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THEORY OF FORECASTING FOREIGN EXCHANGE RATES VIA PPP FOR
LONG TERM PULP AND PAPER INVESTMENTS

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1. Introduction

We are living in a world of globalization where the multinational companies have projects and sales in all continents and various currencies. The core of the business can remain the same, but the conditions will vary depending on the country and currency. New investments in the pulp and paper sector are important decisions due to their long term nature and the capital intensity (Bergman and Johansson 2000). Building a new pulp mill project can cost almost 2 billion dollars (Stora Enso press release 2011). The investment of that size easily affects the future of the company for the next 50 years. When evaluating investment with that magnitude the correct data is crucial to receive reliable results on which the investment decision can be based on.

When major investment is planned a feasibility study is carried out and financial model is done to calculate the profitability and the sensitivity of the project. Financial model is describing the complete picture of financial implications for investors. The structure of the model is complex with many different variables depending on the regulation in the investment country. (FAO 1973) Some of the variables are more crucial to the project's Net Present Value (NPV) than the others. One of the important variables is currencies. When investing to a foreign country the effect of the foreign exchange rate can have a major impact on the project's value. The foreign exchange risk by definition is a possible direct or indirect loss in the cash flows, assets and liabilities. (Papaioannou 2006) The definition itself illustrates that currency risk are not always stabile or even noticeable. The risks can vary during the investment years, when moving from construction to operational phase and when debt portfolio is formed.

The long term equilibrium value of foreign exchange rates has been gotten a lot of attention from the researchers. Also the investment banks are using lot

of their efforts to create forecasting model for currencies. The most well known method for searching the equilibrium rate is the Purchasing Power Parity (PPP), where the value of the currency is measured with differences in countries price levels. Many of the top economists have been participating on almost a hundred year debate of PPP's functionality. Economists like; Cassel, Krugman, Rogoff, Lothian and Taylor have all given their views on the functionality of PPP.

1.1 Research problem

This thesis is investigating the forecasting of currency rates for long term period and its effect to long term investment in the pulp and paper sector. The main questions are; how well can future foreign exchange rates be forecasted via PPP in today's currency markets? What is the implication of incorrect forecast for long term investment project?

1.2 Structure of the paper

This thesis is structured as follows: First in the chapter 2, the theory of PPP will be introduced and it will be examined from the long term foreign exchange rate equilibrium perspective. Secondly in the chapter 3, the earlier studies of PPP will be investigated and the main debates on the theory will be introduced. Thirdly the foreign exchange markets will be introduced and the main products will be listed and explained in chapter 4. In this chapter the market restrictions and limitations will be studied from the forecasting point of view. Fourthly in the chapter 5 the sensitivity of investment calculations to foreign exchange movements will be illustrated via hypothetical investment case. The last chapter, chapter 6, will provide the conclusions based on the earlier chapters.

2. Theory of PPP

To forecast future values of stocks, commodities and currencies has been employing researchers for the past 100 years. No one has found a formula that would work perfectly in all the known, and unknown for that matter, market conditions. Perfectly working model should not be possible to build under effectively working markets and many of the researchers have been trying to find the long term equilibrium value for currency pair instead. The long term forecasting of equilibrium rates knows different theories, but the most well know theory is Purchasing Power Parity (later PPP). It can be said that inside the wide field of PPP researches there are still many questions which do not have unanimous answers. PPP still is one of the main theories for forecasting long term foreign exchange rates and the next section will take a brief look on the wide and wild field of studies of PPP.

2.1 History

The PPP was first brought to public attention in Salamanca, Spain in the sixteenth century. Since then the theory has been under debate and it has been developing towards its current form. This current form of PPP that we know today was developed by Gustav Cassel in 1918. (Officer 1982) During that time World War 1 had ended and the inflation was a major concern globally. The theory helped to find the nominal foreign exchange rate between the major economies. The fairly simple theory of PPP says that the nominal exchange rate between currencies should be measured through its purchasing power. A unit of currency of one country will have the same purchasing power in another country. For the previous to hold, the nominal foreign exchange rate should correct all the price differences between two countries. (Taylor and Taylor 2004)

It has been widely agreed that PPP can be only used for long term foreign exchange rate forecasting and that the theory will not hold on short term. (Froot and Rogoff 1994, Rogoff 1996, Lothian and Taylor 1996) If the price for basket of goods is the same in two countries, the foreign exchange rate should be 1. In order the PPP to work the rates need to be mean reverting in the longer time spans. It would leave the inflation difference as the only driver of the currencies in the longer run.

Main test for PPP have been static testing and more advanced unit root testing has only being taken place during the past 20-30 years. The tests can be divided in to three groups based on the test methods and null hypothesis'. Stage 1 tests, which include the correlation based tests. The null hypothesis of those tests is if PPP holds. The stage 1 tests were mainly used between early 1970's and early 1980's

Stage 2 test consist from stationarity tests for real exchange rates. The null hypothesis being if the real exchange rates follow random walk or alternatively if PPP holds for long-term periods. These methods were mainly in use from 1980's onwards.
Stage 3 tests are based on co-integration-based tests between nominal exchange rates and relative prices. The stage 3 tests were taking into use at the same time as the stage 2. (Froot and Rogoff 1994)

It is also agreed that PPP is not a value where the currency would remain extensive amount of time. It is rather an equilibrium level that draws the currency rate towards it, in long term. The pace of the movement is still under discussion and it will be addressed later on this paper.

2.2Nominal and real foreign exchange rate

To understand the difference between nominal and real foreign exchange rate is a key to understand the PPP theory. The nominal exchange rate is what can be seen for Reuters or Bloomberg screens. It is the market rate at that given moment. Mussa (1986) says "the real exchange rate between two countries may be defined as the relative price of one country's consumption basket in terms of the consumption basket of the other country." The high correlation between nominal and real exchange rates has been proved and is widely agreed, also that shocks are affecting to both real and nominal exchange rates.

