracy would be increase while using the hybrid model of forecast with the Intelligent System. By combining the ARFIMA-ANN model to improve the accuracy of forecast.

1.9 Organization of Study

The rest of the project report is organized as follow. The literature review about time series, forecast and seasonality, ARFIMA, ANN and ARFIMA-ANN hybrid model is covered in Chapter 2; Methodology, Project Framework, the data analysis framework and necessary processes are presented in Chapter 3. Chapter 4 is about the data collection and data interpretation. The last chapter (Chapter 5) is about a summary of other chapters, result further research works and conclusion of the study.

1.10 Conclusion

Forecasting is one of the challenge tools in many industries as to have the small percentage error of forecast would help the company to reduce the amount of cost. Many research and study had been done to upgrade the Forecasting System to Intelligent System by hybrid the model in order to get as accurate as possible comparing with the customer demand.

Forecasting is not only have to be the judgmental method, but if implementing with the quantitative model, the decision making for the next 3 quarter would as much as possible reducing the cost of inventory, production and etc. To have the best decision making, manager need to select the best method of forecasting for the company, in order to achieve the company's mission. Selecting most appropriate model of forecasting such as, ARFIMA, and ARFIMA-ANN hybrid model for the demand of customer is the aim of this study.

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