Foreign Exchange Rate Risk Measurement and Management of a Group of Companies headquartered in Germany and doing Business in US and China

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Abstract

Using Siemens as inspiration, this thesis analyses approaches to measurement and management of exchange rate risks. Exchange rate fundamentals are examined to provide an understanding of exchange rate drivers. Our analysis indicates that only the spread in interest rates is statistically significant in the determination of exchange rate developments. We find transaction risk to be quantifiable and easier to measure than operating risk, but that operating risk has larger impact on company valuation. Risk measures are subject to uncertainty as they are based on assumptions possibly not satisfied. Interpretation should therefore be done with care. Management of exchange rate risk should be conducted using both financial and natural hedging, and the two methods should be considered complementary rather than substitutes. While transaction risk is optimally hedged using financial instruments, operating risk should be managed through natural hedging. Hedging is not solely a task solved in the financial department, but should include top management. Neither measurement nor management of exchange rate risk is an exact science, and caution should be exercised when assessing risks and hedging possibilities.
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1 Introduction

Globalization has led to increased trading across borders and corporations have established new subsidiaries and affiliates all over the world. According to the WTO the global trade has increased about a 100 times since 1950\(^1\). This tremendous increase in global trading has encouraged several companies to engage in foreign markets, but global operations necessitate dealing with exchange rate risks. Corporate managers engage in foreign markets in order to achieve increases in revenue and larger profits. The expansion to new markets brings a lot of potential, but along with it comes risk. Exchange rate risk can hardly be avoided, but companies might not be fully aware of just how much currency movements can erode profits and potentially even threaten the very existence of the corporation.

In the process of mitigating exchange rate risk, companies around the world use financial products to hedge. The increase in global trade has therefore pushed the demand for financial products upwards, and led to an increase in both numbers of financial products and in the scope of the market\(^2\).

Financial managers seem to have trouble managing exchange rate risks, but even proper measurement can be a complicated task. The search for precise tools to measure and manage the risk is an on-going process, which indicates that sufficient models and theories have not yet been made. Prediction of exchange rates would be very beneficial indeed and several attempts to set up theories and models for prediction have been made in decades, but no significant results has yet been achieved.

In this thesis it is our intention to take the existing theories into consideration and see if we can contribute through a practical approach, which can be helpful when companies are measuring and not least managing exchange rate risk.

\(^1\) http://webservices.wto.org/resources/profiles/CP/TO/2011/TOT_e.pdf
\(^2\) Papaioannou Michael, Exchange rate Risk Measurement and Management: Issues and Approaches for Firms.
2 Problem statement

The main purpose of this thesis is to analyse the implications of exchange rates for companies doing business globally. The focus of the thesis will be on a group of companies headquartered in Germany and doing business in the US and China. This way emphasis is on the currencies of the three biggest markets in the world; the US dollar, the Chinese Yuan Renminbi and the euro. Siemens will act as stand-in for the group of companies headquartered in Germany, and will be used for illustrative purposes and examples throughout the thesis.

To address the implications of foreign exchange rates, a basic understanding of the fundamentals of the three currencies and markets the company operate in is necessary. Fundamentals are both important in assessing market possibilities and determinant in the development of exchange rates. An analysis of macroeconomic fundamentals will therefore be conducted, including both separate analyses of selected macroeconomic factors and an analysis of which factors are important in the determination of the development of the exchange rates.

Having knowledge of the possible financial and competitive impact of exchange rate movements enables companies to better assess the risks associated with it. Measuring the exposure of Siemens’ financial positions and operations by separating and categorising cash flows by currencies provides the basis of measuring risk. A review of different kinds of risks creates an overview of the possible implications of exchange rate movements, and risk-calculations using a battery of methods quantify the risk into a euro measure.

After having acquired an understanding of the currencies and markets and quantified Siemens’ exposure through risk-calculations, possible hedging methods addressing the risk under the existing market conditions need to be analysed. To mitigate the calculated risk, both financial and natural hedging can be possible methods. Creating a hedging strategy that both addresses the risk and possibly creates value can be a difficult task though, and considerations about the possible implications need to be thoroughly assessed.
2.1 Main questions

To address the problems mentioned in our problem statement, the following main questions will be answered:

*What are the characteristics of the currencies and markets Siemens operate in?*

We will answer the question by performing an analysis of the fundamentals of exchange rates. The analysis will provide information about the macroeconomic characteristics of the markets, and study what the determinants of the exchange rates are.

*What are the exchange rate risks for a German company doing business in the US and China, and how can they be measured?*

The question will be answered by first reviewing the different kinds of exchange rate risks Siemens faces. Afterwards an analysis of different approaches to measure exchange rate exposure will be performed, and a range of measurement methods will be applied to measure Siemens’ exchange rate risk.

*How can exchange rate risks be managed?*

An analysis of different hedging approaches will be performed to answer this question. The analysis will be performed on basis of the characteristics of the currencies and markets Siemens operate in and the risk measured in the former sections. In answering the question both financial and natural hedging will be included, and the implications of hedging exchange rate risks for Siemens will be analysed.

2.1.1 Description of Siemens and its role

The thesis builds on a real, but modified group of companies doing business in the US and China. In the thesis it will be assumed that only three markets and their currencies exists; the euro area, the US and China. As severe modifications have been assumed, the thesis in effect builds on a hypothetical group of companies. As mentioned in the problem statement, Siemens will be used for examples and illustrative purposes. Siemens has both sales and production in all of the countries, but as shall be shown they do not offset each other. Siemens uses the euro as their
functional currency, which means that their consolidated financial statements are reported in euros.

We must emphasise that the thesis is not a case study of Siemens. Siemens is merely used because they are exposed in the USD and RMB, and using an actual company will provide realistic challenges and settings.

2.1.2 Delimitations
We will only focus on USD and RMB exchange rate risks. These are the main currencies Siemens are exposed in, and along with the EUR they represent the currencies of the world’s three biggest economies. Exposure in all other currencies will be ignored by assuming that only the three markets and currencies exist at all. We will use exchange rates up until the 26th of April 2013. Movements and rates after these dates will not be included in our analyses.

Emphasis will be put on transaction and operating exposure in this thesis, as we see these risks as being the most interesting exposure. Translation risk will thereby be excluded, as it does not have direct economic impact on a company.

The focus of the thesis will be on long term implications of exchange rates, as long term movements are the ones that can really affect businesses. Little emphasis will therefore be put on daily movements.

We will not calculate Value-at-Risk on a longer horizon than one year. VaR figures are calculated from historical exchange rates at different time horizons. VaR levels can be converted into other time horizons, but doing so include a risk of converting using a biased factor. The longer we convert into the future, the bigger the effect of using a biased conversion factor will be. We do not have enough data reflecting the current exchange rate regimes to directly calculate VaR’s on a longer horizon than one month. VaR levels calculated for longer than a one year horizon would therefore become unreliable.

As the scope of the thesis is exchange rate risk in general, an in depth analysis of Siemens will not be performed. Siemens will be used as an example and for illustrative purposes, and an actual analysis of Siemens businesses is assessed to be unnecessary. Neither will we perform analysis of Siemens’ competitors and their cost bases. While this might be interesting in regard to the actual exchange rate risk Siemens are facing, it is out of the scope of the thesis.

2.2 Disposition & methods
The thesis will be organised in accordance with our problem statement, and will follow the structure illustrated in figure 1.

2.2.1 Exchange rate fundamental analysis

*What are the characteristics of the currencies and markets Siemens operate in?*

The section will start by a presentation of the historical development in the EUR/USD, EUR/RMB and USD/RMB exchange rates and the reasons for major movements. The section will be continued by answering the question through macroeconomic analysis. The macroeconomic factors will include monetary policies, balance of payments, GDP and GDP growth measures, government debt levels and inflation levels. The analysis will serve as foundation for development of hedging strategies later in the thesis. Simple correlation calculations will be used to determine the relationship between the different macroeconomic factors and the development in exchange rates. Significant correlations will give us alternative factors to steer by, rather than exchange rates alone.
2.2.2 Measurement of foreign exchange rate risk

*What are the exchange rate risks for a German company doing business in the US and China, and how can they be measured?*

It can be a complicated task to accurately measure a corporation’s foreign exchange rate exposure and risk. However, good assessments are crucial to enable financial managers to make good decisions. Failure to do so can prove fatal for a corporation.

2.2.2.1.1 Risks

The section will begin by introducing the different kinds of exchange rate risks a company faces. Different kinds of risk have different attributes and need different hedging methods.

2.2.2.1.2 Estimation of exposure

The beginning of this section will involve estimating Siemens’ USD and RMB cash flows through analysis of their 2012 annual report. Siemens future cash flows are in effect their exposure, which will be the primary focus in this thesis. Estimation of cash flows will simply be done by categorising cost and revenues into different currencies, and subsequently use a standard method of calculating free cash flow from a financial report.

2.2.2.1.3 Approaches to risk measurement

The section will include introductions to a range of different approaches for companies to measure risk. The introduction will include an assessment of their strengths and weaknesses and their usability.