The increasing volatility caused by ending the Bretton Woods in 1973 and the difference in volatilities between currency pairs is also widely agreed by the researchers. (Frankel and Rose 1994) Below the graph 1 shows the three month volatility of eurusd and its development during the last 8 years. (Bloomberg)
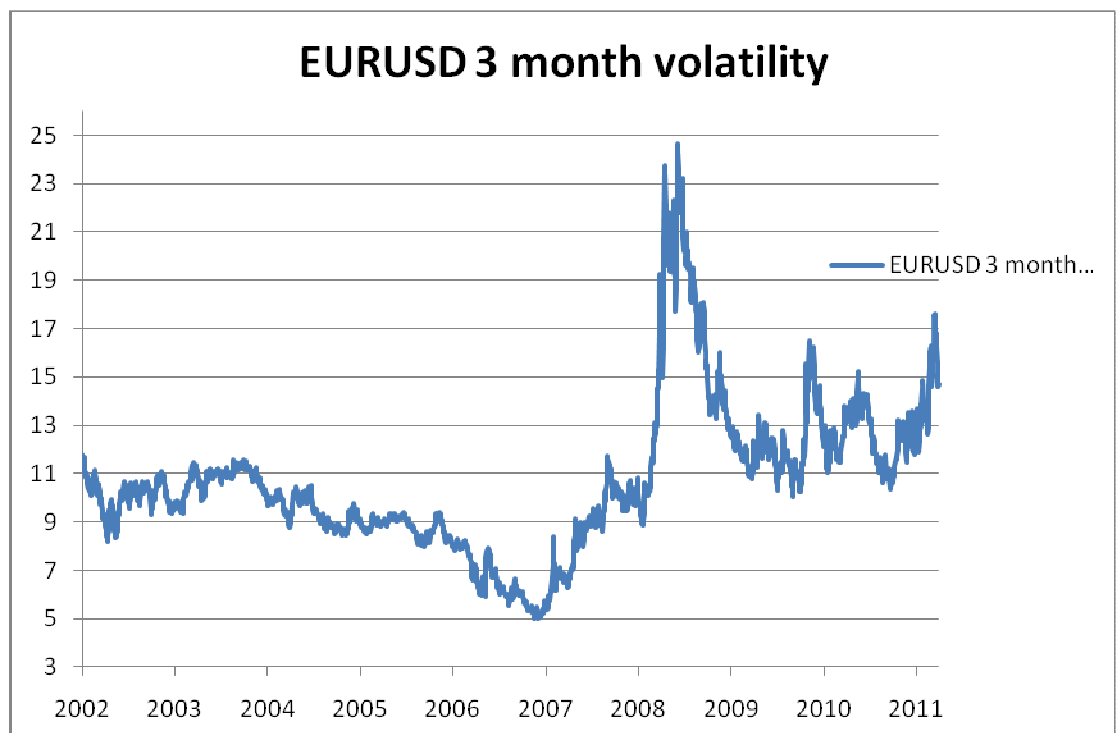
Graph 1: eurusd 3 month volatility 2002-2011 (Bloomberg)

The graph 1 is not telling us how the ending Bretton Woods affected to the volatilities, but it is rather showing the more relevant situation of the past years. As we can see from the graph 2, we are entering to more volatile environment again. The volatility spike in 2008 was never seen before, but the latest moves don't rule out that it wouldn't be seen again. The volatility is a increasing the challenge to predict long term equilibrium rates, as one can imagine.

2.3 Absolute and relative PPP

The PPP can be divided in two different theories, absolute and relative PPP. The PPP mentioned in the earlier paragraph was the more traditional absolute PPP. The absolute purchasing power is based on the assumption that price for basket of goods in the domestic country is the same as the basket of goods in a foreign country, when they are converted to common currency (Balassa 1964). This theory expects the absence of transaction and transport costs and perfectly competed markets (Deaton and Heston 2009). Hence currency rate is based on equalization in the prices between two countries. This theory is also the theory know as law of one price. The formula can be written into following form.

$$P=P*/W \tag{1}$$

Where   P   price of given basket of goods

               P*   price of given basket of goods abroad

               W   nominal exchange rate between domestic country and foreign country

The relative PPP is based on changes in the prices rather than equalization of the purchasing power at all times. The long-term validity of the following formula is the condition for relative PPP to hold.

P= c(P*/W)   (2)

Where   P   price of given basket of goods
               P*   price of given basket of goods abroad
               c   constant
               W   Nominal exchange rate between domestic country and
                          foreign country

In the above formula, c shows that the ratio between the purchasing powers of domestic and foreign country will have to stay constant, in order for relative PPP to hold. If we add in a growth component we will have the following formula.

"W= "P*"-"P"   (3)

Where   "-"   growth
               W   Nominal exchange rate between domestic country and
                          foreign country
               P   price of given basket of goods
               P*   price of given basket of goods abroad

 If the domestic price for basket of goods would rise permanently and the foreign country would not change. The long term inflation in the home country would rise and nominal foreign exchange rate would change according to the inflation difference. If the foreign exchange rate would keep on changing constantly with the same pace as the inflation difference, then the relative PPP holds. This means that the difference of long term inflation rates is equal to the nominal exchange rate movement. (Rogoff 1996, Deutsche Bundesbank) Generally the absolute form of PPP has been rejected to work in the real world, due the limitations arising from the tariffs, transaction and

transport costs. As a theoretical model it's a working model, but the reality changes the framework too much. For the past decades the researchers have more concentrated on the functionality of relative PPP. The main issues of this debate reviewed on the chapter 3.

2.4 How to calculate PPP?

The calculation process for PPP is not mathematically complicated. The complexity comes from choosing the correct variables. There are three crucial factors to be solved for calculations are briefly listed below.

First problem is the period which is chosen to be the base rate i.e. when the currency pair was in its fair value (JP Morgan 2008). For example in the case of eurusd we can go back to 1999 and choose the 1,13 to be the fair value of eurusd. By even a year change to the PPP base rate we can see substantial movements in the PPP value. If we change the base period to be 2000 the PPP goes to 0,96 and if we change one year downwards to 1998 the PPP value is 1,19. As the movement between the base years show, it makes a real difference which base year is chosen.

