A comparison of the prediction performances by the linear models and the ARIMA model

Take AUD/JPY as an example
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Ying Zhang and Hailun Wu
Abstract

With the development of the financial markets, the foreign exchange market has become more and more important for investors. The daily volume of business dealt with on the foreign exchange markets in 1998 was estimated to be over $2.5 trillion dollars (the daily volume on New York Stock Exchanges is about $20 billion). Today (2006) it may be about $5 trillion dollars. More and more people notice the foreign exchange market, and more and more sophisticated investors research such markets.

The purpose of this thesis is to compare different methods to forecast the exchange rate of the money pair AUD/JPY. Firstly we studied the relationship between the AUD/JPY exchange rate and some economic fundamentals by using a regression model. Secondly, we tested whether the AUD/JPY exchange rate had any relationship with its historical records by using an ARIMA model. Finally, we compared the two model forecasting performance. A secondary purpose is to test whether the Market Efficiency Hypothesis works on the money pair AUD/JPY.

In the study, data from January 1986 to June 2006 were chosen. To test which method produces better forecasts, we chose data from January 1986 to December 2002 to build up the prediction functions. Then we used the data from January 2003 to 2006 June to evaluate which predicting method was closer to the reality. In the comparison of the forecasting performances, two approaches dealing with the unknown future fundamentals were used. Firstly we assumed that we could do perfect predictions of these regressors, that was, our predictions of these regressors were the same as the actual future outcomes. So we put the real data for the fundamentals from January 2003 to June 2006 into the regression function. Secondly we assumed that we were in real life situation, and we had to predict the regressors first in order to get the predictions of the exchange rate.

The results of the comparison were that the AUD/JPY exchange rate could to some extent be predictable, and that the predictions by the ARIMA model were more accurate.

Key words:

Foreign exchange market, AUD/JPY, regression model, ARIMA model
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Chapter one: Introduction

This chapter will give the readers the general background of this topic, the reason why we choose this topic, and what and how we are going to study.

1.1 Background

With the development of the financial markets, the foreign exchange (currency or forex or FX) market has become more and more important for investors. Especially after the abolishment of fixed exchange rate systems in most countries, the floating exchange rates made a tremendous contribution to the development of the foreign exchange market and made the trading volume grow.

Business internationalization combines the whole world tightly. Economies are not independent any more and economic changes, e.g. interest rate changes in different countries, influence each other.

Investors around the world, corporations and individuals seek investment opportunities. In the process the foreign exchange rate plays an important role. People use the forex market to hedge, to speculate, and to serve multinational trades.

The development of computer systems and the internet have changed the forex market ulteriorly. By far most of the forex businesses are processed on the internet. Moreover the front end-back office systems provide full accounting coverage, ticket writing, back office processing and risk management implementation at a fraction of the previous cost. Besides, the information is open to all investors. Because there is no so called inside information, the forex market is assumed to be the most efficient market. The foreign exchange market is by far the largest market in the world, in terms of cash value traded, and includes trading between large banks, central banks, currency speculators, multinational corporations, governments, and other financial markets and institutions. The forex market is liquid and active all the time.

More and more people utilize the forex market, and more and more sophisticated investors research such markets. One important topic concerns how to predict the exchange rate movements. Good prediction of future movements is crucial for agents to act in an appropriate way.

In this thesis we choose one money pair AUD/JPY to study. The Australian dollar (AUD) and the Japanese yen (JPY) are two of the most traded and popular currencies in the world. AUD is popular for the stable economy in Australia, the lack of government intervention, and its commodity based character. JPY is widely used as a reserve currency, and is highly dependent on imported oil. Nowadays the
appreciations of the oil price make JPY worthy more attention. The interest rate differentials between Australia and Japan make the AUD/JPY as a popular carry trade currency. This cross money pair boasts nearly most of the attractive characters, so it is worthy and interesting to focus on this money pair.

1.2 Purpose of this paper

The purpose of this thesis is to compare different methods to predict the exchange rate of the money pair AUD/JPY.

Firstly, we study the relationship between the AUD/JPY exchange rate and some economic fundamentals. By such means, the predictions can be more specific, and quantified. In this part we formulate a regression model (see Appendix A) with selected fundamentals, studying the relationship between the change of the exchange rate and the change of the fundamentals.

Secondly, we test whether the AUD/JPY prices have any relationship with the historical prices so that we can predict the future more accurately by using the AUD/JPY historical data. In this part an ARIMA (Autoregressive Moving Average) model is used. (See the Appendix B). The ARIMA model is usually used to predict future values in a series.

The last part of the purpose is to compare the two methods mentioned above. By comparing prediction from the two methods with reality, we can get a conclusion about which method is better for this money pair.

A secondary purpose is to test whether AUD/JPY is predictable. The results from the regression and the ARIMA model can clearly show whether AUD/JPY can be predicted or whether this market is just efficient.

To sum up, there are four steps composing our purpose:

1. Using the fundamentals to predict.
2. Using historical exchange rate data to predict.
3. Comparing these two methods in term of prediction.
4. To test whether AUD/JPY is efficient or predictable.

1.3 The limitation of the study

The empirical study composes the main part of this thesis. However, the precision of the study can be discussed. In the first part of the empirical study, we try to build up the relationship between the foreign exchange rate and fundamentals. These fundamentals are released according to its own schedule, not at the same time. So
when we formulate the regression model, some factors should use the expectation, not the real numbers. Furthermore, GDP and CPI are released quarterly, the other factors are monthly. To include all these useful factors, we divide GDP and CPI by three so that we can get the monthly data, and formulate all the monthly data and predict the monthly trend of foreign exchange.

In the second part of the empirical study, we use an ARIMA model to predict the weekly movement. The selection of the ARIMA (p,1,q) model is only decided by AIC (Akaike’s information criterion). For more exactitude results, this point can be improved.

1.4 Definitions

**Foreign exchange (forex):** Foreign exchange is simply the mechanism which values foreign currencies in terms of another currency. An exchange rate is therefore the price of one currency in terms of another.1

**ARIMA:** Autoregressive moving average (ARIMA) models, sometimes called Box-Jenkins models after George Box and G.M.Jenkin, are typically applied to time series data2.

**AIC (Akaike’s information criterion):** A criteria to gauge how the model fits the data. The lower the AIC the better the model fits the data.

**Unit root tests:** Statistical tests of the null hypothesis that a time series is non stationary against the alternative that it is stationary are called “unit root” tests.3

**ACF (autocorrelation function):** A mathematical representation of the degree of similarity between a given time series and a lagged version of itself over successive time intervals. It is the same as calculating the correlation between two different time series, except that the same time series is used twice - once in its original form and once lagged one or more time periods.4

**PACF (partial autocorrelation function):** The partial autocorrelation of $Y_t$ and $Y_{t-k}$ is the least squares regression coefficient on $Y_{t-k}$ in a regression of $Y_t$ on a constant and k lagged values of $Y_t$.5

**Regression:** Linear regression model uses independent variables to explain and/or predict the outcome of Y.6

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2 http://en.wikipedia.org/wiki/Autoregressive
4 http://www.investopedia.com/terms/a/autocorrelation.asp.
5 Econometric analysis, second edition , William H. Greene page 557
6 http://www.investopedia.com/terms/r/regression.asp.
**Time series**: The chronological sequence of observed prices $X$ at time $t$, for example, $X_1$, $X_2$, $X_3$, . . . , $X_{1006}$ is called a time series

### 1.5 The outline of the paper

**Chapter One:**
The chapter includes the general background of the topic, the purpose and motivation to choose this topic, research method and the limitation of the study.

**Chapter Two:**
This chapter deals with the scientific approach, research method and the collection of data.

**Chapter Three:**
The chapter introduces the information concerning the forex market, e.g. like the classification of the forex markets, characteristics, determination of the exchange rate, quoting habit, and the general information concerning the AUD/JPY exchange rate.

**Chapter Four:**
The chapter presents the theoretical foundations used in order to choose the economic fundamentals. The Purchasing Power Parity (PPP), the International Fisher Effect (IFE) and the hypothesis of market efficiency theories will be presented.

**Chapter Five:**
The chapter presents the empirical study. In this chapter, we will take use of the regression mode and the ARIMA $(p,I,q)$ model to predict the AUD/JPY exchange rates, and then compare which of the methods produces the most accurate predictions.

**Chapter Six:**
In this chapter, we will summarize our study and present our final conclusions from the analysis.

**Chapter Seven:**
At the end of our research, we deem that it is necessary to assess the whole research work to ensure it meet the requirements of an acceptable scientific approach. An acceptable scientific research should meet the criteria of validity and reliability, and these will assure the practical applicability.

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Chapter Two: Methodology

This chapter deals with the scientific approach, research method and the collection of data.

2.1 Choice of subject and preconceptions

Both of the two authors are studying in the Master’s Program in Accounting and Finance at the Umeå School of Business. We find ourselves very interested in the investment issues, especially in foreign exchange. As a result of that, we read plenty of financial news about it. It is obviously that the foreign exchange market is developing rapidly in the whole world. The prediction of exchange rates becomes more and more important. Therefore, we choose A Comparison of the Prediction Performances by the Linear Models and the ARIMA Model to be our thesis subject.