2.2.2.1.4 Value-at-Risk

One of the possible risk measurement approaches is Value-at-Risk (VaR). In this section Siemens risk will be measured using three different VaR methods:

- Variance-covariance
- Historical simulation
- Monte Carlo simulation

Characteristics and assumptions behind the methods will be elaborated, and the results interpreted.
2.2.2.1.5 Alternative volatility measures

VaR risk measures can be helpful in assessing a company’s risk, but in some instances other measures are more useful. In instances of financial turmoil, the assumptions behind the VaR methods might not be satisfied, and the VaR measures cannot be accurately calculated. This section will shortly introduce alternate methods that can be used when normal volatility measures do not work, or if more accurate measures are needed.

2.2.2.1.6 Measuring operating exposure

In this section Siemens’ exposure is measured using a method we developed from the theories described by Grant and Soenen in their paper “Strategic Management of Operating Exposure”. Both the market demand effect and competitive effect is considered using this alternate method and elasticity of demand, cost in both EUR and the currency in which the cost was originally incurred and pass-through is accounted for.

2.2.3 Management of foreign exchange rate risk

*How can exchange rate risks be managed?*

2.2.3.1.1 Hedging

This part of the thesis addresses management of foreign exchange rate risk. This part is divided into three parts:

- Financial hedging
- Natural hedging
- Main considerations and implications to hedging activities

2.2.3.1.1.1 Financial hedging

Different financial instruments will be reviewed, and their use for hedging will be analysed. An analysis of pros and cons, along with their implications and limitations will be part of the review.

2.2.3.1.1.2 Natural hedging

Different approaches to naturally hedge exchange rate risks will be analysed. The approaches include marketing strategies, production strategies and the incorporation of flexibility in sourcing of input and production. In the analysis, their use in Siemens’ specific situation will be included, and examples will be made to illustrate how the strategies can create economic advantages.
2.2.3.1.2 Main considerations and implications of hedging

The section will be ended by summarising the different means of hedging, and explain which methods apply to different kinds of purposes and situations. Suggestions on how Siemens’ should use the hedging methods will be made, while taking into consideration the macroeconomic factors analysed in answering main question number one, and the risk calculated in answering main question number two. The basic question of whether hedging is a good idea or not is obvious. The last part of this section presents arguments for and against hedging, and the pros and cons of conducting hedging activities.

2.3 Empery

The thesis is based on secondary empirical data. The primary sources of data are official institutions like; ECB, Federal Reserve Bank, People’s Bank of china, IMF, OECD, The World Bank etc. Exchange rates and macroeconomic data are derived from these sources. The exchange rates are constituted by the EUR/USD, EUR/RMB and USD/RMB rates, and the macroeconomic data is official figures tracked data back to 1981. The data has been used for calculations of correlations, volatility and VaR levels.

A series of published articles has been used as a source of information about important theories on measurement and management of exchange rate risk. The articles are mainly published by the formerly mentioned official institutions and universities. For this reason their credibility is assessed high.

Publicly available data from Siemens is used to derive numbers and information for analysis purposes. This primarily includes Siemens’ annual reports. We have used Siemens’ annual report for 2012 to provide data for cash flow calculation. Annual reports back to 2002 are used for information on exchange rate risk, competitive situation and hedging activities in the company. As we do not have information about besides what is publicly disclosed, we have taken the liberty of making assumptions where necessary.
3 Exchange rate fundamental analysis

Main question 1 from the problem statement is answered in this part:

*What are the characteristics of the currencies and markets Siemens operate in?*

Knowledge about the markets and currencies Siemens operates in is necessary to be capable of properly analysing exchange rate risks and propose hedging strategies. In this section analyses of selected fundamental economic factors will be performed to provide information about both the markets and currencies Siemens operate in.

**Figure 2, fundamentals of exchange rates**

The fundamental analyses of exchange rates will start in the centre of figure 2 by reviewing the exchange rates in a historical perspective. The historical review is meant to provide basic knowledge and understanding about the three currencies and the history of their exchange rate regimes. Second section in the fundamental analyses will contain an analysis of the present exchange rate regimes, providing valuable information for the assessment of Siemens exchange rate risks and develop hedging strategies addressing the risks. In third section, economic performance, an analysis of development in GDP level and GDP growth will be performed. Developments in GDP can indicate how the markets can be expected to develop in near future. Fourth section, about fiscal policy, covers balance of payments and government debt levels. The balance of payment is a vital figure to shed light on market equilibriums and government debt levels has proved to be an important determinant in exchange rates during the European debt crisis. Inflation levels will be covered in the fifth section, providing information about the
development in price and salary levels. The information will be important in the development of hedging strategy later in this thesis. All factors are interconnected, and all must concurrently be taken into consideration when assessing the exchange rates. The section on exchange rate fundamental analysis will end by performing analysis to find out how explanatory the formerly mentioned macroeconomic factors are in explaining exchange rate developments.

3.1 Historical exchange rates and developments

Figure 3 shows the exchange rates between EUR/USD, EUR/RMB and USD/RMB from 1981 until 26st of April 2013.

![Exchange rates 1981 - 2013](image)

The following sections will shortly outline the major developments in the exchange rates and give possible explanations for these developments.

3.1.1 EUR/USD exchange rate historical development

The euro was established as a functional currency the 1\textsuperscript{st} of January 1999, but it was not before 2001 that actual notes and coins were introduced. In the period 1999-2001 the currency was

\[ \text{http://www.federalreserve.gov/releases/h10/hist/default1999.htm} \]
therefore only used for the purpose of electronic transactions. As the euro did not exist before 1999, the euro rates before this year are the ECU (Euro Currency Units), which was calculated using a weighted average of 12 of the then 15 currencies of the EU member states. The ECU was replaced by the Euro on a 1:1 basis on January 1st 1999. Because the ECU is a weighted average between 12 currencies, there are many factors explaining the development from 1981 – 1999. As the main purpose of this assignment is not an analysis of historical exchange rates, but this section is merely included to clarify history and bring light to the possibilities of future development, the analysis of the EUR/USD exchange rates will focus only on the period after the introduction of the euro.

At the introduction of the invisible euro 1st of January 1999, the EUR/USD rate was $1.17. In the years until the introduction of coins and notes 1st of January 2002, the euro dropped steadily from $1.17 to $0.89, equivalent to a 24% devaluation of the euro. A possible reason for the drop is uncertainty about the euro, as the market might have questioned whether it would go smoothly or whether the introduction would cause problems. In the following six years from January 2002 – December 2007 the euro rose from $0.89 to $1.46, equivalent to an increase of 57%. In the same period the U.S. debt grew 60%, which might have led the market to question the strength of the U.S. dollar. When reaching the financial crisis in 2008, the euro exchange rate became more volatile. Investors still thought that the subprime mortgage crisis would mainly affect the U.S. at this time. The euro started at $1.46, but as the crisis spread to Europe the euro plummeted to a level of $1.24 by end October 2008. The euro recovered to a level of $1.39 by the end of 2008. 2009 was also a year of rather high volatility in the EUR/USD exchange rates. The euro started out at $1.39 but plummeted to $1.25 in March. The reason was that ECB increased its interest rate, which would normally lead to an increase in the exchange rate, but the market got concerned that the increase would head off chances of economic recovery in Europe and therefore the increase in interest rates led to the opposite effect. ECB realized that their strategy had failed, and they began to lower the interest rate which led to a recovery of the euro. From March to December the euro

6 http://www.ecb.int/home/glossary/html/glosse.en.html#192
7 http://useconomy.about.com/od/inflation/p/Euro-To-Dollar-Conversion.htm
8 http://useconomy.about.com/od/inflation/p/Euro-To-Dollar-Conversion.htm
rose 20%, and ended at $1.43 at the end of the year\(^9\). During the year ECB lowered its interest rate, both nominal and relative to the Fed Funds Target. The drop in interest rate would normally have led to a decrease in the price of euro, but as the market was concerned about high U.S. debt levels, investor fled from the dollar and dollar denominated bonds and thereby pushed up the euro rate\(^10\). In the time from 2008 until today the EUR/USD exchange rate has been very volatile. General economic health in the regions, and figures such as government debt levels, economic growth, employment figures etc. has been of big concern. During the years of 2011 and 2012 the debt levels in the Eurozone started to rise to disturbingly high levels with Spanish and Italian bonds reaching an unsustainable level of 7%, and the economic situation in Greece leading them to defaulting on debt. The economic situation has led to doubts about the survival of the euro, as controversies between the Eurozone countries arose when bailout plans had to be made for the countries gone bankrupt. The situation has led to the market fleeing the euro and therefore a decrease of the euro overall compared to the pre-financial crisis level.

### 3.1.2 USD/CNY exchange rate historical development

As can be seen from figure 3 the USD/CNY rate has been managed throughout the past many years, and therefore the development in the exchange rate has been determined by a few changes in policy in the period.