After deciding the base rate, we encounter the second problem. Was the euro fair valued against SEK at the same time it was fairly valuated against the dollar? If it wasn't, will choosing that period as the base rate bring inconsistencies to the model? (JP Morgan 2008)

The third variable that needs to be correctly chosen is the index for the inflation. In the case of eur, usd and sek the two choices are CPI (Consumer Price Index) and PPI (Producer Price index). There are arguments for both of the earlier mentioned to be used as the inflation measurement. Craig (2005) points out in his report, that CPI has fewer components which are tradable and hence that better measurement for PPP inflation is PPI. He argues that the products included in PPI are more liquid and tradable. To be able to evaluate the different indices we will take a brief look on what the CPI and

PPI actually measure. Table 1 shows the different components effecting to the CPI/PPI changes and their weights for the respective figure. The indices are based on the year 1990 levels and are showing the US CPI and PPI baskets. (Bloomberg)

CPI	100 %
Food and beverages	15 %
Housing	42 %
Apparel	4 %
Transportation	17 %
Medical care	7 %
Recreation	6 %
Education and communication	6 %
Other goods and services	3 %
PPI	100 %
Finished consumer goods	75 %
Capital Equipment	25 %

Table 1: CPI and PPI breakdown for usd (Bloomberg)

CPI measures the market price of the basket of consumer goods, the weights (as shown above) of the goods are based on the consumer spending patterns. How the weights work, is that, for example transportation has about 17% weight on the total index. If the transportation price arises by 2%, the index will rise by 0,34 points. Given that we are comparing United States of America, European Monetary Union area and Sweden we can expect some similarities on the consumer pattern due that all the countries are developed countries. If we would include countries with substantially lower GDP per capita, we would have to rethink the consumer pattern again.

Like mentioned earlier some researchers find PPI as more useful for PPP purposes, due the more tradable products. Although many of the earlier studies are done with using the CPI as the measure of the inflation, I would

be inclined to use PPI as the base. Just by a simple look to the table tells that many important components of the index can be affected by simply domestic changes which are not necessarily arising from the increased/decreased productivity of the sector.

(Bloomberg, Deutsche Bundesbank monthly report)

For the actual calculation I will use Bloomberg tool, due the usability advantages. Bloomberg give the opportunity to jump from base year to another and from an index (CPI, PPI) to another conveniently. The Bloomberg PPP tool calculates the PPP's with the following formula (Bloomberg):

PPP= Average Exchange Rate * [(Foreign CPI[t] / Foreign CPI[average])   (4)
/ (Base CPI[t] / Base CPI [average])]

Like mentioned above, if PPI is chosen to be the index for calculations, the formula would look the following (Bloomberg):

PPP= Average Exchange Rate * [(Foreign PPI[t] / Foreign PPI[average])   (5)
 / (Base PPI[t] / Base PPI [average])]

Another source for PPP's is the OECD, unfortunately they only publish refreshed PPP numbers every third year and that would eliminate the possibility on quarterly or even yearly updates. (OECD 2011 PPP report)

3 Ongoing debates on the PPP

PPP theory has a long history in the field of finance and economics and the debate on the PPP is very much ongoing. The mean reversion of the currency rates haven't been unanimously agreed the power of the earlier

tests have been questioned. Also the pre and post Bretton Woods data and bring their own challenges for researchers, as well as the role of transaction costs in the PPP. (Taylor and Taylor 2004) What is the correct way to choose the base period for PPP? How the currencies behave, are they mean reverting or do they just follow random walk? How do the transaction costs affect on the PPP? Is the convergence towards PPP linear or non-linear? The earlier mentioned issues, which are crucial for PPP's ability to forecast long term exchange rates, will be addressed in the following part of this paper.

3.1 Correct period for base rate

The correct period for base rate was briefly touched earlier. The currency can be fairly valuated against another currency but can be over valuated against another currency at the same time. This issue arises from the balance of payments and how the country can be having surpluses against one country and deficits against another. This would give different base years for different currencies and could lead to inconsistencies. (JP Morgan FX strategy 2008) Just to highlight the importance of the issue, have a look of the graph 3 below. (Bloomberg)
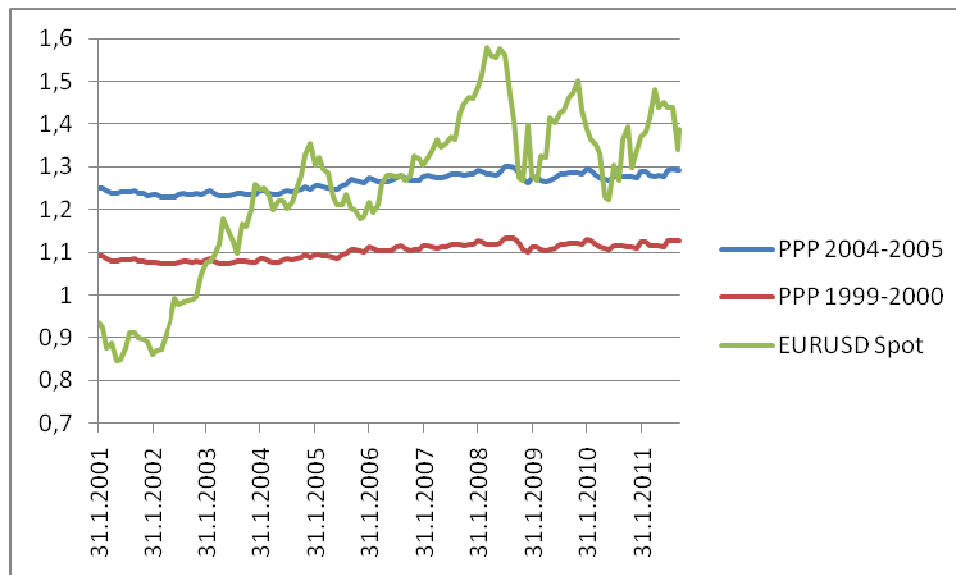
Graph 2: Effect of base year change in PPP (Bloomberg)

Graph 2 illustrates the difference in PPP values, when the base year has been changed with 5 years. As we can see the difference between the PPP values is some 20 figures i.e. 0,2. To illustrate the importance further, the error means that for every million euros, there is 200.000 usd difference between the base rates. For projects worth of billions of euros, the difference will be catastrophic.