Our preconceptions are theoretical knowledge that we possessed on the subject and practical experiences in the field of interest. Our inspiration on this topic comes from some articles on the foreign exchange market. Based on the knowledge that we learned from the modules of Accounting and Finance, we formed our theory outline on this topic. Furthermore, we took the statistic course “Analysis of Financial Data”, which provides us enough knowledge on how to do the analysis with the statistical tools.

2.2 Scientific approach

Under the usual sense, there are two kinds of main methods, deductive and inductive. The deductive approach begins with an existing theoretical basis, and then develops a theory and a hypothesis, finally uses a designed research strategy to validate the hypothesis. On the other hand, the inductive approach means the researchers create a new theory out of the empirical findings.

Our scientific approach is deductive. In this study the work began by surveying many research articles within the area to get a good understanding of the topic. During this process many ideas came up from which the research question was developed. The underlying theories is something that is not described in research articles about the chosen topic, but we find it important to show that we have an understanding for them and also to give the reader some knowledge about them because it will increase the understanding for the issue. In our case the model for usage was already available in many research articles. Therefore we found it appropriate to use in this study as well.
2.3 Research method

The two principal methods for currency predictions are fundamental analysis and technical analysis. Fundamental analysis relies on painstaking examination of the macroeconomic variables and policies that are likely to influence a currency. Technical analysis is the antithesis of fundamental analysis in that it focuses exclusively on past price and volume movements, while totally ignoring economic and political factors. Technical analysis focuses on the price actions and is based on the history of the exchange rate. It assumes that all the fundamental information has already been included into the prices.

Usually the fundamental analysis of forex or other securities is descriptive words about macroeconomic variables, financial statements or some other fundamental factors. In a typical forex fundamental analysis, the commentator usually talks about the outcome of the newly released fundamental indicator, how much it was expected to be, and how the market reacts and going to react to the spread between the prediction and the reality; In a technical analysis, commentators usually analyze based on different kinds of charts, for example, candles charts to analyze the trends, the speculating points, stop loss and profit limit levels. In this thesis we express the descriptive words of a fundamental analysis in terms of a regression function. By using numbers to describe the relationship between exchange rate and the fundamental variables, readers would get a more persuasive prediction.

In the second part of the empirical study, we use an ARIMA model to describe the exchange rate with historical data. Likewise, we hope the predictions can be quantified, straightforward, and easy for the readers. To build an ARIMA model one essentially use Box-Jenkins methodology (1976), which is an iterative process and involves four stages; Identification, estimation, diagnostic, checking and forecasting. The whole process starts with the checking of stationarities and seasonality in the series. A brief idea about the series can be obtained by plotting it in a graph against the time. Further analysis of the series is performed on the basis of either a unit-root test or correlogram techniques. If underlying series is non-stationary, then first it is converted into a stationary series by differences. Once stationarity and seasonality have been addressed, the next step is to identify the order, and then to estimate the parameters and forecast the future values of the variables. One should also check whether forecasts are accurate or not. There are various statistical measures available for this purpose. In this thesis we use the mean squared prediction error, and mean absolute prediction error criteria to compare the forecasting accuracy.

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8 Mahesh Kumar Tambi, “Forecast exchange rate - A Uni-variate out of sample Approach”.
9 Mahesh Kumar Tambi, “Forecast exchange rate - A Uni-variate out of sample Approach”.

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9
2.4 The collection of data

The information gathering was done by using many different sources, and with a critical approach to their contents. The Umeå University Library (UB) was frequently used during the entire work process. The books were searched and found through ALBUM, the search system service for books in the library.

Internet is the famous powerful tool applicable when searching for information. An important issue, though, is that one has to be careful with regard to information, in determining whether it can be considered scientific or not. This circumstance has been taken into account when we used the search engines, such as Google.

The time series of data in the foreign exchange market are from Data stream Advance, by Thomson Financial, which is a vast database of economic, company, and finance data.

The chosen data are monthly AUD/JPY exchange rates, monthly oil price, monthly gold price quarterly Australian GDP, the ten year government bond of Australia, the Australian CPI, the Australian retail sales, the Australian trade balance, Australian unemployment rate, Japanese CPI, Japanese industrial production, Japanese trade balance, Japanese Tankan survey. The chosen period of all these data is from 1986-01-01 to 2006-06-30. The software used to analyze the data is SPSS (Statistical Package for the Social Sciences).
Chapter Three: The foreign exchange market and general information of the AUD/JPY exchange rate

The chapter introduces the information concerning the forex market, e.g. like the classification of the forex markets, characteristics, determination of the exchange rate, quoting habit, and the general information concerning the AUD/JPY exchange rate.

3.1 Introduction of foreign exchange market

To get to know the foreign exchange (forex) market, we need to introduce the concept of foreign exchange first. Foreign exchange is simply the mechanism which values foreign currencies in terms of another currency. An exchange rate is therefore the price of one currency in terms of another.\(^{10}\)

“The foreign exchange market is not a physical place; rather, it is an electronically linked network of banks, foreign exchange brokers, and dealers whose function is to bring together buyers and sellers of foreign exchange”.\(^{11}\) The forex markets can be classified as the spot market and the forward market.

The spot market is where the spot deals are carried out. “A spot deal consists of a bilateral contract between a party delivering a specified amount of a given currency against receiving a specified amount of another currency from a second counterparty, based on an agreed exchange rate, within two business days of the deal date”.\(^{12}\) A spot rate is the price at which currencies are traded for immediate delivery or in two days in the interbank market.\(^{13}\)

The forward market is where contracts are made to buy or sell currencies for future delivery.\(^{14}\) Any deal ranging within three days and three years is a forward deal.\(^{15}\) A forward rate is the price at which foreign exchange is quoted for delivery at a specified future date.\(^{16}\) The exchange rates we mentioned in this thesis are all spot rates.

\(^{10}\) Trading in the global currency markets, Cornelius Luca, prentice hall Englewood cliffs, New Jersey 07632, p.1.
\(^{15}\) The forward currency market consists of two instruments: forward outright deals and swaps. A forex swap is an over the counter short term interest rate derivative instrument. It is the most heavily traded product on the foreign exchange market.
The forex market has some characteristics as follows:

It is sensitive to a large and continuously changing number of factors. Forex is affected by many factors such as GDP (Gross Domestic Production), CPI (Consumer Price Index), interest rates, inflation rates and so on. These factors are released during a fixed period of time.

It concentrates on several currencies. The major currencies include USD (the US dollar), EUR (Euro), JPY (Japanese yen), GBP (British pound), CHF (the Swiss Franc), CAD (Canadian dollar), AUD (Australian dollar), NZD (New Zealand dollar).

It is a large market and is highly liquid in the major currencies. The trading volume is huge, for example, the average daily international foreign exchange trading volume was $1.9 trillion in April 2004 according to the BIS study Triennial central bank survey 2004.

It is thought to be extremely efficient relative to other financial markets. There is practically no inside information. All the investors can equally access the news which is released according to the economic calendar.

It has long trading hours. The Forex market is open 24 hours a day, 5.5 days a week. Because of the decentralized clearing of trades and overlap of major markets in Asia, London and the United States, the market remains open and liquid throughout the day and overnight. Most other markets are dictated by the time zones of their trading locations.

3.2 The determination of exchange rates

To analyze the forex market, we should describe the determination of exchange rates first. Only holding the root, can we handle and analyze the problems. After we understand how the foreign exchange rate is determined, the analysis of the forex market can be converted into the analysis of these determinants. The predictions are of course based on the analysis of these determinants.

The exchange rates mentioned in this section are the exchange rates under a floating exchange rate system, in the absence of government intervention. In some countries, like China, sovereign interventions still exist. Residents can still not trade exchange freely.

To understand how exchange rates are set, it helps to recognize that “they are market-clearing prices that equilibrate supplies and demands in the foreign exchange markets”. Figure one shows the equilibrium exchange rate. When the supply of euro is higher than the demand, the euro depreciates; when the demand of euro is higher than the supply, the euro appreciates. The difference between the demand and the supply of one currency generates the change in the exchange rate.

Figure 1: Equilibrium exchange rate

![Diagram of Supply and Demand](image)

(From Multinational Financial Management. Seventh edition, Wiley and Sons, p39)

According to the asset market model, “the exchange rate between two currencies represents the price that just balances the relative supplies of, and demands for assets denominated in those currencies.” People trade on expectations in the forex market, and changes in the expectations lead to changes in demand and supply of a currency and the exchange rates. Consequently, it is not difficult to understand why fluctuations always happen before the release of market data. So the release of news concerning factors that affect the equilibrium exchange rate should be cared a lot. Important factors are:

- Relative inflation rates

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3.3 Basic knowledge of quoting

Currencies are traded in pairs, for example, AUD/JPY. This is a money pair. The long position (to buy) of AUD is just the short position (to sell) of JPY. The value of a currency is determined by its comparison to another currency. The first currency of a money pair is called the "base currency", and the second currency is called the "quote currency". The money pair shows how much of the quote currency is needed to purchase one unit of the base currency.24

The currency in front, AUD, will be the one that is going up in value if the money pair is going up, and if the money pair is going down, then the AUD would be getting weaker. That is, AUD is the base currency; the quote is based on AUD, for example, AUD/JPY 82.6400. The price of one AUD equals 82.6400JPY.