At January 1981 the first round of RMB devaluation took place, and at the same time the State Council introduced an "internal settlement rate" of RMB/USD 2.80. The "internal settlement rate" lasted until 1985 where it was abolished and the dual exchange rate system was thereby ended\(^11\). In 1988 China allows enterprises to trade the RMB at rates that reflects market demand more closely by setting up “semi-official” currency swap centres\(^12\).

The 1\(^{st}\) of January 1994 the USD/CNY exchange rate was devaluated from under 6 to 8.7 overnight. This is easily seen by the large jump in the chart above. From 1994 till 1996 the RMB appreciated steadily to around 8.28. The RMB was pegged to the U.S. dollar at this rate during the Asian crisis

\(^9\) [http://useconomy.about.com/od/inflation/p/Euro-To-Dollar-Conversion.htm](http://useconomy.about.com/od/inflation/p/Euro-To-Dollar-Conversion.htm)

\(^10\) [http://useconomy.about.com/od/inflation/p/Euro-To-Dollar-Conversion.htm](http://useconomy.about.com/od/inflation/p/Euro-To-Dollar-Conversion.htm)


\(^12\) [http://www.reuters.com/article/2010/06/19/china-economy-yuan-idUSSGE65l02S20100619](http://www.reuters.com/article/2010/06/19/china-economy-yuan-idUSSGE65l02S20100619)
from 1997 – 1999. From 1999 to 2005 the RMB continued to appreciate after international pressure on China to let it do so. In 2005 The USD/CNY rate was revalued to 8.11 along with a revise of the Chinese currency system. In 2008 the RMB had appreciated to a USD/CNY rate of 6.83 and to withstand the pressure from the financial crisis a narrow peg around this rate (+/- 0.3%) was established\textsuperscript{13}.

In 2009 China announced reforms aiming to increase currency rate flexibility. As can be seen from figure 3, this has led to a series of incremental increases in the RMB over the USD in the period May 2010 till March 2013. The increase in the RMB rate comes after a period with a lot of pressure, especially from USA, to let the RMB appreciate to better reflect equilibrium rates.

\subsection*{3.1.3 EUR/CNY exchange rate historical development}

The reason for the development in the EUR/RMB exchange rate can mainly be explained by the development between the EUR/USD exchange rates and the USD/RMB, as the Chinese Yuan Renminbi effectively has been pegged to the USD. In 2009 the PBoC announced a change in exchange rate strategy though, allowing the RMB to fluctuate within upper and lower bounds of a reference currency basket\textsuperscript{14}. For this reason the euro might gain more direct impact on the RMB rate in the future. Looking at the EUR/USD and the EUR/RMB rates in figure 3 however, it can be seen that the rates have fluctuating very closely since 2008. A simple correlation calculation between the daily EUR/USD and daily EUR/RMB exchange rates in the period of January 1\textsuperscript{st} 2008 till April 26\textsuperscript{th} 2013 shows a correlation coefficient of 93%, and the correlation of the daily EUR/USD and daily EUR/RMB currency returns in the same period amounts to 99%. So even though the EUR might gain influence on the development of the RMB rates, much still indicates that the USD is the dominant currency in the basket of currencies China lets the RMB fluctuate upon.

With the current economic policy of China, an increasing USD will also mean an increasing RMB in euro value. Having the same kind of exposure in both the U.S. and China will therefore mean doubling the exchange rate exposure, as the currency fluctuations must be expected to be highly correlated. Having production in China and sales in the U.S. on the other hand, will mean that only

\textsuperscript{13} http://www.e-ir.info/2010/11/17/the-euro-and-the-rmb/
\textsuperscript{14} Bank of Finland Institute for countries in Transition, Monetary policy in mainland China, p. 2
little hedging is necessary against fluctuations between the two currencies, and only hedging of the net profits to the euro would be needed.

3.2 Exchange rate regimes

While several economic factors have influence on exchange rates, the probably biggest factor in determining the exchange rates are political influence. Through national banks, governments of countries can influence the exchange rates by controlling interest rates and by direct intervention in the foreign exchange market. In an open market economy, interest rates affect the exchange rates directly as interest rates are the offered yield on a risk free investment. The higher the yield, the more demand for the currency to deposit. The upward pressure will therefore, ceteris paribus, lead to an increase in the exchange rate for a given currency.

To avoid the effects of the economic factors on the exchange rates, or to affect exchange rates for other reasons, national banks can intervene in the exchange rate markets by buying or selling the country’s own currency or another country’s currency, thereby directly impacting demand and supply for currencies involved in the transaction. In that way monetary policy can offset general economic exchange rate determinants, and exchange rate development and determination can therefore be political determined rather than market based prices, i.e. trading equilibriums.

3.2.1 Monetary Policy of Euro area

Germany is a part of the Eurozone, and its monetary policy is therefore a part of an overall monetary policy for the Eurozone. The primary and overriding objective of the euro system is to maintain price stability, while a subsequent objective is to support the general policies in the European Union\textsuperscript{15}. Instruments used to achieve price stability include “open market operations”, “standing facilities” and “minimum reserve requirements for credit institutions”\textsuperscript{16}.

ECB has the option of intervening in foreign exchange markets if it is found necessary\textsuperscript{17}, but normally eschews active exchange rate management\textsuperscript{18}. It is worth noticing though, that Mario Draghi made a comment about the currency’s exchange rate not being a target for ECB, but that

\begin{footnotesize}
\begin{enumerate}
\item[18] HIS Global Inc., Spain Country Monitor, Jan 2012, p. 23
\end{enumerate}
\end{footnotesize}
they still take exchange rate developments into account\textsuperscript{19}. Exchange rate intervention by the ECB, although unlikely, can therefore not be ruled out as a possibility in the future. In case other countries monetary policies should include foreign exchange interventions that potentially might interrupt price stability in the euro area, ECB might intervene.

ECB’s foreign reserves consist of US Dollars, Japanese Yen and gold along with special drawing rights\textsuperscript{20}. The development in the aggregated foreign exchange reserves and the balance of payments in the past 9 years can be seen in figure 4 along with total reserves to GDP and ECB’s overnight lending rates.

The foreign reserves in the euro area has increased from USD 369 billion in 2003 to USD 769 billion in 2011, equivalent to an increase of 102\%. At the same time the balance of payment has been fluctuating between a surplus of USD 111 billion and a deficit of USD 97 billion, with USD 33 billion being the average surplus in the 9 year period. As can be seen from the chart, the foreign reserves have been fluctuating between 4-6\% of GDP in the Eurozone in the period of time. There is a trend

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{figure4.png}
\caption{Figure 4 Source: Based on data retrieved from The World Databank - Interest rates are from ECB.int\textsuperscript{21}}
\end{figure}

\begin{itemize}
    \item \textsuperscript{19} [Link to Source]
    \item \textsuperscript{20} [Link to Source]
    \item \textsuperscript{21} [Link to Source]
\end{itemize}
of increasing reserves during the period which stems from an increase in the years 2008-2010. The reason for the increase can probably largely be found in increased volatility in the currency markets after the financial crisis set in, but a general trend of increasing reserves must also be expected as global trade increasingly account for bigger proportions of the region’s GDP.

In general the limited level of the foreign exchange reserves in comparison to the size of the euro area’s economy and the fluctuating BOP sizes does not indicate speculative intervention in the foreign exchange rates by the ECB. It can therefore be concluded that ECB has not been intervening in the foreign exchange rates on a material scale. Although it cannot be ruled out that the ECB might exercise the option of currency intervention in future, the general policy of ECB is not to intervene, and our assessment is therefore that future interventions are unlikely.

While direct exchange rate intervention is not assessed likely, ECB’s loose monetary policy will have an effect on exchange rates. It can be seen from the chart that ECB’s marginal facility rates overall has been decreasing over the years, from a level of 3% end 2003 to a level of 1,75% end 2011. During 2004-2007 ECB increased the interest rate, probably in an attempt to slow down an overheated economy, but after 2007 ECB has been lowering the interest rates on an almost consistent basis. (Although it is not visible in figure 4, small fluctuations have been present in the period but end year rates have been consistent. It must also be noted that the deposit-lending spread in interest rates has been fairly stable, and deposit rates has therefore been following the same trend as lending rates). While lowering interest rates is an attempt to stimulate economic activity, a side effect is making deposits in euro denominated bank accounts less attractive and thereby a weakening of the euro. The 11th of July 2012 the marginal lending facility rates was lowered to 1,50% and deposit rates lowered to 0%. This leaves little possibility for ECB to lower interest rates further, and thereby also little possibility to affect exchange rates further in a downward direction.