3.2 Balassa-Samuelsson effect

Balassa-Samuelson effect is named after Bela Balassa and Paul Samuelson, who both wrote on article on 1964. Both were driving the same points. They were saying that, when all the prices are transformed to common currency the prices of rich countries will still be higher. The argument behind that was the higher productivity relative to the poor countries. They further argued that the difference of productivity inside the country can falsely indicate adjustments to exchange rate. If we assume one small economy with fixed rate and two types of products, traded and non-traded, can increase its productivity in traded goods. If we further assume that the productivity of the non-traded goods won't rise with the same pace and the price ratio between traded and non-traded goods will remain the same. This will increase the relative price of non-traded goods. This would falsely indicate a need for a larger adjustment of currency rate based on the PPP theory. (Balassa 1964, Samuelson 1964, Rogoff 1996, MacDonald and Ricci 2001)

Samuelson concluded that "had Cassel tried to calculate PPP for mobile goods (the same meaning as traded goods) he would have found the ruling rate to be the correct one."

De Gregorio and Wolf (1994) argue in their study that the Balassa-Samuelson effect is relevant only for long term periods and Engel (1999) claims that for

dollar the non-traded goods have very little impact. Froot and Rogoff (1994) claim that the Balassa-Samuelson effect is weaker for industrialized countries for the floating regime period. Balassa-Samuelson effect is usually considered as a problem in the PPP. Given the countries under the study (European Monetary Union countries, USA and Sweden) Balassa-Samuelson effect should not skew the results much, since all the countries are considered to be developed markets.

3.3 Law of one price

Like mentioned earlier the absolute PPP theory is based on the law of one price. This means that the goods or basket of goods are equally priced in two different countries, if converted to common currency. The reasoning behind the law of one price is that arbitrage (i.e. the possibility for yield without any risks) shouldn't exist in perfect markets.

Will the law of one price hold? Craig (2005) pointed out reasons in his report why the price of one law doesn't hold in practice. He argued that the goods differ from a country to another and are not always perfect substitutes. Also when the goods are sold in different locations, one of the locations can offer a service on top of the good, when the actual price is paid on a good and the service and then the goods wouldn't be perfect substitutes anymore. He also criticises excluding the transaction costs and states that going over the border always increases the price. In practice the law of one price works very well for commodities which are in tradable form, for example gold. Commodity prices which are tight to services and local components will vary more. (Rogoff 1996)

3.4 Mean Reverting or Random walk?

Like mentioned in the beginning, the idea of the PPP is based on (amongst other factors) currencies to mean revert in the longer time span. If a unit root

can be found (i.e. not mean-reverting), that would put the functionality of PPP under a serious doubt. In the latest research there has been debate whether or not the currency rates actually mean revert, or if they just follow the random walk. If the currencies are not mean reverting or non-stationary the PPP does not hold even for the longer term periods and it cannot be used as reliable forecast for future foreign exchange rates. Froot and Rogoff (1994) say that the stationary is harder to find and proof due the slow convergence towards PPP. The slow convergence is especially a problem, when used data is only for floating rates, and even more so, if they are floating against each other.

There have been a lot of researches on this field and the results are changing depending on the power of the tests and the time spans used. The mean reversion with two century dataset was proven to exist by Lothian and Taylor (1996). They found different explanation percentage for different currency pairs, but more importantly they both illustrated significant mean reversion. The earlier studies mainly were lacking the power and even today's tests would be more reliable if there would be more data from the past Bretton Woods time (Froot Rogoff 1994). There have been tests for only floating rate regimes and the random walk hypothesis was rejected by Whitt (1992), but the debate on the sufficiency of the time span for the data continues when we consider only the floating rates. Some of the researchers are claiming that the static tests are not sufficiently powerful to test random walk hypothesis. They recommend using the unit root testing, but also the powerfulness of the Dickey-Fuller test (Dickey and Fuller 1979), used by Whitt for example, has been argued against. Since the data from the floating rates regime is increasing every day, we can expect that further and more powerful tests from this area will be seen in the near future.

3.4.1 Fixed or floating currency and the effect mean reversion

Consensus had been during the fixed rates (before ending the Bretton Woods 1973) that the long term foreign exchange rate of major industrialized countries are fairly stable (Friedman and Schwartz 1963). When the Bretton Woods system collapsed and the main currencies went floating, it increased the volatility on the currencies which also put the relevance of the PPP as a long term forecasting method under question. That started the debate of the exchange rates and whether they are mean reverting or if they follow the random walk. During the 1980's a lot of research was done on this topic and the results were mainly concluding that the exchange rate movements followed random walk. (Adler and Lehman 1983) Later on the 80's same research was done and the results were quite the opposite. Glen (1988) found that in a monthly data there is a substantial deviation from the random walk, but there wasn't any evidence on the mean reversion, at least not for periods up to 32 months. He also found that when the tests were done with annual data, the hypothesis of random walk couldn't be rejected. However almost all the tests involve data from the pre-floating (fixed) period. That decreases the creditability of PPP in the floating environment.

Many of the PPP researches are done many years ago and they have been using data from both fixed and floating regimes or only fixed rates data. Also the tests haven't been as powerful as they are nowadays. Lately the criticism towards the sufficient power of the unit root tests has been rising. The researchers like Campbell and Perron (1991) claim that the tests have been rejecting the null hypothesis of unit roots, when they have been actually false. However Taylor (2001) claims that the methodology the empirics use, have a low frequency data and linear model specification and are biased towards slow convergence and random walk.