3.4 Literature review

In the initial age, till 1980s forecasting of exchange rates was primarily done through structural models. Meese and Rogoff (1982) compared a number of time series and structural models on the basis of out-of-sample forecasting accuracy and they found that a random walk model performs as well as any estimated model at one to twelve month horizons for the dollar/pound, dollar/mark, dollar/yen and trade-weighted dollar exchange rates.25

Kilian (1997), Berkowitz and Giorgianni (1997), Groen (1997), and Berben and Van Dijk (1998) that questioned the statistical robustness of the results from studies finding that monetary fundamentals forecast nominal exchange rate returns (percent changes in the exchange rate) and argued that it was difficult but possible to beat random walk models.26

John Faust (2002) s’ findings are different from the Meese and Rogoff’s. He found that long-horizon exchange rate predictability was present in only a two-year window of data vintages around that originally used. He also found that the models consistently perform better using original release data than fully revised data, and sometimes forecasts better using real-time forecasts of future fundamentals instead of

actual future fundamentals.\textsuperscript{27}

In recent time, Balke and Fomby (1997), Taylor and Peel (2000), Taylor, Peel and Sarno (2001), and Kilian and Taylor (2003) all investigate the case where nominal exchange rates are not too responsive to variations in the fundamentals when the deviations from equilibrium values are small, but exhibit strong or smooth mean reversion when the deviations are too large. Indeed, they find evidence of adjustment of this type.\textsuperscript{28}

### 3.5 General information of the money pair AUD/JPY

#### 3.5.1 The Australian dollar

“The Australian dollar (AUD) is currently the sixth-most-traded currency in the world foreign exchange market (behind the U.S dollar, the Japanese yen, the Euro, the British pound and the Canadian dollar), accounting for approximately 4-5\% of worldwide foreign exchange transactions. The Australian dollar is popular with currency traders due to the relative lack of government intervention in the foreign exchange market, the general stability of the Australia economy and government as well as the prevailing view that it offers diversification benefits in a portfolio containing the major world currencies (especially because of its greater exposure to Asian economies and the commodities cycle)”.\textsuperscript{29} The most widely traded Australian dollar money pairs are AUD/USD, EUR/AUD, AUD/CAD, AUD/JPY, GBP/AUD, and AUD/NZD.

AUD is a commodity currency, for it is very closely tied to the commodity (mineral & farm) export prices. When commodity prices raise, AUD usually tend to rallies; when commodity prices slumped or when domestic spending overshadowed its export earnings outlook, AUD generally tend to fall. The AUD has a positive correlation with commodity prices.

The concept of correlation will also be mentioned later. In the world of finance, it is a statistical measure of how two securities move in relation to each other.\textsuperscript{30} It is expressed by the correlation coefficient:

$$
\rho_{i,j} = \frac{\text{cov}(R_i, R_j)}{sd(R_i)sd(R_j)}
$$

$\rho_{i,j}$ is the correlation between variables $R_i$ and $R_j$, $\text{cov}(R_i, R_j)$ is the

\textsuperscript{27} Mahesh Kumar Tambi, “Forecast exchange rate - A Uni-variate out of sample Approach”.


\textsuperscript{29} http://en.wikipedia.org/wiki/Australian_dollar.

\textsuperscript{30} http://www.investopedia.com/terms/c/correlation.asp.
covariance between variables $R_i$ and $R_j$, and $sd(R_i)sd(R_j)$ is the product of the standard deviations of the variables $R_i$ and $R_j$.

The correlation coefficient is bounded to value between -1 and +1, if the coefficient is positive, when one variable move in one direction, the other will move in the same direction. If the coefficient is negative, they will tend to move in opposite directions. If the coefficient is zero, the movement will be completely random. The table below just shows the correlation between AUD/JPY and the gold price.

**Table 1: Correlation between AUD/JPY and the gold prices**

<table>
<thead>
<tr>
<th>AUD/JPY</th>
<th>Gold Perth Mint Sell A$/Oz</th>
</tr>
</thead>
<tbody>
<tr>
<td>One month</td>
<td>0.712268</td>
</tr>
<tr>
<td>Three month</td>
<td>0.531406</td>
</tr>
<tr>
<td>Six month</td>
<td>0.667342</td>
</tr>
<tr>
<td>One year</td>
<td>0.800304</td>
</tr>
<tr>
<td>One year and five month</td>
<td>0.607708</td>
</tr>
</tbody>
</table>

The data used to calculate the correlations which are shown in the table are from January 2005 to May 2006. The results show that AUD/JPY has positive correlations with the gold prices. The highest is 0.800304, and the lowest is also more than 0.5. This example gives a very good support that AUD/JPY usually have a positive correlation with the gold prices.

### 3.5.2 The Japanese yen

As mentioned above, the JPY is the second most traded currency. It is widely used as a reserve currency after the United States dollar and the euro. The Japanese yen money pairs include USD/JPY, EUR/JPY, CHF/JPY, AUD/JPY, CAD/JPY, and NZD/JPY. Japan is highly dependent on imported oil. Higher oil price can impede both production and economy growth in Japan as it makes input costs significantly more expensive. Consequently, JPY is greatly tied with the oil price. Exactly speaking, it is negative correlated with the oil price. The correlations between AUD/JPY and the oil prices are shown in Table 2.
Table 2: Correlation between AUD/JPY and the oil price

<table>
<thead>
<tr>
<th>JPY/ AUD</th>
<th>Oil price</th>
</tr>
</thead>
<tbody>
<tr>
<td>One month</td>
<td>-0.493349011</td>
</tr>
<tr>
<td>Three month</td>
<td>-0.673086365</td>
</tr>
<tr>
<td>Six month</td>
<td>-0.655365257</td>
</tr>
<tr>
<td>One year</td>
<td>-0.600169316</td>
</tr>
<tr>
<td>One year and five month</td>
<td>-0.631416809</td>
</tr>
</tbody>
</table>

All the results presented are negative, which proves again that Japanese yen usually has a negative correlation with the oil prices.

3.5.3 Characteristics of the money pair AUD/JPY

AUD/JPY is a cross pair. A pair of currencies traded in forex expressed without USD is called cross currency pair, that is, one foreign currency is traded for another without having to first exchange the currencies into American dollar. Historically, an individual who wished to exchange a sum of money into a different currency would be required to first convert that money into U.S dollars, and then convert it into the desired currencies; cross currencies help individuals and traders bypass this step.

The money pair AUD/JPY is often used in a carry trade. Carry trade is defined as: a strategy in which an investor sells a certain currency with a relatively low interest rate and uses the funds to purchase a different currency yielding a higher interest rate. A trader using this strategy attempts to capture the difference between the rates. For example, let's say a trader borrows 1,000 yen from a Japanese bank, converts the funds into AUD and buys a bond for the equivalent amount. Let's assume that the bond pays 4.5% and the Japanese interest rate is set at 0%. The trader stands to make a profit of 4.5% (4.5% - 0%), as long as the exchange rate between the countries does not change. It is highly sensitive to interest rate outlook changes in both Australia and Japan.

This money pair is greatly affected by the gold price and the oil price. As mentioned above, Australia is a big gold export country, and Japanese economy depends enormously on oil. The AUD/JPY is actively traded during Asian banking hours, when Japanese and Australian banks are open.

Chapter Four: Theories

The chapter presents the theoretical foundations used in order to choose the economic fundamentals. The Purchasing Power Parity (PPP), the International Fisher Effect (IFE) and the hypothesis of market efficiency theories will be presented.

To guide us in the choice of economic fundamentals to use, we revive some theories

4.1 Purchasing Power Parity (PPP)

The PPP theory has two versions. In its absolute version, purchasing power parity states that the price levels should be equal worldwide when expressed in a common currency, in other words, a unit of home currency should have the same purchasing power around the world. To guide us in the choice of economic fundamentals to use, we revive some theories

The relative version of PPP, which is used more commonly, states that the exchange rate between the home currency and any foreign currency will adjust to reflect changes in the price levels of the two countries. It can be expressed as:

\[
\frac{e_t}{e_0} = \frac{(1 + i_h)^t}{(1 + i_f)^t}
\]

or

\[
e_t = e_0 \cdot \frac{(1 + i_h)^t}{(1 + i_f)^t}
\]

where \( e_t \) is the spot exchange rate in period \( t \), \( e_0 \) is the exchange rate at the beginning of the period, \( i_h \) is the inflation rate in the home country, and \( i_f \) is the inflation rate in the foreign country.

The PPP is often represented by the following approximation:

\[
i_h - i_f = \frac{e_t - e_0}{e_0}
\]

That is, the change rate of an exchange rate during a period should be equal to the

---

inflation differential for that same time period. For example, if country A’s inflation rate is 10%, and country B’s inflation rate is 5%, country B’s currency should appreciate roughly 5% compared to country A’s currency. The rational for the PPP is that a higher inflation rate should cause the currency to depreciate against a country with lower inflation rate.