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3.2.2 Monetary Policy of the United States of America

“The Federal Reserve sets the nation’s monetary policy to promote the objectives of maximum employment, stable prices, and moderate long-term interest rates.” While this indicates that the primary economic concerns of the Federal Reserve are domestic, international affairs that may interfere with the aims might lead to foreign exchange interventions. “Under flexible exchange rates, the main aim of Federal Reserve foreign currency operations has been to counter disorderly conditions in exchange markets through the purchase or sale of foreign currencies.” Thereby the Federal Reserve indicates that it does not enter into foreign exchange rate interventions for speculative purposes, but rather limits its interventions to special occasions were correction of skewed exchange rates are absolutely necessary. According to the Federal Reserve U.S. authorities have only intervened rarely since 1995 due to prior experiences and as it are reluctant to let foreign exchange issues be seen as a major focus of U.S. policy. In the period 1999 to 2012 the Federal Reserve has only intervened two times; in Q1 2011 they bought $1 billion Japanese Yen in coordination with Japanese and other countries monetary authorities and in Q3 2000 they bought 1.5 billion euros in coordination with ECB and other countries monetary authorities. As the Federal Reserve has only intervened 2 times, and both times in coordination with the monetary authorities of the other affected currency, a clear message about U.S. authorities not conducting speculative foreign exchange rate interventions is being communicated.

In figure 5, a chart of balance of payments and foreign exchange rate reserves during the past 9 years shows consistent trade balance deficits in the range of USD 377 billion and USD 801 billion. In the same period the foreign exchange reserves has been increasing on a consistent basis from USD 184 billion in 2001 to USD 37 billion in 2011, equivalent to an increase of 192% over the 9 year period. During the period the U.S. total reserves as a share of GDP has been fluctuating between 1.5% – 3.6% with a trend of increasing reserves. As with the trend in the Eurozone, the reserves have primarily been increasing after the financial crisis set in around 2008, and has been

\[\text{Equation}\]

\[\text{Reference}\]

23 System Publication, The Federal Reserve System - Purposes & Functions, p. 15
25 System Publication, The Federal Reserve System - Purposes & Functions, p. 54
continuing to increase throughout the years to follow. Also in the U.S. a general trend of increasing reserves must be expected as global trade increasingly account for bigger proportions of the US economy’s GDP.

![USA figures](image)

*Figure 5 Source: Based on data retrieved from The World Databank - Interest rates are from The Federal Reserve*[^28]

Although the foreign exchange reserve have increased significantly over the period, the level of the reserves are not at a high level compared to the size of the U.S. economy and their significant level of foreign trade taken into consideration. The consistent and significant trade deficits indicate that the U.S. dollar might be overvalued as the U.S. lack competitiveness. The fact that many countries, China included, hold large proportions of their reserves in U.S. dollars means that the U.S. can finance their trade deficits without having the dollar devaluing[^29]. So in spite of U.S. making on-going trade balance deficits, clearly indicating that the current exchange rates does not reflect a trade equilibrium, demand for the U.S. dollar means that foreign exchange rates movements does not work to balance out inequality. Should the trend of reserves being held in U.S. dollars change though, significant drops in the USD value must be expected.

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[^28]: http://www.frbdiscountwindow.org/historicalrates.cfm?hdrID=20&dtlID
Even though USA can easily finance its trade deficits by the worldwide demand for USD, the Federal reserve must be aware of the risk that a change in the popularity of the U.S. dollar may potentially bring in future, and also from the viewpoint of U.S. government, a strong U.S. dollar means lack of competitiveness and thereby loss of jobs. The risk of a future drop in the demand for U.S. dollar and the consistent trade balance deficits are therefore great incentives to intervene in the exchange rates. The fact that the U.S. authorities have not yet done so shows the reluctance of intervening in the currency markets. A direct U.S. intervention in foreign exchange rates is therefore assessed as being unlikely.

In spite direct and official intervention in the exchange rates is assessed as being unlikely, actions that are indirectly affecting the exchange rates are still being taken as part of the U.S. monetary policy. During the past years the Federal Reserve has been lowering interest rates and increased money supply through quantitative easing programs, in the pursuit of economic stimulus after the financial crisis in 2008. As can be seen from figure 5, the federal reserve has lowered the primary discount rate (short term/overnight deposits) from 6,25% end 2006 to 0,75% end 2011. While the loose monetary policy is aimed at stimulating the weak economy, the side effect of lower interest rates and increased money supply is a lower dollar rate. From January 2009 to January 2011 the U.S. dollar experienced a real effective exchange rate depreciation of over 10%. The Fed’s USD 1.725 trillion asset purchases as part of the Quantitative Easing program accounts for 6,5% of this increase according to the Federal Reserve Bank of St. Louis. So even though loose monetary policy does not aim at affecting exchange rates, it has a significant impact on them. Given the economic difficulties the U.S. are facing with severe trade balance deficits, U.S. authorities are hardly sorry for the side effects the loose monetary policy brings, as it will strengthen U.S. competitiveness and improve federal budgets.

3.2.3 Monetary Policy of China

According to the Peoples Bank of China (PBoC), two of the major functions it has to conduct is: “regulating financial markets, including the inter-bank lending market, the inter-bank bond market and the foreign exchange market; preserving the stability of the financial system and controlling financial risks.”

R. Portes, Monetary policy and exchange rates at the zero lower bound, Journal of Money, Credit and Banking, Supplement to Vol. 44, No. 1 (February 2012), p. 158
"market, foreign exchange market and gold market" and "maintaining the Renminbi exchange rate at adaptive and equilibrium level; Holding and managing the state foreign exchange and gold reserves"\textsuperscript{32}. More specifically the objective of the Chinese monetary policy is to "maintain the stability of the value of the currency and thereby promote economic growth"\textsuperscript{33}. In order to do this the Peoples Bank of China applies instruments such as: "reserve requirement ratio, central bank base interest rate, rediscounting, central bank lending, open market operation and other policy instruments specified by the State Council"\textsuperscript{34}.

While the monetary policy communicated by the Peoples Bank of China emphasizes managing the RMB exchange rates at an adaptive and equilibrium level, the currently used strategy of PBoC is a managed floating exchange rate regime where the RMB is allowed to fluctuate within upper and lower bounds of a reference currency basket\textsuperscript{35}. Looking the foreign exchange reserves in China and the current account surpluses over the last ten years, in figure 6, clearly shows increasing foreign exchange reserves and overall also increasing trade balances, indicating that PBoC is keeping the Yuan Renminbi at a level lower than trade-equilibrium.

\textsuperscript{32} http://www.pbc.gov.cn/publish/english/952/index.html
\textsuperscript{33} http://www.pbc.gov.cn/publish/english/970/index.html
\textsuperscript{34} http://www.pbc.gov.cn/publish/english/979/index.html
\textsuperscript{35} Bank of Finland Institute for countries in Transition, Monetary policy in mainland China, p. 2
Current account balance surplus for China has risen from USD 43 billion in 2003 to USD 202 billion in 2011, peaking with a surplus of USD 421 billion in 2008. The consistent and overall increasing surplus on the current account balance indicates that the competitiveness of China is good, and probably has increased during the period. At the same time the foreign exchange reserves has increased steadily from USD 416 billion in 2003 to a remarkable USD 3.255 billion in 2011, equivalent to an increase of 682%. In comparison with GDP, the Chinese total reserves have increased from 25% of GDP in 2003 to 49% of GDP in 2009 and 2010. The reserves as share of GDP has dropped to 44% in 2011, but looking at the increase in the actual reserves, it can be concluded that the explanation must be found in increasing GDP rather than decreasing reserves. A comparison between China and U.S. and the euro area respectively, clearly shows that China has piled up massive level of reserves. In 2011 the Chinese reserves are more than 4 times bigger than the reserves in the euro area, and more than 6 times bigger than the ones in the U.S. when looking at the current dollar value. As a percentage of the GDP the Chinese reserves are almost 8 times the size of the euro area and more than 12 times the size of the U.S. As the economies of the euro area and the U.S. generally are more open economies than the Chinese economy, one would think

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36 BersteinResearch, Chinese Banking: a primer on the market, The Peoples Bank of China and monetary policy, p. 25
36 http://www.gecodia.com/China-1-year-Lending-Rate--China-Central-Bank-Interest-Rate_a1258.html
36 http://www.tradingeconomics.com/china/interest-rate
that less reserves where needed in China than in the euro area and in the U.S. respectively. The size of the Chinese reserves can therefore hardly be explained by general buffers for the use of international trade and capital movements.

The increase and level of foreign reserves is a good indication of the Peoples Bank of China intervening in the foreign exchange rates by increasing the supply of the Chinese Yuan Renminbi or increasing demand for counter currencies, and thereby weakening the RMB. This is believed to be done through strict currency controls, where the Peoples Bank of China sterilizes the impact of currency inflows through open market operations - that is buying the currency inflows in exchange for Renminbi and soaking up excess liquidity by issuing debt into the market\textsuperscript{37}.