3.5 Half-life in PPP

The half-life in PPP is the number of years that it takes for deviations from PPP to halve. This means that the difference between the actual exchange rate and the exchange rate predicted by the PPP is reduced by half every 2.5 to 5 years, everything else remaining constant. (Rogoff 1996) Froot and Rogoff (1994) acknowledge that half-life changes between different countries, but suggest that the consensus for half-life expectation is 4 years for industrialized countries. Rossi (2001) agrees that half-life is different depending on the country, but suggests confidence intervals for most of the countries to be between 6-8 quarters. Interestingly for long time span data, Lothian and Taylor (1996) found that variation in half-lives between two currency pairs can be very high. Their study illustrated 3 year half-life for franc-sterling and 6 year half-life for dollar-sterling. This brings up another interesting question, can we just use an average for half-life, if the variation is so major? In further modelling of the determinants of the real exchange rate McDonald and Ricci (2001) found that half life can be cut to 1 year, simply by adding factors like net foreign asset position, Balassa-Samuelson variable and efficiency of the distribution sector.

3.6 Linear or non-linear movement towards PPP?

One of the debates on the PPP is if the PPP model is linear or non-linear. The standard model expects that the difference between PPP value and current value will diminish in a linear fashion. This would mean that nominal foreign exchange rate will move constantly towards PPP with the same pace. Taylor (2001) criticises this assumption based on the risk aversion and with "band of inaction". "Band of inaction" is a situation where there would be an arbitrage possibility, but the arbitrage is so small that no one will take actions to benefit from it. Schnatz (2006) argues in a case of eurusd, the further the movement is from the PPP value, the faster the movement towards

equilibrium is. The linearity movement in practice seems not acceptable by the researchers, but to incorporate non-linear movements to a model can be somewhat tricky, but it could be simply implemented via percentual change.

Rogoff (1996) mentions that a significant degree of consensus has been reached on the deviations from PPP. He claims that 15% per year is the convergence that many researchers tend to use. The convergence is so slow since the prices are sticky. 15% being a relative figure, the smaller the difference the smaller the movement, which lead us to stay, near the PPP for longer periods of time.

Rogoff also comments that if shocks appear in the financial markets, the annual change towards PPP should be faster than 15%. He sees that the stickiness of the prices decreases during the financial turmoil. Stickiness in the prices can be caused by the interest rate difference between the two currencies and hence the short term rates are not at equilibrium level. (Frankel and Rose 1994, Dornbush 1976)

Interest rate difference or cost of carry is widely used in short to medium term foreign exchange trading. It means that when currencies have different interest rates, the forward points should eliminate the arbitrage for holding the higher yielding currency and swapping it back to the home currency. However it is not a continuing difference and it should only affect to short term periods, which is why it can be seen as "stickiness" when moving towards long term equilibrium.

According to ECB findings (Schnatz 2006) the half-life can be as low as 2-3 quarters, when the real exchange rate is further from the PPP, which would back-up the theory that Rogoff was proposing earlier.

3.7 Does PPP work in practice?

Given the fact that PPP is one of the major theories in the field of economics and that it is steering the thoughts of the top economists there is and there was. It will be impossible to answer the question in the title. However there

are many very good arguments supporting and denying the theory of PPP. During the lifeline of PPP, many researchers have been giving their effort for PPP to be used correctly. One thing that most of the researchers seem to agree is that PPP cannot be used for short term foreign exchange forecasting. For example in the article of Rogoff (1996) he states that "short-run deviations from PPP are large and volatile". Neither for short term forecasting nor trading tool is the PPP useful, but for the long term forecasting it has been used, although there are many different views on its ability to predict long term equilibrium rates. OECD says in its report that PPP values should not be used for long term forecasting. (Bournot et al. 2011) Most likely this statement is given to avoid any misunderstanding, but it leaves some room to think about the validity of PPP in practice.

3.8 How the PPP is tight to foreign exchange forecasting

Even with a lot of disagreement on the PPP's usability as an exchange rate forecasting tool for floating currencies has appeared. Dornbusch and Krugman (1976) say that PPP is a theory for equilibrium rates, rather than for foreign exchange rates. The previous comment is correct, but it was made more for a short term periods and for long term forecasting the equilibrium is the one that counts. PPP in some form is still used in many of the main forecasting models, including the forecasting tools of investment banks (JP Morgan, UBS). It is not perfect, far from it, but it gives an indication on the correct value for currency pair in long term.

4. Foreign exchange markets

4.1 Foreign exchange market conditions in general

The foreign exchange or FX is the biggest asset class, with approximately 800 Billion dollar turnover per day (Federal Reserve Bank of New York 2011).

The market conditions between countries vary with a wide scale. There are freely floating and freely convertible currencies, which is the case for many of the industrialized countries.

Many of the smaller or emerging countries have traditionally had fixed or pegged currency rates, usually against the dollar. Calvo and Reinhart (2002) write that countries are forced to choose between monetary unions, hard peg, freely floating currency or adopting another country's currency. Twelve European countries formed a European Monetary Union (EMU) and Ecuador adopted the US dollar as their currency. Many emerging countries like Brazil, Russia and Poland went to different direction and chose the floating currency. The currency value can be also tight against one currency with acceptable band of change. Usually the currencies are euro or dollar or a combination of the earlier. Inside the band the currency rate can vary previously agreed percentage. Many of the countries like Czech Republic, Cyprus, Latvia and Lithuania which are applying to EMU, have limited their currency moves to ±15%. The ±15% change is only the official limit and the countries can keep their currency fluctuations on a tighter range if they wish. (European Central Bank 2004)

If the currency is threatening to leave the acceptable band, central banks will intervene and stop the movement, or at least try to do so. Forecasting of these kinds of currencies basically comes down to one question, is the central bank of the country in question reliable and strong enough to keep its currency inside the agreed band? To have strongly fixed currency to move against its "fair value" can be somewhat unrealistic, if the fair value is outside the band communicated by the central bank.

Additional interest to currency markets comes from currencies which are not convertible outside the corresponding country. Good example is China, they don't have a fully convertible currency in the same form as the other industrialized countries (JP Morgan 2011).

With the above mentioned differences between currencies, it's worthwhile to think if different currencies can be forecasted via the same model. In my case all the currencies are freely floating and fully convertible. Both currency pairs under inspection are also in the ten most traded currency pairs, eurusd being the most traded currency pair (Bank of International Settlements 2010).