Thus, the PPP theory states that the inflation differential is one economic fundamental of importance.

4.2 The International Fisher Effect (IFE)

The generalized version of the Fisher effect says that currencies with high rates of inflation should bear higher interest rates than currencies with lower rates of inflation.\(^{38}\) PPP implies that exchange rates will move to offset changes in inflation rate differentials.\(^{39}\) The combination of these two conditions is the international fisher effect.\(^{40}\) The IFE can be stated as:

\[
r_h - r_f = \frac{E(e_t) - e_0}{e_0}
\]

\(r_h\) is the interest rate in the home country, \(r_f\) is the interest rate abroad, \(E(e_t)\) is the expected exchange rate at period \(t\), and \(e_0\) is the exchange rate at the beginning of the period \(t\).

If the interest rate in the country A is lower than that in the country B, market participants will believe that they will achieve a positive return if they sell the country currency B and buy the currency A, because the expected exchange rate of currency A in the future will appreciate. They will buy currency A to speculate or to invest in the higher-yielding asset. Increased demand leads to appriciations of prices. Finally the positive expected return is fully arbitraged away. The rational for the IFE is that a country with a higher interest rate will also tend to have a higher inflation rate. This increased amount of inflation should cause the currency in the country with the high interest rate to depreciate against a country with lower interest rates.\(^{41}\)

The IFE states that interest rates have a great effect on the exchange rate. So it should be included as an economic fundamental.

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41 http://www.investopedia.com/terms/i/ife.asp.
4.3 Economic Growth

A nation with strong economic growth will increase the investors’ confidence. Obviously a stronger economy means less risk and more chances to get profit for investors, so it will attract foreign investment capital seeking to acquire domestic assets, which leads to an increased demand of domestic currency. Conversely, a weak economy sometimes brings foreign companies high economic exposure which is a measure of how much a company is going to be affected by exchange rate changes. Depressed economy also leads to low consumption. Admittedly, the demand of guns can be still high though one country is having a war and economy is going to collapse. High cost and low profit usually force foreign companies to stop increasing production and new investors will avoid investing in such country.

Empirical evidence supports the hypothesis that economic growth should lead to a stronger currency. Consequently economic growth indicators like GDP, unemployment rate, trade balance, retail sales, and industrial production are also good pointers for exchange rate changes.

4.4 Efficiency market hypothesis

In 1970, Fama put forward the famous hypothesis called the efficiency market hypothesis (EMH), which described the efficiency of the securities market. “The efficient market hypothesis implies that it is not possible to consistently outperform the market — appropriately adjusted for risk — by using any information that the market already knows, except through luck or obtaining and trading on inside information. Information or news in the EMH is defined as anything that may affect prices that is unknowable in the present and thus appears randomly in the future. This random information will be the cause of future price changes.”

There are three versions of the efficient market hypothesis: the weak, semi-strong and strong forms.

“The weak form hypothesis asserts that prices already reflect all information that can be derived by examining market trading data such as the history of past prices, trading volume, or short interest. This version of the hypothesis implies that trend analysis is fruitless. If such data ever conveyed reliable signals about future performance, all investors already would have learned to exploit the signals.”

“The semi strong form hypothesis states that all publicly available information must be reflected in the price. The strong-form version states that prices reflect all information, including inside

44 Investments, sixth edition, Bodie/ Kane/ Marcus p.373.
information.” 45

Although it is a cornerstone of modern financial theory, the EMH is highly controversial and often disputed. While academics point to a large body of evidence in support of EMH, an equal amount of dissension also exists. For example, “investors such as Warren Buffett have consistently beaten the market over long periods of time, which by definition is impossibility according to the EMH. Detractors of the EMH also point to events such as the 1987 stock market crash (when the DJIA fell by over 20% in a single day) as evidence that stock prices can seriously deviate from their fair values”46.

According to the efficiency market hypothesis, the forex market, as the most efficient market, should be unpredictable. We guess that this money pair AUD/JPY may be consistent with weak form hypothesis. If our study results show that exchange rates are unpredictable, this would be an indication of EMH. If there exists some relationship between historical prices and the present prices, and we can predict by taking use of this relationship, then AUD/JPY can be an exception to the efficiency market hypothesis.

4.5 The selection of the economic fundamentals

Based on the reasons expatiated above, many economic indicators seem important in explaining exchange rate movements. Considering the economic features of Australia and Japan and the significance for exchange rate movements, twelve economic indicators were selected.

Gold Prices
Given that commodity products still account for a large percent of total Australian exports, movements in world prices for commodity export prices can help to explain the long-run exchange rate of such commodity currency as the Australian dollar.

Sometimes it is said that trading the Australian dollar is just like trading gold. Australia is the world's third largest producer of gold, and the Australian dollar usually has a positive correlation with the gold price That is to say, when gold prices rise, AUD tends to rise.

Oil Prices
The Japanese economy is very dependant on imported oil, so changes in the price of oil can affect the value of the Yen. Generally the JPY has a negative correlation with the oil price. The high oil price will enhance the cost of products and services, and further slow down the development of the Japanese economy. Usually when the oil price appreciates, the JPY depreciates.

45 Investments, sixth edition, Bodie/ Kane/ Marcus p.373.
**Australian Employment Data**

Australian Employment Data measure the level of employment in Australia. The employment rate is an economic indicator with multiple significances. In addition, the indicator is used as a major component in the calculation of other economic indicators, such as the GNP, and the GDP. The most commonly used employment figure is the monthly unemployment rate.

**Australian GDP (Gross Domestic Product)**

A measure of Australian economic growth. Steady, stable growth levels are ideal for developed nations. GDP refers to the sum of all goods and services produced in Australia - either by domestic or foreign companies during a given time period.

**Australian CPI (Consumer Price Index)**

Australian CPI gauges the average change in retail prices for a fixed market basket of goods and services. CPI helps investors to measure the inflation in Australia.

**Australian Retail Sales**

Australian Retail Sales is used to gauge the overall strength of the economy and consequently the strength of the currency. Australian retail sales are a significant consumer spending indicator for foreign exchange traders, as it shows the strength of consumer demand as well as consumer confidence⁴⁷.

**Australian Trade Balance**

The data are important for foreign exchange in the long run. Australia is a net exporter, meaning that Australia exports more goods than it imports. Changes in the trade balance can affect the price of the Australian currency.

**RBA (Royal Bank of Australia) Rate Decisions**

Since the AUD/JPY is a hot carry trade, changes in the interest rate outlook can cause sharp movements in the money pair. In this thesis, we use the ten year government bond of Australian as the embodiment of the Australian interest rates.

**Japanese CPI**

A measure of inflation in Japan.

**Japanese Trade Balance**

Japanese imports vs. exports – the Japanese economy is highly dependent on exports; a drastic change in this number can have implications on the value of the Yen.

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Japanese Industrial Production
A measure of activity in the Japanese manufacturing sector. This acts as a gauge for the level of production and growth in the economy.

Tankan Survey
A quarterly business survey assessing Japanese business conditions. The headline number shows the difference between the proportion of optimistic businesses and the proportion of pessimistic businesses. A large positive number means that optimism pervades.
Chapter Five: Empirical study

The chapter presents the empirical study. In this chapter, we will take use of the regression mode and the ARIMA (p,I,q) model to predict the AUD/JPY exchange rates, and then compare which of the methods produces the most accurate predictions.

5.1 Fundamental model

Regression is often used to determine how many specific factors such as the price of a commodity, interest rates, and so on, influence the price movement of an asset. In our thesis, we formulate a multiple regression model which is used to determine how much the economic fundamentals influence the price movement of the AUD/JPY exchange rate. The model is specified as:

\[ \Delta Y_t = \alpha_0 + \alpha_1 \Delta G_t + \alpha_2 \Delta I_t + \alpha_3 \Delta C_t + \alpha_4 \Delta R_t + \alpha_5 \Delta T_t + \alpha_6 \Delta U_t + \alpha_7 \Delta O_t + \alpha_8 \Delta J_t + \alpha_9 \Delta J_{t-1} + \alpha_{10} \Delta J_{t-1} + \alpha_{11} \Delta O_{t-1} + \alpha_{12} \Delta T_{t-1} + \epsilon_t \]

The variables are explained in Table 3. \( \epsilon_t \) is a random error term.