Looking at the People’s Bank of China 1 year deposit rates in figure 6, it can be seen that interest rates have been increased slightly over the 9 year period. This development is contrary to the development in interest rates in the euro area and in the U.S., and part of PBoC’s intervention in the foreign exchange market might be to offset the effect of the differences in monetary policies. However, the combination of both consistent large surpluses in the current account and weakening the Chinese Yuan Renminbi by intervening in the foreign exchange market through increase of the reserves clearly indicates that the Peoples Bank of China is not working towards an equilibrium level in the exchange rates, but rather emphasises promoting economic growth in China. The sustainability of the procedure must be questioned though. The recurring issuance of debt to soak up currency inflows has made Fitch cut in China’s credit rating, and issues such as inflation and shadow banking are also of concern\textsuperscript{38}. As a response to the challenges China has initiated an analysis of the public debt, and further made it first priority for the National Chinese Accountancy\textsuperscript{39}. Facing currently loose monetary policies in the large economies such as the U.S. and the EU, it is doubtful whether China can withstand the currency pressure or if appreciation of the RMB is necessary.

\textsuperscript{37} BersteinResearch, Chinese Banking: a primer on the market, The Peoples Bank of China and monetary policy, p. 31
\textsuperscript{38} http://www.ft.com/intl/cms/s/0/d0fdafbe-a255-11e2-ad0c-00144feabdc0.html
\textsuperscript{39} http://borsen.dk/nyheder/oekonomi/artikel/1/262558/kina_ivaerksaetter_hastegennemgang_af_gaeld.html
3.2.4 Interest rates

Figure 7 shows the EUR/USD exchange rates from 1999-2013, the interest rates set by the ECB and The Federal Reserve and the spread between the interest rates respectively. The interest rates set by the ECB and The Federal Reserve are included as scatters at the days where changes in the rates incurred. This means that the rates are at the former level until a new scatter appears.

![FX & Interest rates 1999 - 2013](image)

**Figure 7 Source:** Based on exchange rates retrieved from federalreserve.gov[^40]; ECB rates from ECB.int[^41]; Fed Funds Target from newyorkfed.org[^42]

During most of the years, the interest rate spread between the ECB and the Federal Reserve seems to explain a big part of the EUR/USD exchange rate development. As can be seen from figure 7, the EUR/USD curve and the Interest rate spread curve follow the same pattern a lot of the time. A calculation shows that the correlation coefficient between the daily exchange rates and interest rate spread in the period January 1st 1999- April 26th 2013 amounts to 0,60. The correlation coefficient has a P-value of 0,00, which indicates that it is highly statistically significant.

Performing analysis between the EUR/RMB exchange rates and the interest rate spreads between the ECB and the PBoC would not make a lot of sense, as the People’s Bank of China perform strict capital controls, and as the Chinese exchange rate has been pegged to the US dollar. Therefore the interest rate in China must be assumed not to have explanatory power for the Chinese Yuan Renminbi exchange rate. As the interest rates are determined by policy rather than economic market powers, further analysis on this will not be conducted.

3.3 Economic performance

GDP can be used as a measure of the dollar value of a country’s production. GDP is therefore an indicator of a country’s ability to create value, which can be consumed both domestically and be exported. The level of GDP indicates the relative industrialisations of countries in comparison to other countries (when accounting for size differences) while GDP growth indicates the direction and speed the countries’ economies are moving in. These measures are therefore interesting in relation to exchange rates, as they are indicators of what drives supply and demand.

Looking at the GDP levels and the levels of GDP growth for the US, China and the euro area in the past 25 years ranging from 1987 – 2011, the difference in GDP levels are obvious.

Figure 8 Source: Based on numbers from databank.worldbank.org
The US is by far the biggest economy, with GDP levels far exceeding that of both the euro area and China. Looking at GDP per capita in the same period would increase the economic difference\(^4\), as the US has fewer citizens than both China and the euro area. Correcting for price levels by using GDP PPP would on the other hand narrow the span between the US GDP compared to both the Chinese and euro area figures due to relatively higher prices in the US\(^4\). A correlation analysis between different GDP measures (GDP, GDP per capita, GDP PPP and GDP per capita PPP) was performed and showed almost perfect correlation between the measures though. This means that when we are looking at the development in the GDP figures, the size and price differences are fairly insignificant.

The higher level of GDP in the US compared to both the euro area and China indicates that the US is better capable of creating value, i.e. producing goods and services. This can probably be explained by the US being more industrialised and, as mentioned before, by the US having higher price levels. The euro area ranks number two in GDP level, far exceeding the GDP of China. The reasons for this are probably the same factors as explaining the difference between US and the euro area.

The gaps between the relative GDP levels of China in comparison with the GDP level of the US and the euro area respectively has decreased during the 25 year period. China has experienced a Real GDP growth in the range of 7-12% majority of the time, while the US and the euro area have experienced Real GDP growth rates of 0-5% majority of the time. The means for Real GDP growth is shown in table 1.

<table>
<thead>
<tr>
<th>Mean GDP growth</th>
<th>Real GDP growth</th>
<th>Real GDP growth</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Arithmetic mean</td>
<td>Geometric mean</td>
</tr>
<tr>
<td>Euro area</td>
<td>1,97%</td>
<td>1,95%</td>
</tr>
<tr>
<td>China</td>
<td>9,98%</td>
<td>9,95%</td>
</tr>
<tr>
<td>United States</td>
<td>2,58%</td>
<td>2,56%</td>
</tr>
</tbody>
</table>

Table 1, GDP growth

\(^4\) Figures compared to GDP per capita in constant 2000 US$ figures from worlddatabank.com
\(^4\) Figures compared to GDP PPP in current international US$ figures from worlddatabank.com
The higher level of GDP growth in China indicates that China is catching up, and the size of the Chinese economy is growing relative to that of the US and the euro area. Ceteris paribus, this should mean upward pressure on the Chinese Yuan Renminbi rate. The GDP growth levels of the US and the euro area has been fairly similar in the 25 year period. However, over the period the US has had a slightly higher growth, meaning that their GDP of has gone from being 43% higher than the GDP of the euro area in 1987 to being 65% higher than the GDP of the euro area in 2011. Ceteris paribus, this should have caused upward pressure on the dollar over the euro (or basket of European currencies existing prior to the euro).

### 3.4 Fiscal policy

#### 3.4.1 Balance of payments

The current account under the balance of payments can be used as an indicator of whether a country is creating more value than is consumed domestically, or if the opposite is the situation. A positive current account indicates that the country succeed in both producing and selling goods and services to trading partners in numbers excessing their import. Surplus on the current account is therefore an indication of either net supply or net demand for trading purposes, and have a direct impact of the determination of exchange rates in a market economy. Stating the connection between trade balances and exchange rates the other way around might be easier comprehensible: “changes in exchange rates change relative prices of import and exports, and changing prices in turn result in changes in quantities demanded through the price elasticity of demand”. The balance of payments was further reviewed in connection with monetary policies in section 3.2, so further analysis will not be performed here.

#### 3.4.2 Government debt levels

Since the end of the Gold standard, currencies are no longer backed by anything but the credibility of the government issuing the currencies. In order to have a well-functioning currency, markets must trust the government to be able to provide and sustain good economically conditions

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allowing the currency to function. Government solvency is an important factor in this matter, as avoiding national bankruptcy is crucial to sustain the currency. High levels of government debt, everything else equal, increases the risk of defaulting on debt and therefore decreases the credit rating of a country, leading to increases on the interest rate level governments have to pay on government bonds\textsuperscript{47}. For this reason, government debt levels can be a factor impacting the exchange rate levels.

In figure 9 government debt as a percentage of GDP is shown for the euro area, China and the US.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{general_government_gross_debt.png}
\caption{General government gross debt % of GDP}
\end{figure}

Looking at the debt levels, it is clear that the debt level of China is significantly lower than that of the euro area and the US respectively. The higher GDP levels in the US and the euro area taken into consideration emphasizes that the nominal debt levels are significantly higher in the US and the euro area. But while the debt level in China is significantly lower, it can also be seen that China’s debt levels has been increasing, especially since the late nineties, and by 2010 the debt level has surpassed 20% of GDP. The increase in debt levels must be seen in combination with the high growth in GDP. The net debt in China has therefore increased more than the relative debt level. Part of the explanation can be found in the monetary policy of China, where the Peoples

\textsuperscript{47} Working Paper Series No. 1419 / February 2012, The euro area sovereign debt crisis, safe haven, credit rating agencies and the spread of the fever from Greece, Ireland and Portugal, , R.A. De Santis, ECB, page 2-3
Bank of China soaks up excess liquidity through issuing debt into the market. This is elaborated further on in section 3.2 about monetary policy.

The debt level of the euro area has been increasing over the 21 year time period, although it is more difficult to see a clear pattern in the debt development. Large parts of the increase have occurred after the financial crisis started in 2007-2008, and can therefore probably be explained by a decrease in tax income and an increase in unemployment expenses. Examples of debt levels affecting exchange rates has also been very apparent in the past few years, where the sovereign debt crisis in Europe and the accompanied questioning about the survival of the euro have been determinant factors in the exchange rate development. Countries like Denmark and Switzerland has been seen as safe havens to a degree that has even meant negative interest rates on government bonds. This flight of money into safety must have led to downward pressure on the euro rate.