4.2 History of foreign exchange markets

During the Middle Ages there were 1500 different currencies in the Europe and in the beginning of the 19th century there was only 38 currencies. The first bills were also introduced in the Middle Ages and they were changeable against gold or silver, which started the banking system in Europe. In the 1870's Germany and USA went to gold standard while other countries still remained in silver or in silver and gold. In 1922 conference was held in Genoa, which resulted into convertible exchange with central bank or government gold reserves. The gold standard was abandoned by the USA and later the European countries, which paralyzed the foreign exchange markets. After the World War 2 the Bretton Woods system was introduced leading by the USA. Bretton Woods was consisted from three main rules. First the currencies were to be pegged, but could be adjusted in the case of fundamental disequilibrium. Second to avoid speculation and the problems bearing from that, the countries could use capital control. Third the International Monetary Fund was founded. (Eichengreen and Sussman 2000) The Bretton Wood system collapsed in 1973 when USA stopped converting its currency to gold. After the system collapsed, the countries could choose if they want to leave their currency to float, or to tight it with a range to another floating currency. Many of the countries went for the floating currency, which increased the volatility in the markets, but also made the markets more efficient. The turnover in US markets in 1998 was more than 60 times the turnover in 1977, which illustrate the pace of the volume increase. (Cross 1998)

In the early 1970's the very controlled foreign exchange market was widely deregulated for developed countries. Like mentioned before, the regulation still vary today between countries. The regulation wasn't the only thing changing. More developed technology was introduced and it helped to transfer the amounts from country to another without physically moving bills. This made the foreign exchange markets more tradable and more liquid. The technology also equalizes the asymmetrical information between the market participants. New technology made possible to follow official publications in real time and gave the same information to all traders around the world. (Cross 1998)

4.3 Markets nowadays

Like mentioned earlier, the foreign exchange has increased its importance for multinational companies. The participants in the foreign exchange market are not only to exporters and importers, but banks, hedge funds and investors. The market participants can be divided into three groups based on their trading behaviour; hedgers, speculators and arbitrageurs. Difference between hedgers and speculators is that hedgers are looking for more security and decrease the volatility in their earnings. The speculators are trying to benefit on the future direction of the markets. They use the foreign exchange as investment rather than a hedge. The arbitrageurs are trying to lock-in a profit from incorrect pricing with two or more securities. (Hull 2009)

Like mentioned under the history chapter, the markets have changed substantially and many of the companies have to take into consideration the foreign exchange movements when operating in their business. The increased volatility has been forcing the companies to concentrate more on their foreign exchange risks and the hedging of those risks.

The markets have been very volatile on the 2011 autumn. Goldman Sachs writes on their 2011 September FX monthly analyst, that the fiscal tension has risen again in the Euro area. They are expecting only slowly improving

fiscal policy and coordination in the Euro area and propose that risk premiums will still remain wide. SEB write in their end of August report that OECD countries are heading towards slowdown, but towards recession. The financial market is constantly waiting new headlines on the Euro area fiscal situation and USA economical data. FED (Federal Reserve Bank) is planning to launch the QE3 (Quantitive Easing) to keep the USA from falling into depression. There are currently many open issues open which can be seen in the financial markets as increased uncertainty and volatility like illustrated earlier.

4.4 Foreign exchange products

The foreign exchange market is developing all the time and new products are introduced every year. The new products are usually based on combination of the old products and just structured differently. Following chapters will give a very brief overview on the most traded and used foreign exchange products. I will only concentrate on the vanilla structures and leave the more complicate digital structures out, due to their irrelevance on the forecasting. Vanilla structure is a structure where options or forwards are either bought or sold and the payout structure is linear for each option or forward. In digital structures the payout is digital and can be triggered by barriers, or it can accumulate payoff. It is important to note that all the foreign exchange products introduced below are physically settled i.e. the currency is actually transferred from account to another. Also all the products are Over-The-Counter (OTC) products and they are not cleared in the exchange. (Hull 2009)

4.4.1 Spot

The very core of the foreign exchange market is spot transaction and it's the earlier mentioned nominal foreign exchange rate. Unlike in other asset

classes the market standard for delivery of currencies is 2nd business day from the transaction and that date is called the spot date. (HSBC) This is understandable in many ways, since same day value wouldn't be possible for Australian dollar, traded at New York time, due the payment cut-off times. All the prices in the Bloomberg or Reuters screens are quoted for spot delivery. The daily liquidity for combined spot market is approximately 400 billion dollars (Federal Reserve Bank of New York 2011). In the practical trading the spot trade is included in all the structures. In options the delta will be carried out with spot transaction, in forwards the starting point is the spot as well as in swaps.

4.4.2 Forward

What happens if the delivery of the currency is needed for same day value or in a month's time? Like explained above the spot price is the "bulk" price. Whenever the delivery differs from spot, it will result in forward points. Forward points are reflecting the interest rate difference of two currencies. The longer better yielding currency is held, the more is paid in forward points and hence lost when converted back to home currency. (Hull 2009) The market is functioning with supply and demand, which can then skew the forward points and give arbitrage possibilities. Simple arbitrage is quite seldom available in the forward market for human traders. The algorithm machines are seeking these possibilities and trade that possibility as long as the arbitrage is available. The daily volume for forward transactions is approximately 130 billion dollars (Federal Reserve Bank of New York 2011). Foreign exchange futures work the same way as the forwards. The difference is that periods and amounts are set and futures are cleared in the exchange (Hull 2009).

4.4.3 Foreign exchange swap

Usually when swap is mentioned in finance, it means the interest rate swap. The foreign exchange swap is very simple structure which combines spot and forward. They are always to opposite direction from each other. This means that dollars can be bought in the spot leg at spot price against the euro. At the same time the dollars are agreed to be sold based on the forward rate on the maturity date of the forward. The swaps are used to convert currency for certain period of time. For example swap can be used for hedging a short term loan, which the borrower wishes to use in some other currency than the loan currency. When the payback of the loan appears the forward will mature and foreign currency from the forward can be used for repaying the loan with earlier agreed rate. The average daily foreign exchange swap volume is approximately 225 billion dollars (Federal Reserve Bank of New York 2011).