Table 3: Variable description

| \( \Delta G_t = \frac{GDP_t - GDP_{t-1}}{GDP_{t-1}} \) | This is the percentage change in the Australian GDP. |
| \( \Delta I_t = INTREST_t - INTREST_{t-1} \) | This is the first difference of the ten year government bond of Australia. |
| \( \Delta C_t = \frac{CPI_t - CPI_{t-1}}{CPI_{t-1}} \) | This is the percentage change in the Australian CPI. |
| \( \Delta R_t = \frac{R_t - R_{t-1}}{R_{t-1}} \) | This is the percentage change rate in the Australian retail sales. |

---

\[ \Delta T_t = \frac{T_t - T_{t-1}}{|T_{t-1}|} \]

This is the percentage change in the Australian trade balance. Since there is an adverse balance of trade, we use the first difference divided by the absolute value of the lagged trade balance.

\[ \Delta U_t = U_t - U_{t-1} \]

This is the unemployment rate change of Australia. Because it already is a ratio, we just use the first difference.

\[ \Delta G O_t = \frac{G O_t - G O_{t-1}}{G O_{t-1}} \]

This is the percentage change in the gold price.

\[ \Delta J C_t = \frac{J C_t - J C_{t-1}}{J C_{t-1}} \]

This is the percentage change in the Japanese CPI.

\[ \Delta J I_t = \frac{J I_t - J I_{t-1}}{J I_{t-1}} \]

This is the percentage change in the Japanese industrial production.

\[ \Delta J T_t = \frac{J T_t - J T_{t-1}}{J T_{t-1}} \]

This is the percentage change in the Japanese trade balance.

\[ \Delta O_t = \frac{O_t - O_{t-1}}{O_{t-1}} \]

This is the percentage change in the crude oil price.

\[ \Delta T A_t = T A_t - T A_{t-1} \]

This is the change of the Tankan survey. It is already measured in percent.

The reason that we process the regressors into the change or percentage change form is that the exchange rate change is always caused by the change of the fundamentals. The exchange rate usually reacts to the fundamental movements, and if the changes of fundamentals are zero, there is no change of exchange rates. Furthermore, to build up a meaningful regression model, it is necessary to make sure that the regressors do not have high mutual correlations, and the processed form can avoid the high correlations among the fundamentals. To test this point, we calculated the correlations among all the regressors, and the results are presented in Appendix D. Since the correlations of the regressors are all smaller than 0.7, problems caused by multicollinearity should not be presented. When all the prerequisites are satisfactory, it is time to build up the model. In Table 4 estimation results for the regression model are presented.
Table 4: Estimation results

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>(Constant)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GDP</td>
<td>9.987 3.782 .188 2.641 .009</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Interest</td>
<td>-1.130 2.934 -.027 -.385 .701</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CPI</td>
<td>4.261 3.185 .095 1.338 .182</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>retailsales</td>
<td>-.891 1.005 -.062 -.887 .376</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tadebalan</td>
<td>-.002 0.06 -.028 -.413 .680</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>unemploy</td>
<td>.296 1.712 .012 .173 .863</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>gold</td>
<td>-3.454 3.421 -.072 -1.010 .314</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JPCPI</td>
<td>10.079 3.067 .243 3.286 .001</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JPindustry</td>
<td>1.942 .893 .162 2.175 .031</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JPtradebal</td>
<td>.056 .072 .054 .783 .435</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>oil</td>
<td>.046 .126 .027 .364 .716</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>tankan</td>
<td>-1.318 .456 -.219 -2.888 .004</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a. Dependent Variable: AUDJPY

In this thesis the significant level for all the estimations is selected as 95%. The results show that only Australian GDP, Japanese CPI, Japanese industry production and Tankan are significant. So we decide to just include these four economic fundamentals in the regression function. The regression model is reduced to be:

\[ Y_t = \alpha_0 + \alpha_1 \Delta G_t + \alpha_2 \Delta JC_t + \alpha_3 \Delta JJ_t + \alpha_4 \Delta TA_t + \epsilon_t \]

We re-estimate the model with four selected fundamentals. The estimation results for the reduced model are presented in Table 5.
Table 5: Estimation results after revising the regression function

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td></td>
</tr>
<tr>
<td>1 (Constant)</td>
<td>80.414</td>
<td>2.384</td>
<td>33.734</td>
<td>.000</td>
</tr>
<tr>
<td>JPCPI</td>
<td>9.448</td>
<td>2.789</td>
<td>.228</td>
<td>3.387</td>
</tr>
<tr>
<td>JPindustry</td>
<td>1.746</td>
<td>.852</td>
<td>.145</td>
<td>2.050</td>
</tr>
<tr>
<td>tankan</td>
<td>-1.379</td>
<td>.444</td>
<td>-2.29</td>
<td>-3.107</td>
</tr>
</tbody>
</table>

a. Dependent Variable: AUDJPY

The new estimation results show that all the regressors are significant. The estimated function is presented as:

\[ Y_t = 80.414 + 9.591 \Delta G_t + 9.448 \Delta JCI_t + 1.746 \Delta IT_t - 1.379 \Delta TA_t \]

5.2 ARIMA model

In statistics, autoregressive moving average (ARIMA) models, sometimes called Box-Jenkins models after George Box and G.M. Jenkin, are typically applied to time series data\(^49\). The chronological sequence of observed prices \(X_t\) at time \(t\), for example, \(X_1, X_2, X_3, \ldots, X_{1006}\) is called a time series. Given a time series of data \(X_t\), the ARMA model is a tool for understanding and predicting future values in this series.

To predict by use of an ARIMA model, it is quite necessary to test whether the time series is stationary. When some of the features of a time series, like the mean, the variance and the covariance, are constant over time it is said to be stationary. In this thesis, we use “unit root tests” to test the stationary assumptions. Statistical tests of the null hypothesis that a time series is non stationary against the alternative that it is stationary are called “unit root” tests\(^50\). The name derives from the fact that an ARIMA process is non stationary if the characteristic polynomial has a root that does not lie inside the unit circle. (See appendix F)

We apply the augmented Dickey-Fuller (ADF) method to test for a unit root\(^51\). The

\(^51\) Introductory econometrics with applications, fifth edition, Ramu Ramanathan, p 458.
test is performed by running the regression model:

\[ \Delta y_t = \alpha + \lambda y_{t-1} + \sum_{i=1}^{p} \theta_i \Delta y_{t-i} + \mu_t \]

\( \Delta y_t \) is the first difference of exchange rate, \( y_{t-1} \) is the lagged exchange rate, 
\[ \sum_{i=1}^{p} \theta_i \Delta y_{t-i} \] is the sum of \( p \) lagged first difference, and \( \mu_t \) is the error term.

The unit root test for \( \lambda = 0 \) is known as the augmented Dickey-Fuller test (ADF). Many economic time series exhibit growth indicating some kind of underlying trend. The modified model for testing a unit root in the presence of a linear trend is

\[ \Delta y_t = \alpha + \beta t + \lambda y_{t-1} + \sum_{i=1}^{p} \theta_i \Delta y_{t-i} + \mu_t \]

In this formula \( t \) is a trend variable. If the calculated t-value of \( y_{t-1} \) is smaller than the critical value, the series is stationary.\(^{52}\) Critical values are obtained from the critical value table by Dickey and Fuller.\(^{53}\) To begin the stationarity test, we plot the time series first, which will give us a straightforward impression of how the time series is like so that we can judge it elementarily. Figure 2 shows a plot of the monthly exchange rate.

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\(^{52}\) Introductory econometrics with applications, fifth edition, Ramu Ramanathan, p 458.
\(^{53}\) Introductory econometrics with applications, fifth edition, Ramu Ramanathan, p 458.
Figure 2: The plot of the monthly AUD/JPY exchange rate

From this plot we can see that the prices vary a lot. It seems that the exchange rates do not move stably. Primarily we doubt the stationarity of the time series. Figure 3 shows the plot of the average exchange rate.
Figure 3: The plot of the average monthly exchange rate of AUD/JPY

It follows a downward trend. If there is a trend in a plot of the mean, usually the time series is nonstationary. However, we must make sure that our surmise is correct. So we decide to do the unit root test to test our surmise. We are going to do the regression of the first difference of the exchange price on the lag price and 5 lagged first differences. Estimations of the unit root test for the AUD/JPY exchange rate are presented in Table 6.
Table 6: Estimation results of the unit root test

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Std Error</th>
<th>t</th>
<th>Approx Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Seasonal Lags</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta y_{t-1}$</td>
<td>.009</td>
<td>.072</td>
<td>.120</td>
<td>.905</td>
</tr>
<tr>
<td>$\Delta y_{t-2}$</td>
<td>.124</td>
<td>.071</td>
<td>1.757</td>
<td>.080</td>
</tr>
<tr>
<td>$\Delta y_{t-3}$</td>
<td>-.102</td>
<td>.068</td>
<td>-1.495</td>
<td>.136</td>
</tr>
<tr>
<td>$\Delta y_{t-4}$</td>
<td>-.027</td>
<td>.070</td>
<td>-3.81</td>
<td>.703</td>
</tr>
<tr>
<td>$\Delta y_{t-5}$</td>
<td>.063</td>
<td>.069</td>
<td>.911</td>
<td>.363</td>
</tr>
<tr>
<td>Regression Coefficients</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$y_{t-1}$</td>
<td>-.059</td>
<td>.021</td>
<td>-2.768</td>
<td>.006</td>
</tr>
<tr>
<td>t (Month)</td>
<td>-.005</td>
<td>.005</td>
<td>-9.53</td>
<td>.341</td>
</tr>
<tr>
<td>Constant $\alpha$</td>
<td>5.478</td>
<td>2.355</td>
<td>2.326</td>
<td>.021</td>
</tr>
</tbody>
</table>

Melard's algorithm was used for estimation.