Also the government debt level in the US has increased during the years following the financial crisis in 2007-2008, and has reached a level over 100% of GDP. In spite of current account deficits and government debt levels surpassing those of the euro area, the US dollar role as other countries foreign reserve currency has meant that devaluation has not occurred even though it might have been expected under the mentioned circumstances. The leverage of the US dollar thereby allows for the US to carry more debt and run larger current account deficits without having the dollar credibility questioned. However, it has been acknowledged that government spending cuts is needed to eliminate budget deficits and thereby get government debt levels under control, which is also why the head of the Federal Reserve Ben Bernanke has warned the

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48 BersteinResearch, Chinese Banking: a primer on the market, The Peoples Bank of China and monetary policy, p. 31
49 Sovereign debt crisis – The normal and the newly poor, D. Chorafas, 2011, palgrave macmilla, pages 148-149
US government about the current debt levels\textsuperscript{54}. Keeping this in mind, it can be expected that further increases in US government debt will lead to a weakened US dollar.

### 3.5 Price and wage indices

#### 3.5.1 Inflation

Differences in inflation levels between countries lead to prices and salaries to develop at different paces. With a 5\% inflation difference, one country’s prices and salaries would increase approximately 28\% more than the other countries prices in a range of 5 years. Starting at similar price and salary levels, the 5 years of inflation differences could potentially deteriorate a country’s competitiveness as an exporter, if nothing were done to offset the price and salary increases the higher inflation brought. The PPP parity suggests that exchange rates will change to offset inflation differences, so that the countries’ competitive levels remain unaltered even though domestic price and salaries develop at different paces\textsuperscript{55}. From this parity theory, also called the law of one price, there should be a correlation between foreign exchange development and the spread in inflation levels between countries.

![Inflation levels](image)

*Figure 10 Source: Based on figures from databank.worldbank.org*

As can be seen from figure 10, the inflation levels in the US and the euro area are fairly similar during the 25 year period, while the inflation levels in China has been significantly different.

\textsuperscript{54} http://www.policymic.com/articles/7148/ben-bernanke-u-s-debt-at-unsustainable-level

Especially the inflation levels during the nineties have been different, where the inflation level peaked at almost 25% in 1995. The higher inflation level should, if the PPP parity is to hold, mean that the Chinese Yuan Renminbi has been decreasing over the euro and the US dollar in the period, and the fairly similar inflation rates in the US and in the euro area should mean little development and variance in the EUR/USD rate. Looking at the historical developments in exchange rates, shown in figure 3 in section 3.1, this does not seem to be the case though. The reason for the PPP parity not to hold in the Chinese case might be found in the description of China’s monetary policy in section 3.2, as the Yuan Renminbi to a high extend has been pegged.

While neither reflected in the GDP growth or inflation figure for 2011, recent developments indicate economic recovery from the financial crisis is gaining ground in the US. Factors such as house prices and equity valuations have increase, which can indicate future economic growth in the US. At the same time the euro area expect only very slow recovery, partly explained by the debt crisis still being a struggle. The situation could well lead to the Federal Reserve increasing their interest rates soon, while the ECB keeping the interest rates low to stimulate the economy. Should this happen the USD will probably increase over the EUR, as formerly mentioned by the correlation rate between interest rate spread and the EUR/USD exchange rate.

### 3.6 Test on economic fundamentals explanatory powers

What determines exchange rates and their developments is a million dollar question, to which there seem to be no simple answer. Supply and demand for currencies is the dominant explanation, but behind supply and demand lays a highly complex system of different factors. Economic factors could be inflation levels, GDP levels and growth, central bank interest rates and fiscal policies of countries, while non-economic factors can be exchange rate regimes and general sentiment.

While the former review of different macroeconomic fundamentals cast some light on the past development and current economic state of the euro area, the US and China respectively, we want

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57 European Comission, European Economic Forecast, European Economy 2/2013
to see if the different factors have direct impact on the exchange rate development. For this purpose correlation coefficients between the yearly exchange rate development and the spread between two countries/areas macroeconomic factors in the 25 year period 1987 to 2011 has been calculated – i.e. the correlation between the yearly EUR/RMB percentage development and the difference in the yearly inflation levels between the euro area and China. T-values underlying the P-values have been calculated using a student t-test. The results are presented in table 2.

<table>
<thead>
<tr>
<th>Explanatory power</th>
<th>EU-China (EUR/RMB)</th>
<th>EU-Us (EUR/USD)</th>
<th>China-US (CNY/USD)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Correlation</td>
<td></td>
<td>Correlation</td>
</tr>
<tr>
<td></td>
<td>coefficients</td>
<td>P-values</td>
<td>coefficients</td>
</tr>
<tr>
<td>ΔFX / Interest rate spread</td>
<td>-</td>
<td>-</td>
<td>0,00</td>
</tr>
<tr>
<td>ΔFX / GDP spread</td>
<td>0,05</td>
<td>0,82</td>
<td>0,01</td>
</tr>
<tr>
<td>ΔFX / Real GDP growth spread</td>
<td>0,03</td>
<td>0,89</td>
<td>0,18</td>
</tr>
<tr>
<td>ΔFX / Government debt % of GDP spread</td>
<td>(0,19)</td>
<td>0,40</td>
<td>0,18</td>
</tr>
<tr>
<td>ΔFX / CPI spread</td>
<td>(0,22)</td>
<td>0,28</td>
<td>0,05</td>
</tr>
</tbody>
</table>

Table 2, test statistics of explanatory variables

As can be seen, the correlation coefficients and P-Values show no significant correlation between these economic fundamentals and the exchange rate developments, except for interest rates. The interest rate factor has only been included for EU-US as sufficient data for China could not be found. Interest rate correlation has been calculated using daily data, whereas as other factors has been calculated using yearly data.

To test if the different factors have any joint explanatory power in explaining the foreign exchange rate development, the following regression analysis has been performed:

\[
\Delta FX_{it} = \alpha + \beta_1 \text{(Interest rate spread)} + \beta_2 \text{(Real GDP growth spread)} + \beta_3 \text{(CPI spread)} + \beta_4 \text{(Spread in government debt as percentage of GDP)} + \epsilon
\]

, where \(\Delta FX_{it}\) is the yearly percentage development in the foreign exchange rates and the betas are as explained below.

\(\beta_1\) (Interest rate spread): The spread in the interest rates of national banks of the two countries involved
\(\beta_2\) (Real GDP growth spread): The spread in yearly Real GDP growth between the two countries involved
\(\beta_3\) (CPI spread): The spread in yearly inflation between the two countries involved
\(\beta_4\) (Spread in Government debt as a % of GDP): The spread in government debt levels as % of GDP between the two countries involved
The regression analyses have been conducted for each of the three foreign exchange rates; the EUR/USD, the EUR/RMB and the USD/RMB. Running the multiple regressions analyses for the three exchange rates produces the same conclusions with all coefficients coming out insignificant, and the adjusted R-square come out negative for the EUR/USD. The specified regression analyses results can be seen in appendix 1. It is worth noticing, that due to the overlap in the factors, such as GDP level, Real GDP growth and inflation levels, there is a high risk of multicollinearity in the regressions. Due to the clearly insignificant results, we have not corrected for this and run new multiple regression analyses.

Keeping the Chinese monetary policy in mind, it is not surprising that the economic fundamentals do not have explanatory power in regards to the Chinese exchange rate development. Any significant correlation would probably have been random rather than explanatory. However, from the test it can instead be concluded that the People’s Bank of China do not set the Yuan Renminbi exchange rate in accordance with these economic fundamentals.

As both the US and the euro area have a high degree of free market economy, and do rarely intervene in the exchange rates, one could have expected to find higher explanatory power in the macroeconomic factors. As described in section 3.2.4 about interest rates, the Federal Reserve / ECB interest rate spread might be able to explain majority of the development in the EUR/USD exchange rate since the introduction of the euro in 1999. As described in the section, we find a correlation of approximately 0.60 between the interest rate spread and the exchange rate development, but the remaining 0.40 is still unexplained. A study conducted by the ECB indicates that fundamentals, such as government debt, have little explanatory power in describing the euro exchange rate\textsuperscript{59}. These results are in accordance with our studies, showing no significant correlation between the exchange rates and the economic fundamentals in the past years.

3.7 Part Conclusion

This part of the thesis sought to answer the question:

\textit{What are the characteristics of the currencies and markets Siemens operate in?}

Figure 2 at the beginning of this section, showed four main factors that we assessed would be important to have knowledge about and that might have an impact on the exchange rate development between the euro, the US dollar and the Chinese Yuan Renminbi.

A review of monetary policies reveals that the ECB and Federal Reserve have a “no intervention policy”, and that their main instruments are the interest rate and support programs such as quantitative easing. The interest rate spread between the ECB and the Federal Reserve proved to be very determining for the EUR/USD exchange rate, and as such an important factor to consider when developing hedging strategy. The people’s Bank of China pegs the RMB to a basket of currencies, where the USD is by far the most important currency. Looking at China’s huge surplus on balance of payments and their increasing currency reserves, it is clear that China deliberately keep the RMB lower than at an equilibrium state to improve Chinese competitiveness. Recent increases in debt level raises the question of whether China can withstand the upward pressure on the RMB or not.