4.4.4 Option

Options are widely in use at foreign exchange markets. Given the relatively small effect that option pricing and availability provide for the forecasting process, I will just give a very brief look. Options, either call or put options are mainly used to protect positions and they function the same way as stock options (no dividends). In currencies the option always refers to the first currency of the currency pair. So buying a eurusd call means buying a right to buy euros against dollars at certain rate at certain time. The most used form of options is the european options, but american and asian options are also available. The difference between the earlier mentioned options types is that european options can be only executed on one specific date. The american options can be executed at any point during the life time of the option. The asian options are average options, where the exercise price is compared to an average of certain period. The pricing of the options is tied into level of volatility in the markets the higher the volatility more expensive the option is. The volatility skew affects on the pricing as well and it shows the market

positioning between call and put options. (Hull 2009) In options the volatility is the relevant part when thinking about the forecasting process, more volatility in the markets the bigger the margin of error in the forecast. The daily volume of the OTC options is approximately 50 billion dollars (Federal Reserve Bank of New York 2011).

4.5 Liquidity in Foreign exchange markets

Like mentioned in the beginning of this chapter, the foreign exchange market is the most traded market volume wise. In the Table 2 we can see how the volume has developed from 2001 to 2010. (Bank of International Settlements 2010)

Global foreign exchange market turnover by currency pair[1] Daily averages in April, in billions of US dollars and percentages								
Currency pair	2001		2004		2007		2010	
	Amount	%	Amount	%	Amount	%	Amount	%
US dollar/euro	372	30	541	28	892	27	1,101	28
US dollar/yen	250	20	328	17	438	13	568	14
US dollar/sterling	129	10	259	13	384	12	360	9
US dollar/Australian dollar	51	4	107	6	185	6	249	6
US dollar/Swiss franc	59	5	83	4	151	5	168	4
US dollar/Canadian dollar	54	4	77	4	126	4	182	5
US dollar/Swedish krona	6	0	7	0	57	2	45	1
US dollar/other	193	16	300	16	612	18	705	18
Euro/yen	36	3	61	3	86	3	111	3
Euro/sterling	27	2	47	2	69	2	109	3
Euro/Swiss franc	13	1	30	2	62	2	72	2
Euro/other	22	2	44	2	123	4	162	4
Other currency pairs	28	2	50	3	139	4	149	4
All currency pairs	1,239	100	1,934	100	3,324	100	3,981	100

Table 2: Global foreign exchange market turnover by currency pair (Bank of International Settlements 2010)

There are few important issues to notice from the table 2. The first point is to notice that the volume of trading is increasing every year and that trend seems to be continuous. The second point is how the three main currency pairs (EURUSD, USDJPY and GBPUSD) hold approximately 50% of the global currency market.

Even though the foreign exchange market is the most liquid market globally, it doesn't mean that liquidity is not a problem in the foreign exchange market as well. The liquidity is not the same for every currency pair and the most traded currency pairs seem to have the best liquidity. The eurusd is clearly the currency pair with best liquidity (Mancini et. al. 2011)

Francis Breedon indentifies two types of stress events in the foreign exchange markets. First is a high volatility and high turnover and the second is high volatility and low turnover. The latter will create tightening of the liquidity and widening of the bid-ask spreads. The foreign exchange actually liquidity has decreased dramatically during the financial crisis. The worsening liquidity can be seen from the wider bid-ask spreads during the financial crisis. (Mancini et al. 2011) The foreign exchange market is at the same time the most traded market, but the liquidity problems can't still be ignored. Evans and Lyons (2001) are claiming that volume of the market doesn't affect on the liquidity. They also found that public information flow affects on the liquidity. This phenomenon is very visible also in nowadays, bid-ask spread widens just before and after important publication.

5. Investment calculations and foreign exchange rates

In this chapter investment calculations will be introduced and how the effect of exchange rates to the profitability of the project will be illustrated. The most common investment calculations are Net Present Value (NPV) and Internal Rate of Return (IRR). Both of them are based on the discounting the future cash flows. The NPV of a project is the discounted benefits of an investment deducted by the discounted costs of the investment. The IRR of the project is the discount rate which gives the project a zero NPV. (Sloman 1991, p. 309-310) The discount rate used in the calculations should reflect the cost of capital for the company and Weighted Average Cost of Capital (WACC) is commonly used to discount a project. If the project is in a more risky environment than the company normally operates, then the discount rate

should be different. (Krüger et al 2011) Like mentioned in the earlier chapters, the investments in the pulp and paper sector are long term investments with high capital utilization and the modelling has a very important role on planning of the investment. The long investment tenor makes the profitability calculations very sensitive on the discount rate and for long term foreign exchange rates.

5.1 Hypothetical investment case in the pulp and paper sector

To give the correct meaning of the foreign exchange forecasts for a long term project, a hypothetical case of a foreign investment in the pulp and paper company will be illustrated. Even with the case being hypothetical, it will try to capture all the relevant variables which foreign exchange can effect.

If we assume that the home currency of the company is euro, which means that the company reports its results in euros and all the foreign investments are also converted to euros when reporting. If we further assume that the investment is done via new subsidiary which will receive all its income in dollars, but will report its results in euros. We assume 10% discount rate and 30 year investment tenor for the investment. The starting year of the investment is 2012. We expect 2 years of construction during which the company doesn't have any sales. The project will start cash generation in 2014 and will generate constant net cash flow until 2041. All cash flows are expected to be received or paid in the last day of the year.

The Capital Expenditure (capex) is assumed to be 50% in SEK and 50% in EUR. The capex is paid out on the first two years of the project and the payments are done in the currencies respective to the contracts. In this investment case capex is seen as all the equipment needed for the investment. The contracts of capex investments were done with currency levels of eurusd 1,40 and eursek 9,20, which was the market rate when the contracts were signed. The actual money movement will occur during first two

years and without hedging the contract's euro denominated price can vary for the SEK denominated portion of the capex.

The foreign exchange risks of the investment are the following;

- All the income is in foreign currency (usd)
- Capex is 50% in foreign currency and 100% in a different currency than the income.