The critical value at the 5% and 10% significant level (250 observations) are -3.43 and -3.13. When the t-value is smaller than the critical value, we reject the null hypothesis $\lambda = 0$, that is when $t < \text{critical value}$, the time series is stationary. The result shows that the t-value here is -2.768, far bigger than -3.43 and -3.13. So the monthly AUD/JPY exchange rate is non-stationary in level form.

To make a non-stationary time series stationary, one method is to transform this time series into its first difference form, $\Delta y_t = y_t - y_{t-1}$, so we reform the time series into the first difference form and test for the stationarity of the newly reformed time series. Estimation results for the stationarity of the first difference are presented in Table 7.
Table 7: Unit root test of the first difference

<table>
<thead>
<tr>
<th></th>
<th>Estimate</th>
<th>Std Error</th>
<th>t</th>
<th>Approx Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Seasonal Lags</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$\Delta y_t - \Delta y_{t-1}$</td>
<td>-.413</td>
<td>.561</td>
<td>-.736</td>
<td>.462</td>
</tr>
<tr>
<td>$\Delta y_t - \Delta y_{t-2}$</td>
<td>.057</td>
<td>.446</td>
<td>-.128</td>
<td>.898</td>
</tr>
<tr>
<td>$\Delta y_t - \Delta y_{t-3}$</td>
<td>-.142</td>
<td>.209</td>
<td>-.683</td>
<td>.495</td>
</tr>
<tr>
<td>$\Delta y_t - \Delta y_{t-4}$</td>
<td>-.099</td>
<td>.168</td>
<td>-.588</td>
<td>.557</td>
</tr>
<tr>
<td>$\Delta y_t - \Delta y_{t-5}$</td>
<td>.016</td>
<td>.119</td>
<td>.135</td>
<td>.893</td>
</tr>
<tr>
<td>Regression Coefficients</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$t$ (Month)</td>
<td>.003</td>
<td>.002</td>
<td>1.462</td>
<td>.145</td>
</tr>
<tr>
<td>Constant $\alpha$</td>
<td>-.615</td>
<td>.061</td>
<td>-10.138</td>
<td>.000</td>
</tr>
<tr>
<td></td>
<td>-.477</td>
<td>.292</td>
<td>-1.633</td>
<td>.104</td>
</tr>
</tbody>
</table>

Melard’s algorithm was used for estimation.

After changing the time series into the first difference form, the t-value is -10.138, so the time series is stationary. We also tried many other ADF tests with different orders of the AR components. The results are similar. The time series of monthly prices itself is non-stationary, but the time series of the first differences is stationary. The time plot of the first difference is shown in Figure 4.
Figure 4: Time plot of the first difference

From the graph we can see that the new time series fluctuates concentrating around the line of zero, which is a typical plot of a stationary time series. Based on the ADF test results and this time plot feature, we can conclude that the series of the first difference is stationary.

Given that the first difference series is stationary, we can fit an ARIMA model to the differenced series. By graphing the ACF and the PACF, (auto correlation function and partial auto correlation function), we try to decide the order of the AR and the MA parts of the model (see appendix B). The ACF and PACF are shown in Figure 5 and 6.
Figure 5: Autocorrelation function (AFC)

DIFF(exchange,1)

Lag Number

ACF

Coefficient
Upper Confidence Limit
Lower Confidence Limit

Coefficients are plotted against lag numbers, indicating no significant autocorrelation.
The PACF is used to determine the order of the AR component, and ACF to decide the order of the MA component. The selection criterion is AIC (Akaike’s information criterion). The smaller AIC is, the better the fit of the model. Table 8 shows the AIC values for a number of ARIMA(p, I, q) models.
Table 8: AIC values for the ARIMA(p, I q) models

<table>
<thead>
<tr>
<th>ARIMA I=1</th>
<th>P=1</th>
<th>P=2</th>
<th>P=3</th>
<th>P=4</th>
<th>P=5</th>
<th>P=6</th>
<th>P=7</th>
<th>P=8</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q=0</td>
<td>1131.395</td>
<td>1131.633</td>
<td>1130.488</td>
<td>1132.054</td>
<td>1133.841</td>
<td>1134.562</td>
<td>1136.033</td>
<td>1137.012</td>
</tr>
<tr>
<td>Q=1</td>
<td>1133.125</td>
<td>1132.494</td>
<td>1132.168</td>
<td>1132.106</td>
<td>1133.968</td>
<td>1135.37</td>
<td>1138.402</td>
<td>1139.038</td>
</tr>
<tr>
<td>Q=2</td>
<td>1131.74</td>
<td>1133.039</td>
<td>1134.171</td>
<td>1133.586</td>
<td>1133.567</td>
<td>1137.078</td>
<td>1139.412</td>
<td>1137.37</td>
</tr>
<tr>
<td>Q=3</td>
<td>1131.814</td>
<td>1133.751</td>
<td>1133.404</td>
<td>1135.163</td>
<td>1137.199</td>
<td>1139.204</td>
<td>1138.133</td>
<td>1137.58</td>
</tr>
<tr>
<td>Q=4</td>
<td>1132.963</td>
<td>1134.589</td>
<td>1135.231</td>
<td>1137.201</td>
<td>1136.178</td>
<td>1138.944</td>
<td>1137.506</td>
<td>1144.318</td>
</tr>
</tbody>
</table>

The results show that **ARIMA (1, 1, 0)** has the smallest AIC, 1131.395, so it is going to be the model with the best fit. Estimations for the ARIMA (1,1,0) are shown in Table 9.

Table 9: Estimation results for the ARIMA (1,1,0)

<table>
<thead>
<tr>
<th>Parameter Estimates</th>
<th>Estimates</th>
<th>Std Error</th>
<th>t</th>
<th>Approx Sig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-Seasonal Lags</td>
<td>-.019</td>
<td>.071</td>
<td>-.271</td>
<td>.787</td>
</tr>
<tr>
<td>Constant</td>
<td>-.332</td>
<td>.269</td>
<td>-1.234</td>
<td>.219</td>
</tr>
</tbody>
</table>

Melard's algorithm was used for estimation.

Thus, the model to be used in the forecast comparison is given by:

\[
\Delta Y_t = -0.332 - 0.019\Delta Y_{t-1}
\]

5.3 Forecasting performance

The full sample is from January 1986 to June 2006. To test which predicting method is better, we choose data from January 1986 to December 2002 to build up the prediction function. Then we use the data from January 2003 to 2006 June to check...
which predicting method is closer to the reality. Predictions from the fundamental model are built on the following estimated model:

\[ Y_t = 80.414 + 9.591 \Delta G_t + 9.448 \Delta JC_t + 1.746 \Delta HI_t - 1.379 \Delta TA_t \]

Because Australian GDP and Japanese Tankan are quarterly released, and each of the four factors has its own schedule to be released, we can not get those four factors at the same time. Furthermore, when we predict for the next month, all the fundamentals are also unknown. To forecast the exchange rate, we have to forecast the regressors first.

In the comparison of the forecasting performances two approaches dealing with the unknown future fundamentals are used. Firstly assume that we can do perfect predictions of these four factors, that is, our predictions of these four regressors are the same as the actual future outcomes. So we put the real data for the fundamentals from January 2003 to June 2006 into this regression function above, and see the result of the predictions. The results are shown in Appendix C. Secondly we assume that we are in real life situation, and we have to predict the four regressors first in order to get the predictions of the exchange rate. In this approach we just use simple linear functions to predict the future values of the regressors.

Appendix E presents estimation results concerning the models used to predict the regressors. The prediction results of the regression models under the real life situation and the perfect prediction situation and the results of the ARIMA (1,1,0) are all shown in Appendix C.

To compare the accuracy of the predictions, we calculate the mean squared prediction errors, and mean absolute prediction errors. The results are shown in Table10 and 11.
Table 10: Mean squared prediction errors

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Squared errors of</td>
<td>42</td>
<td>.01726</td>
<td>362.72307</td>
<td>57.8425640</td>
<td>82.59923180</td>
</tr>
<tr>
<td>perfect predictions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Squared errors of</td>
<td>42</td>
<td>.01441</td>
<td>325.03727</td>
<td>53.1477345</td>
<td>73.60121481</td>
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<tr>
<td>real life predictions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Squared errors of</td>
<td>40</td>
<td>.01532</td>
<td>24.46964</td>
<td>4.7322174</td>
<td>5.61072175</td>
</tr>
<tr>
<td>ARIMA predictions</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Valid N (listwise)</td>
<td>40</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</table>

Comparing both approaches of the fundamental model with the ARIMA forecasting method, we get the result that the squared errors of ARIMA (1,1,0) model have the smallest mean and standard deviation.
Table 11: Mean absolute prediction errors

<table>
<thead>
<tr>
<th>Absolute errors of perfect predictions</th>
<th>N</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>42</td>
<td>.13137</td>
<td>19.04529</td>
<td>6.0705200</td>
<td>4.63716887</td>
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<tr>
<td>Absolute errors of real life predictions</td>
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<td>4.5052987</td>
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<tr>
<td>Absolute errors of ARIMA predictions</td>
<td>42</td>
<td>.00000</td>
<td>4.94668</td>
<td>1.7290362</td>
<td>1.24672175</td>
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<tr>
<td>Valid N (listwise)</td>
<td>42</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

The result presented in Table 11 also shows that predictions by ARIMA (1,1,0) are the closest to the reality, that is, ARIMA (1,1,0) is the most accurate model among the three predicting methods.
Chapter six: Conclusion

In this chapter, we will summarize our study and present our final conclusions from the analysis.