Analysis of GDP levels shows that China experience higher growth than both the US and euro area. When developing strategies several years ahead, the growing market must be taken into consideration. Government debt levels show that both the US and the euro area have very high debt levels at the moment. The high debt levels raises doubt about the credibility of the US and euro area governments, and as such also about the currencies they vouch for. As has been seen in the recent years, such doubt can lead to increased volatility. The Inflation level of China surpasses that of the US and the euro area by far. This must be taken into consideration in cost calculations when e.g. deciding where to locate production plants, as the cost saving advantages China has to offer at the moment might be diluted in the years to come.

Having conducted further analysis on these factors, we must conclude that only monetary policy can be proven to have statistical significance on the exchange rate developments. However, this does not mean the other factors; economic performance, fiscal policies and the price and wage indices in the countries are not important factors in regards to exchange rate development, and in regard to assessing risk and development of hedging strategies. Our assessment is that exchange rates are determined by numerous factors, but that only very few affect directly enough to have statistical significance. Relying on fundamentals as indicator of the currency developments is
therefore not possible, and predicting future development is therefore impossible. However, indications do show that the RMB might be undervalued and that the US might be recovering at a faster pace than the euro area. If any prediction was to be made though, both the USD and RMB would increase over the EUR in the future.

4 Measurement of foreign exchange risk

This part of the thesis focuses on measurement of foreign exchange rate risk. The second main question from the problem statement, which is quoted below, will be answered:

What are the exchange rate risks for a German company doing business in the US and China, and how can they be measured?

In order to properly manage exchange rate risk, good risk estimations is a necessity. Proper measurements of exchange rate risk are therefore crucial for the next part of the thesis. Along with the findings in the section about exchange rate fundamentals, measurement of risk will be important in developing a hedging strategy.

One of the challenges in the subject of foreign exchange rate risk is measurement of exposure. The exposure relates to many different factors, some of which is very difficult to quantify. Indirect risk is a good example of this. A firms’ ability to identify and quantify the exact exposure is therefore the real challenge of hedging foreign exchange rate risk, rather than finding proper financial instruments to do it with. This section will begin with a review of different risks, followed by estimation of cash flows in USD and RMB. After this, a number of different risk measurement approaches will be introduced, which will shed light on corporations’ different possibilities and potential pitfalls.

60 Aabo, Exchange rate Exposure and Strategies of Industrial Companies, page 380
4.1 Exchange rate risks

Exchange rate risk can roughly be defined as “the variance in expected cash flows arising from unexpected exchange rate changes”\(^{61}\). In the introduction, exchange rate risks are divided into four different categories as illustrated in table 3.

<table>
<thead>
<tr>
<th>Risk</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Transaction</td>
<td>Risks regarding changes in contractual cash flows occurring from operating the business on a daily basis.</td>
</tr>
<tr>
<td>Translation</td>
<td>A risk occurring when accounts of subsidiaries are converted to the functional currency of the mother company.</td>
</tr>
<tr>
<td>Operating</td>
<td>Risk regarding future cash flows in foreign currencies where time and amount are unknown.</td>
</tr>
<tr>
<td>Indirect</td>
<td>Exposure to foreign exchange rates as a consequence of the competitive environment</td>
</tr>
</tbody>
</table>

Table 3, Different kinds of risk

This section will serve as an introduction to the different risks that will be further addressed throughout the thesis.

4.1.1 Transaction risk

Transaction risk is the foreign exchange rate risk connected with contractual agreements in foreign currencies. Because we are talking about contractual agreements, both the money amount and the time of execution are often times known factors – i.e. a company has committed to pay a certain amount of a foreign currency at a specific point in time in exchange for a deliverance of raw materials. If the foreign currency increases over the functional currency of the company between the day of agreement and the day of settlement, the company ends up paying more than it had originally expected. It is important to remember that the fact that a contract is negotiated in a foreign currency does not lead to exchange rate risk by itself. The risk only appears when a time gap between the negotiation and the execution of the contract is added. If no time gap is present, the negotiators have full knowledge about the spot rates at time of execution, and therefore no exchange rate risk is associated with the contract. The typical contracts constituting a transaction risk are accounts receivables and accounts payables negotiated in another currency than the

\(^{61}\) Eiteman et al. Multinational Business Finance, page 285
company’s functional currency, export and import contracts settled in a foreign currencies and loans denominated in foreign currencies.

4.1.2 Translation risk
Translation risk relates to accounts of foreign subsidiaries, whose functional currency is different from that of the mother firm. When a group report is prepared, financial figures of the mother company and all of its subsidiaries are consolidated into one report. If subsidiaries are individually reported in a different currency, their financial figures must be converted into the functional currency of the parent company. This is where translation risk appears. Translation loses are only calculated loses, while transaction loses and operating loses actually have cash flow impact.

Translation risk differs in characteristic from transaction and operating risk, as these two are forward looking and focuses on the future development of FX rates. Translation exposure on the other hand relates to the corporate reporting, which concerns past events. As a corporation’s value is calculated based on the net present value of future cash flow, academics have argued that translation exposure has no influence on firm value and as a result should be neglected. Prior empirical studies have showed that the investor behaviour is not affected by companies exposed to translation exposure compared to those which are not. None the less, studies also prove that financial managers do monitor and control translation exposure. This conflicting view between theory and practice could cause some problems. Using financial instruments to hedge translation risk can be costly as financial institutions charge commission and as the company need to use resources to monitor and handle the translation exposure. As it does not create value to hedge translation risk, the use of resources would lower the value of the company. Another implication is that foreign debt hardly can be used to hedge both translation exposure one the one hand, and transaction risk and operating risk on the other hand. This further adds to the argument that translation risk should not be hedged.

62 Dhanini, The management of translation exchange rate risk in MNC’s, page 34
63 Dhanini, The management of translation exchange rate risk in MNC’s, page 35
64 Dhanini, The management of translation exchange rate risk in MNC’s, page 36
4.1.3 Operating risk

Operating risk, or economic risk, basically refers to the risk of a firm’s future operating cash flows fluctuating due to exchange rate volatility. The foreign currency cash flows can stem from both revenues from export and domestic sales of foreign subsidiaries, or from operating expenses recognized in foreign currencies. Opposite to transaction risk, the cash flows referred to when talking about operating risk are unknown in both time and amounts, although the company might hold expectations about them. Also opposite to transaction risk, the cash flows referred to in operating risk are potentially infinite, as they are only limited by the discontinuance of the company’s operations. Due to the uncertainty about the size and the timing of the foreign currency cash flows, operating risk is by far the most difficult risk to hedge, and due to the potential time horizon, hedging must happen on a strategic level rather than just in the treasury department.

4.1.4 Indirect risk

A company without any kind of import or export business can be vulnerable to exchange rates, if they have competitors at their domestic market who have their cost base in another currency. Thereby corporations can be affected indirectly by changes in exchange rates. An example is that competitor’s goods can become cheaper in the domestic market if the exchange rates changes in their favour. Moffet and Karlsen call this competitor exposure. Multinational companies meet more indirect risks when competing with companies who have different cost bases than themself. Exchange rate risk is therefore a constant issue, and minimising vulnerability to changing exchanges rates is therefore a struggle for practically all firms. Siemens addresses some perspectives on indirect risk in their annual report of 2009, where they report that they are exposed to fluctuations in the EUR/USD exchange rate, and that their competitors have different cost bases than they do. As a result of this, an increase in euro against US dollars will be unfavourable for their competitive position, as many of their competitors have a cost base denominated primarily in US dollars. Competitive risk therefore clearly applies to Siemens.

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65 Moffet & Karlsen, Managing Foreign Exchange Rate Economic Exposure, page 162
66 Siemens annual report 2009, page 103
Indirect risk might be argued to be included in operating risk, but we include this fourth risk to emphasise the range of companies and operations the risk affect.

4.2 Siemens foreign currency cash flows

In this section Siemens’ US Dollars and Chinese Yuan net cash flows are estimated from information given in their annual report. Siemens inform about new orders in their annual report, and the new orders correspond well to one year’s revenue. As orders are contracts, revenue and associated costs can be considered contractual agreements. The one year cash flow can therefore represent their expected financial positions in USD and RMB.

The estimated cash flows are presented in table 4, and will be used to calculate VaR measures for Siemens. More detailed calculations can be seen in appendix 2.