We expect no balance sheet currency exposure, since the balance sheet is in euros and no foreign currency debt is expected to be taken for the investment (100% equity investment). Also the capex payments are paid immediately and they are not spread between the years. The cash flow profile of the investment is shown in the table 3

Year	Capex(EUR)	Capex (SEK)	Income (USD)	NPV Euro
2012	- 250 000 000,00	- 2 300 000 000,00		- 454 545 454,55
2013	- 350 000 000,00	- 3 220 000 000,00		- 578 512 396,69
2014			200 000 000,00	107 330 685,84
2015			200 000 000,00	97 573 350,77
2016			200 000 000,00	88 703 046,15
2017			200 000 000,00	80 639 132,86
2018			200 000 000,00	73 308 302,60
2019			200 000 000,00	66 643 911,46
2020			200 000 000,00	60 585 374,05
2021			200 000 000,00	55 077 612,78
2022			200 000 000,00	50 070 557,07
2023			200 000 000,00	45 518 688,24
2024			200 000 000,00	41 380 625,68
2025			200 000 000,00	37 618 750,62
2026			200 000 000,00	34 198 864,20
2027			200 000 000,00	31 089 876,54
2028			200 000 000,00	28 263 524,13
2029			200 000 000,00	25 694 112,84
2030			200 000 000,00	23 358 284,40
2031			200 000 000,00	21 234 804,00
2032			200 000 000,00	19 304 367,28
2033			200 000 000,00	17 549 424,80
2034			200 000 000,00	15 954 022,54
2035			200 000 000,00	14 503 656,86
2036			200 000 000,00	13 185 142,60
2037			200 000 000,00	11 986 493,27
2038			200 000 000,00	10 896 812,06
2039			200 000 000,00	9 906 192,78
2040			200 000 000,00	9 005 629,80
2041			200 000 000,00	8 186 936,19

Total	<mark>65 710 331,18</mark>

Table 3: Net cash flows of the investment

The table 3 shows the cash flow profile calculated with a constant rates of eurusd 1,40 and eursek 9,20, which are the same rates as the capex investments were done. All the cash flows are presented as net figures and the net income is expected to be USD 200 million per year starting from 2014. If the project is done without any forecast for the currencies, the NPV will be EUR 65,7 million positive. The currency moves that would benefit the project would be higher eursek during first two years and lower eurusd between 2014 and 2041. If the USD average rate forecast is changed 5% towards stronger usd to 1,33, the NPV will be EUR 123,5. The 5% change in the currency rate resulted in 88% increase in the NPV.

Since the eursek rate was constant, the euro denominated capex remained constant. If we assume 5% weaker sek for the first two years together with the stronger usd, the NPV will be EUR 148 million, which is 125% higher than with the capex rates. If the foreign exchange impact is reviewed from the IRR perspective, the results are; for capex rates 10,74%, for the 5% usd appreciation 11,38% and for 5% usd appreciation and 5% sek depreciation 11,69%.

If the table 3 is analyzed further, it's visible how important the first years are for the investment profitability, due the lower discount rate. Also the fact that capex investments are done during the first two years increases the importance. If the long term equilibrium rate is used from the beginning as a constant, the capex investment is vulnerable on the slow convergence and the fact that the forecast levels non-hedgeable levels. If the forecasting is started with market rates, the foreign exchange risk from the capex investment can be hedged with the forecasted rates. This provides stability for the first years in the investment calculations, but still leaves open the point that equilibrium rate should be used. According to the PPP theory, the forecasted rate should convergence towards PPP value with around 15%

yearly. Another method is to use the half-life of the PPP for convergence. Many of the researchers found that half-life changes when the difference from the spot changes. Based on that, the percentual movement seems more rational way to move towards long term equilibrium.

The earlier example shows that investments with cash flows in foreign currencies are very dependent on the currency movements in the future. Incorrectly forecasted foreign exchange rates can make a profitable project seem as non-profitable and more importantly vice versa. All the investments should be done by using the best knowledge available at the investment moment. There is no certainty that the forecasts are correct, but rather that they are commonly accepted and carried out consistently. The consistency comes very important when two projects with different currency exposures are compared.

6. Conclusions

The long-term investments in the pulp and paper sector need reliable forecast to measure the profitability of the projects correctly. Due the globalization the investments are often done to foreign countries in foreign currency. The long term investment calculations need long term foreign exchange forecasts which have to be consistent and reflecting the best knowledge available. Purchasing Power Parity is the most traditional way of measuring the equilibrium value of the currency. The valuation is done via the basket of goods pricing in two countries with the expectation that all countries have same purchasing power. The moving variable in this calculation is the nominal foreign exchange rate which should change according the price difference in two countries. The relative PPP is taking into consideration the long term inflation difference of the two countries and the equilibrium (PPP) value is changed yearly with the inflation difference.

The functionality of the PPP as a forecasting tool has been under a debate for a long period of time. Depending on the power of the tests, the time span of the data series and the floating or fixed regime data, the results have been changing from good indicator to useless tool for forecasting. What the researchers have widely agreed that PPP can't be used for short term forecasting. The researchers agree that PPP has a half-life, in which the difference to the market nominal rate will halve. The half-life indications also change depending on the data and the testing methods, but are around 2-4 years. The linearity of the movement towards half-life is also been debated, but many researchers have found that nominal rate moves faster towards PPP value when the difference is greater. Based on those findings percentual change towards PPP has been proposed and 15% was proposed by Rogoff in 1996.

Like illustrated on the earlier chapters, the first few years are very important for investment calculations when discounting method is used. Based on that and to the half-life expectation, the first years of the forecast shouldn't be fixed to the PPP value directly. They should rather be taken from the market levels and adjusted with forward points for appropriate period. Forward points even for the most traded currencies are liquid approximately up to 5 years. These limitations would suggest on using a model with a combination of long term equilibrium value and market rates.

The chapter 5 illustrates the severity of the error in foreign exchange forecasting and points out the importance for foreign currency investments. The NPV and the IRR move more than 80% when the average currency rate is adjusted only by 5%. The same investment calculation also illustrates the importance of understanding the risk on the different phase of the investment. The objective of the study was to illustrate the risks in long term investments and how they effect on the long term forecasting of foreign exchange rates and via that to NPV and IRR of the investment.

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