Floating exchange rate system, business internationalization, and the development of computer systems and the internet drive the development of the foreign exchange market. People use the forex market to hedge, speculate, and serve multinational trades. One important topic is how to predict the exchange rate movement. Good prediction of future movements is crucial for agents to act in an appropriate way. In this thesis we choose one money pair AUD/JPY to study. Our purpose is to compare which model among the regression model and ARIMA model that is better for monthly AUD/JPY exchange rate prediction. During the process we are also going to get a side conclusion about whether AUD/JPY is efficient or predictable.

There are four steps composing our purpose:

1. Using the fundamentals to predict.
2. Using historical exchange rate data to predict.
3. Comparing these two methods in term of prediction.
4. To test whether AUD/JPY is efficient or predictable.

In this thesis, we selected fundamentals according to different economic theories and built a regression model based on economic fundamentals. Considering the economic characters of Australia and Japan, the oil prices and gold prices are also enclosed in this regression model. Then we used an ARIMA model to predict based on historical data. To compare the two predicting method, we divided the sample into two parts. The fist part which is used to build up model is from 1986-01-01 to 2002-12-31. The second part which is used to test the accuracy of predictions is from 2003-01-01 to 2006-06-31.

We were very surprised that oil and gold prices were not significant for the money pair AUD/JPY in monthly rate prediction, even though it was shown by examples that AUD was positively correlated with gold prices and JPY was negatively correlated with oil prices.

From our study, the AUD/JPY exchange rate does have a relationship with the economic fundamentals, Australian GDP, Japanese CPI, Japanese industry production and Tankan. However some other important fundamentals which were supposed to be significant had no evident affections on the predictions of the monthly AUD/JPY exchange rate. One possible reason may be that most fundamentals usually have obvious influences on long term trends; however, monthly interval is not a term that is long enough. For this money pair, the Japanese economy seems to have more
influence on the monthly exchange rate than the Australian economy. At the same time, the money pair AUD/JPY can be predicted by use of the historical data. The prediction results of the ARIMA model is more accurate than those based on the fundamental regression model.

Based on the results shown by the ARIMA model and the regression model, we conclude that there are indications of that the exchange rate of AUD/JPY does not exhibit a random walk. Thus, the AUD/JPY is to some extent predictable.

The analysis methods used in this thesis are also applicable for stock analysis, bond or other financial securities.
Chapter seven: Credibility criteria

At the end of our research, we deem that it is necessary to assess the whole research work to ensure it meet the requirements of an acceptable scientific approach. An acceptable scientific research should meet the criteria of validity and reliability\textsuperscript{54}, and these will assure the practical applicability.

7.1 Validity

Validity is concerned with the relationship between theoretical framework and empirical study, and is decided by the materials collected. In another words, it measures the extent of its results from the gathered information that have been interpreted correctly. Therefore, it shows the precision and genuineness of the research.

In the theoretical framework, we reviewed a great deal of articles and books, read carefully to find relevant information in those literature materials, and did the summary that covers a large part of the theories available in our research area.

In the empirical study, due to this thesis is a quantitative study, validity in this case need be certain by if the collected materials are adequate and if there are a sufficient number of data. We achieved this through collecting different kinds of information from case object, including statistic from history data, investigation and relevant documentations.

7.2 Reliability

Reliability expresses the consistency of the research findings and the rigorous use of an acceptable scientific methodology. Although we have used the quantitative research method, which may result in weak reliability, the reliability is ought to be discussed to avoid misunderstandings. In the theoretical study, all the materials are from literature articles and textbooks, which has well-accepted reliability. When we do the empirical study, all the materials come from the dependable published information. We took them through both of taking notes and recording, which ensure the collected data with high reliability. In the analysis part, we did the analysis systemically close to the information in the previous chapters. Whereas every part is unique, from our particular data, the results in this thesis are reliable.

\textsuperscript{54} Hair, J. F., Babin, B, Money A. H., Samouel P., Essentials of Business Research Methods, 2003, John Wiley & Sons, USA.
Appendix A: Linear regression model and multiple regression model

Linear regression\(^{55}\) is a statistical measure that attempts to determine the strength of the relationship between one dependent variable (usually denoted by Y) and a series of other variables (usually denoted as Xi).

Y is conventionally also called the "response variable". The terms "endogenous variable" and "output variable" are also used, and the other variables Xi are called the independent variables, explanatory variables, exogenous variables, regressors, and input variables.

The two basic types of regression are linear regression and multiple regression. Linear regression uses one independent variable to explain and/or predict the outcome of Y, while multiple regression uses two or more independent variables to predict the outcome. The general form of each type of regression is:\(^{56}\)

Linear Regression: \(^{57}\)

\[
Y = a + bX + \varepsilon
\]

Multiple Regression: \(^{58}\)

\[
Y = a + b_1X_1 + b_2X_2 + b_3X_3 + \ldots + b_tX_t + \varepsilon
\]

Y is the variable that we are trying to explain, X is the variables that we are using to explain the variation in Y, a is the intercept, b is the slope, and \( \varepsilon \) is a random error term. In multiple regression the separate variables are differentiated by using subscripted numbers.\(^{59}\)

Regression takes a group of random variables, thought to be explaining Y, and tries to find a mathematical relationship between them. This relationship is typically in the form of a straight line (linear regression) that best approximates all the individual data points.

\(^{55}\) http://www.investopedia.com/terms/r/regression.asp.
\(^{56}\) http://www.investopedia.com/terms/r/regression.asp.
\(^{57}\) http://www.investopedia.com/terms/r/regression.asp.
\(^{58}\) http://www.investopedia.com/terms/r/regression.asp.
\(^{59}\) http://www.investopedia.com/terms/r/regression.asp.
Appendix B: ARIMA model

In statistics, autoregressive moving average (ARIMA) models, sometimes called Box-Jenkins models after George Box and G.M. Jenkin, are typically applied to time series data. The chronological sequence of observed prices \(X\) at time \(t\), for example, \(X_1, X_2, X_3, \ldots, X_{1006}\) is called a time series.

Given a time series of data \(X_t\), the ARIMA model is a tool for understanding and predicting future values in this series.

It is usually written as ARIMA \((p,q)\). ARIMA\((p,q)\) is a combination of the AR model and the MA model. The current value of a variable can be explained in terms of two factors, a combination of lagged values of the same variable and a combination of a constant term plus a moving average of past error terms. A moving average for some time period is the arithmetic mean of the values in that time period.

The letter “I” in the ARIMA model represent the number of time that the original series needs to be differentiated to make it stationary.

\[
y_t = c + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \ldots + \alpha_p y_{t-p} + \epsilon_t + \beta_1 \epsilon_{t-1} + \ldots + \beta_q \epsilon_{t-q}
\]

**AR (Autoregressive) model**

Simply speaking, the autoregressive model is the method to use the past data to explain future data.

\[
y_t = c + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} + \ldots + \alpha_p y_{t-p} + \epsilon_t
\]

Where \(\alpha_1, \alpha_2, \alpha_3, \ldots, \alpha_p\) are the parameters of the model, \(c\) is a constant and \(\epsilon_t\) is an error term.

**MA (moving average) model**

An moving average (MA) model is presented as:

\[
y_t = c + \epsilon_t + \beta_1 \epsilon_{t-1} + \ldots + \beta_q \epsilon_{t-q}
\]

---

60 http://en.wikipedia.org/wiki/Autoregressive
where $\beta_1, \beta_2, \beta_3, \ldots, \beta_q$ are the parameters of the model, and $\varepsilon, \varepsilon_{-1}, \varepsilon_{-2}, \ldots, \varepsilon_{-q}$ are the error terms.

**Procedures**

The general approach to time series modeling

- Plot the time series against the time, and examine the main features of the graph, checking in particular whether there is
  - A trend
  - A seasonal component
- Remove the trend and seasonal components to get stationary residuals. To achieve this goal it may sometimes be necessary to apply a preliminary transformation to the data so that we can convert non stationary series into a stationary form, like the first difference form or log return form\(^63\).
  - fist difference form\(^64\):
    $$y_t = x_t - x_{t-1}$$
  - log return form  The natural logarithm of the simple gross return\(^65\)
    $$y_t = \ln(1 + r_t) = \ln x_t - \ln x_{t-1}$$
    Choose a model to fit the residuals, making use of various sample statistics including the sample autocorrelation function\(^66\).

- Forecasting will be achieved by forecasting the residuals and then inverting the transformations described above to arrive at forecasts of the original series\(^67\).

To use ARIMA model, according to the procedures above, the specific prerequisites and procedures should be as follows:

**Firstly we plot the time series.** Then we check the stationarity autoregressive variable which is required to make predictions. A time series is said to be stationary when its statistical properties keep constant over time.

- $E(y_i)$ is a finite constant\(^68\)

---

\(^{63}\) Introduction to time series and forecasting, second edition, Peter J. Brockwell, Richard A. Davis p 14.

\(^{64}\) The class notes by Xavier de Luna and Suad Elezovic, Department of Statistics Umea University.

\(^{65}\) The class notes by Xavier de Luna and Suad Elezovic, Department of Statistics Umea University.

\(^{66}\) Introduction to time series and forecasting, second edition, Peter J. Brockwell, Richard A. Davis p14.

\(^{67}\) Introduction to time series and forecasting, second edition, Peter J. Brockwell, Richard A. Davis page 14

\[ V(\gamma_1) \] is a finite constant \(^{69}\)

\[ Cov(\gamma_t, \gamma_{t-s}) \] depends only on the lag “s” \(^{70}\)

It means the mean and the variance will converge into a constant and do not change through time. That the \( Cov(\gamma_t, \gamma_{t-s}) \) depends only on the lag “s” means as long as the spread of the lag orders is “s”, the covariance should be the same. All of these are only the understanding on the definition lay. In this thesis we choose another reasonable and practical way, unit root test. We handle this part firstly by time plots and unit root test.

**Secondly**, we identify the order of the autoregressive and moving average terms by the autocorrelation plot and the partial autocorrelation plot. They can be plotted together with bands. These autocorrelations and partial autocorrelations are pictured as bars. The order mentioned here is just how many bars should be included into the function. One bar represents one lag.

**ACF** (autocorrelation function) to assess the degree of dependence in the data, one of the important tools we use is the sample autocorrelation function of the data. ACF is a useful device for describing a time series process, in much the way that the moments are used to describe the distribution of a random variable.

The correlation between \( X_t \) and \( X_{t-1} \) is \(^{71}\)

\[
\hat{\rho}(X_t, X_{t-1}) = \frac{\sum_{i=2}^{n}(X_i - \bar{X})(X_{i-1} - \bar{X})}{\sum_{i=1}^{n}(X_i - \bar{X})^2}
\]

which is called *autocorrelation of order 1*. Autocorrelation of order zero is 1.

**PACF** (partial autocorrelation function). The partial autocorrelation of \( \gamma_t \) and \( \gamma_{t-k} \) is the least squares regression coefficient on \( \gamma_{t-k} \) in a regression of \( \gamma_t \) on a constant and k lagged values of \( \gamma_t \). \(^{72}\)

\(^{71}\) The class notes by Xavier de Luna and Suad Elezovic, Department of Statistics Umea University
\(^{72}\) Econometric analysis, second edition, William H. Greene page 557
\[ k = 1: Y_t = \alpha_1 + \beta_{11} Y_{t-1} + \epsilon_t, \]
\[ k = 2: Y_t = \alpha_2 + \beta_{21} Y_{t-1} + \beta_{22} Y_{t-2} + \epsilon_t, \]
\[ k = 3: Y_t = \alpha_3 + \beta_{31} Y_{t-1} + \beta_{32} Y_{t-2} + \beta_{33} Y_{t-3} + \epsilon_t \]

The parameters \( \beta_{11}, \beta_{22}, \beta_{33}, \ldots \) are called partial autocorrelations of order 1, 2, 3…

Usually we use PACF to determine the order of AR, and ACF to decide the MA orders.

**The rule is** when partial autocorrelations or the auto correlations become zero, we know that it is not worth introducing more lags into the model.

**Thirdly,** after we decide the order of the lags, we fit the model. This process is done by SPSS.

We also use the methodology of “testing down”. At the first stage many possible autoregressive and moving average terms are include. Then lags are dropped according to the significance of their coefficients.

The significance of the models is determined by AIC (Akaike’s information criterion). The smaller AIC is, the better the model fitted. All the possible ARIMA(p,q) will be tried. AIC is calculated by the computer program SPSS. According to the AIC, the best ARIMA would be found.

We forecast prices step by step. First we predict one step ahead, and then use this for a two step ahead prediction and so on. So given \([ Y_t, Y_{t-1}, Y_{t-2} \ldots ]\), we can get the prediction of \( Y_{t+1} \).

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73 The class notes by Xavier de Luna and Suad Elezovic, Department of Statistics Umea University
Appendix C: Predictions

The table below shows the predictions by the two fundamental models and the ARIMA model.

<table>
<thead>
<tr>
<th>perfect prediction</th>
<th>real life situation prediction</th>
<th>ARIMA prediction</th>
<th>real value</th>
</tr>
</thead>
<tbody>
<tr>
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Appendix D: Correlation between regressors

The tables show the correlations between the regressors.

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<th>AUS trade balance</th>
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<td>-0.019997597</td>
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<td>JP CPI</td>
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<td>JP industry condition</td>
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<td>AUS retail sales</td>
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<td>oil</td>
<td>Tankan</td>
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</table>
Appendix E: estimation results for models used to predict the regressors

These results are for regressor predictions which are used in the real life situation.

GDP

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
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<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td></td>
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<tr>
<td>1 (Constant)</td>
<td>781.528</td>
<td>474.610</td>
<td>1.009</td>
<td>1.647</td>
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<tr>
<td>LAGS(GDP,1)</td>
<td>1.009</td>
<td>.004</td>
<td>1.000</td>
<td>270.669</td>
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</table>

*a. Dependent Variable: GDP*

\[ G_t = 781.528 + 1.009G_{t-1} \]

Japanese CPI

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
<td></td>
</tr>
<tr>
<td>1 (Constant)</td>
<td>1.037</td>
<td>.536</td>
<td>.990</td>
<td>1.936</td>
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<td>LAGS(JPCPI,1)</td>
<td>.990</td>
<td>.005</td>
<td>.997</td>
<td>181.065</td>
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</table>

*a. Dependent Variable: JPCPI*

\[ J_{C_t} = 1.037 + 0.990J_{C_{t-1}} \]

Japanese industrial

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
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<tr>
<td></td>
<td>B</td>
<td>Std. Error</td>
<td>Beta</td>
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<tr>
<td>1 (Constant)</td>
<td>3.707</td>
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<td>.016</td>
<td>.974</td>
<td>61.283</td>
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*a. Dependent Variable: JPINDUSTRY*
$J_{t} = 3.707 + 0.961J_{t-1}$

Tankan

<table>
<thead>
<tr>
<th>Model</th>
<th>Unstandardized Coefficients</th>
<th>Standardized Coefficients</th>
<th>t</th>
<th>Sig.</th>
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</thead>
<tbody>
<tr>
<td>1 (Constant)</td>
<td>-.270</td>
<td>.954</td>
<td>-250</td>
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<td>LAGS(tankan,1)</td>
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</table>

a. Dependent Variable: tankan

$TA_{t} = -0.27 + 0.954TA_{t-1}$
Appendix F: Unit root test

This part is something about the definition of unit root

\[ y_t + \alpha_1 y_{t-1} + \alpha_2 y_{t-2} = (1 + \alpha_1 L + \alpha_2 L^2) y_t \]

\[ L^k y_t = y_{t-k} \]

\[ 1 + \alpha_1 L + \alpha_2 L^2 \] is called characteristic polynomial.

As for \( Y = \alpha Y_{t-1} + \mu \) if \( \alpha = 1 \), this AR (1) model is non-stationary.

The null hypothesis is \( \alpha = 1 \).

It can be rewritten as \( (1 - \alpha L) Y_t = \epsilon_t \) if the characteristic polynomial is \( 1 - \alpha L \) has a root \( 1/\alpha \), which will lie on, not inside, the unit circle when \( \alpha = 1 \), so the null hypothesis can’t be rejected.
References

Books


Articles


Berben, R.B. and van Dijk, D.J., “Does the absence of co integration explain the typical findings in long horizon regressions?” Econometrics Institute.


Mahesh Kumar Tambi, “Forecasting exchange rate-a uni-variate out of sample Approach” (Box-Jenkins Methodology) (Author is a Research Scholar at IIMT and can be contacted at mkt_jpr@rediffmail.com).


Websites

http://www.fxcmtr.com

Essays from this website:

Chief Strategist Kathy Lien, Commodity Prices and Currency Movements, FXCM, January 25, 2006

Senior Currency Strategist Boris Schlossberg, How to Scalp Fundamentally, FXCM, May 10, 2006

Chief Strategist Kathy Lien, Using Currency Correlations to Your Advantage, FXCM, May 19, 2005

Jason Van Bergen, A Primer On The Forex Market, FXCM, September 17, 2003

Currency Strategist Boris Schlossberg, Common Questions about Currency Trading, FXCM, February 8, 2006

http://en.wikipedia.org

http://www.investopedia.com

http://www.thomson.com/financial/financial.jsp

http://www.yahoo.com

http://www.answers.com/topic/effidient-market-hypothesis

Class note:

Xavier de Luna, Suad Elezovic, The class notes, Department of Statistics Umea University.