<table>
<thead>
<tr>
<th>Euros</th>
<th>Cash Flow from U.S.</th>
<th>Cash Flow from China</th>
</tr>
</thead>
<tbody>
<tr>
<td>Revenue</td>
<td>16,425,497.600</td>
<td>5,861,484.800</td>
</tr>
<tr>
<td>Cost of goods sold and services rendered / materials</td>
<td>8,391,487.483</td>
<td>2,994,525.800</td>
</tr>
<tr>
<td>Cost of goods sold and services rendered / production costs</td>
<td>2,784,895.321</td>
<td>1,969,346.312</td>
</tr>
<tr>
<td>Gross profit</td>
<td>5,249,114.795</td>
<td>897,612.689</td>
</tr>
<tr>
<td>Research and development expenses</td>
<td>1,109,181.041</td>
<td>178,485.451</td>
</tr>
<tr>
<td>Marketing, selling and general administrative expenses</td>
<td>877,420.904</td>
<td>117,339.980</td>
</tr>
<tr>
<td>Income from continuing operations before income taxes</td>
<td>3,262,512.851</td>
<td>601,787.257</td>
</tr>
<tr>
<td>Net interest expenses</td>
<td>302,784.849</td>
<td>-</td>
</tr>
<tr>
<td>Income from continuing operations before income taxes</td>
<td>2,959,728.002</td>
<td>601,787.257</td>
</tr>
<tr>
<td>Taxes (35% / 25%)</td>
<td>1,035,904,801</td>
<td>150,446,814</td>
</tr>
<tr>
<td>Net income</td>
<td>1,923,823.201</td>
<td>451,340.443</td>
</tr>
</tbody>
</table>

When estimating free cash flows categorised by currency, there are many aspects to consider. As mentioned the cash flows are based on information given in Siemens annual report, but due to limited information a lot of assumptions have been made. In the following the overall approach used and assumptions made in estimating the cash flows will be described.

4.2.1 Revenue

Revenue is of course all sales in US dollars and Chinese Yuan Renminbi respectively. The revenue will primarily be generated in subsidiaries in the US and China, but also export from Germany or
other subsidiaries, which is settled in US Dollars or Chinese Yuan Renminbi, must also be accounted for.

US revenue has been calculated by accumulating external revenue from Siemens’ different business sectors, where exact US revenue figures are disclosed. Revenue in China’s has been estimated from China’s part of new orders in Asia/Australia as a percentage of the total Asia/Australia revenue.

4.2.2 Cost of goods sold and services rendered

4.2.2.1 Materials
Cost of materials will often have a high correlation with the USD, as Raw materials often are settled in US Dollars. In effect, a rather large part of Siemens costs could be US dollar denominated, even though they might be settled in another currency. It cannot be seen from the annual accounts which currencies Siemens’ costs are denominated in though. For this reason, cost of materials for the US and China has been estimated from the percentage of revenue generated in the countries, multiplied by total costs of materials.

4.2.2.2 Productions costs
Production facilities in the US or China will of course result in large parts of production costs being denominated in USD and RMB. This especially goes salaries and indirect productions costs. Other functions like marketing, administration and R&D could still be conducted in Germany though.

Production costs for the US has been estimated from the number of production facilities in the entire “Americas” and the percentage of employees located in the US as a part of all “Americas”. There are a total 80 production facilities in all of America. Employees in the US equals 67,86% of total in America. 67,86% of the production facilities in America are therefore estimated to be in the US, which equals 54. Salaries are estimated from an average salary for a factory worker in the US multiplied by the number of estimated employees in the US. Non salary production costs are estimated from the 54 estimated plants located in the US out of all plants Siemens has worldwide.

50 out of 300 production facilities are located in China, and the number of employees in China is estimated as 50/300 of total employees in Siemens. Salaries are estimated from an average salary
for a factory worker in China multiplied by the number of estimated employees in China. Non salary production costs are estimated from the 50 estimated plants located in the China out of all plants Siemens has world-wide.

4.2.3 Research and development expenses

10.983 R&D workers are employed in all of America. As with production workers, 67.87% of these employees are estimated to be employed in the US, amounting to 7.453 people. The R&D salary expense incurred in the US is calculated by multiplying the estimated number of R&D employees with the average salary of a scientific worker in the US. Non salary R&D costs are estimated as 7.453 / all Siemens’ R&D employees multiplied by total non R&D costs.

China’s revenue is estimated to account for 37% of total Asia/Australia and the R&D employees in China is therefore estimated to be 37% of all the R&D employees in Asia/Australia. R&D salary expenses are estimated from the estimated number of R&D employees in China multiplied with an average salary of a scientific worker in China. Non salary R&D costs are estimated as the percentage of R&D employees in China out of all Siemens’ R&D employees, multiplied by total non R&D costs.

4.2.4 Marketing, selling and general administrative expenses

The number of US employees in these departments is estimated as the residual between estimated total number of employees in the US minus the number assigned to production and R&D. An average salary for an employee in this department is assumed to be the average of and R&D and a production worker. The salary expenses are estimated as the number of employees in these departments, multiplied by the average estimated salary. Non salary expenses are estimated as employees in these departments in the US out of all Siemens employees in these departments, multiplied by total non-salary cost of these departments. China is estimated in the same way as the US.
4.2.5 Net interest expenses & loans

Interest expenses are calculated based on the overview of debt given in the annual report. Siemens might have a little interest income in US, but this is ignored as they state that most of their cash and equivalents are held in euro. The interest expenses in US sums to the equivalent of 302,79 million euro. No USD loans are due to payment within the next year, and Siemens have no debt in Yuan.

As can be seen from the annual report, Siemens is already using debt to hedge some of their cash flows in US dollars, but they do not have any debt in Yuan. Siemens might have come to some of the same conclusions about the Yuan being fundamentally undervalued, and therefore they do not dare to have debt in Yuan. As earlier mentioned, it might be the case that Siemens invest more in China than estimated in here. This could mean that their cash flow in Yuan Renminbi is actually offset by investments and as a result nothing is left to hedge using debt.

4.2.6 Taxes

Taxes are deducted assuming tax rates of 35% in US and 25% in China.

4.2.7 Depreciations

We believe that majority of depreciations stem from production facilities, so depreciations are estimated from the numbers of production facilities assumed to be located in the US and China respectively. The total number for depreciation, amortizations and impairments is 2,744 billion and depreciations allocated to US and China using formerly mentioned approach amounts to 496,53 million euro and 338,43 million euro respectively.

4.2.8 Investments

Siemens does not state how their capital expenditure is distributed throughout different countries. CAPEX are for the US and China is estimated using same method as depreciations, and

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67 Siemens annual report 2012 page 173
68 Siemens annual report 2012 page 82
70 Siemens annual report 2012 page 85
with a total CAPEX of 4,2 billion in 2012\textsuperscript{71}, 760 million is assumed to be spent in the US while 518 million euro is assumed to be spent in China. It could have been argued that investments would be higher for US and China, as Siemens state that they on a continuous basis try to adapt their cost structure in different countries to balance revenue more equally. This topic is addressed later in this thesis when addressing hedging possibilities though.

4.2.9 Working capital

Working capital changes is not considered in the USD and RMB cash flow estimations. Siemens does not inform about this topic, and estimating working capital development would be comprehensive and the results doubtful due to in inadequate information. Receivables and payables, which are significant parts of working capital, can be argued to unimportant as they are just cut-off items. E.g. revenues recognised will not lead to an ingoing cash flow before in 30 days, but at the same time revenue generated 30 days ago will be an ingoing cash flow today. And as we have assumed that the 2012 revenues and costs are unaltered in the year to come, only small changes in working capital would be expected. Net working capital is therefore expected to be unaffected.

4.2.9.1 Net cash flows from foreign operations

We end up with a net cash flow from US that equals approximately 1,67 billion euro and approximately 271,8 million euro from China.

We must emphasise that the calculations of net cash flows are based on a large number of estimations and assumptions. As Siemens hold more information about their financial figures, they could make more exact calculations. They also have thorough knowledge about their investments plans, and therefore less uncertainty would be present if they calculated their free cash flow themselves.

4.3 Value-at-Risk analysis

To better assess the foreign exchange rate exposure Siemens has in effect of its positions and cash flows in USD and RMB respectively, a series of Value-at-Risk (VaR) analyses will be performed. The

\textsuperscript{71} Siemens annual report 2012 page 2
VaR analysis will produce estimates of how much the USD and RMB exchange rates will possibly decrease toward the euro at different levels of confidence, and thereby how much Siemens risk losing on its USD and RMB positions and future cash flows.

Value-at-Risk (VaR) calculations are often used for measuring risk on financial instruments. By applying the VaR methods, a company can gain knowledge about the risk of holding derivatives, whether it is held for speculative or hedging purposes. Financial instruments can be a tool to hedge the company against unforeseeable currency movements, but to do so companies should know their FX risk to make the financial hedging in the first place. In this section VaR analysis will be based on the cash flows estimated in the former section, and not on instruments.

The VaR analyses mainly address transaction risk, i.e. known cash flows. Performing VaR calculations based on one year cash flows result makes sense though, as new orders in Siemens correspond very well to one year's revenue. The calculated VaR percentages can be used for more purposes though, and the VaR amounts also give a good indication of exchange rate risk if all factors except for exchange rates are fixed.

There are more ways to perform VaR analysis. We have conducted the VaR analysis using three different methods:

1. Variance-Covariance / parametric method
2. Historical simulation
3. Monte Carlo simulation

The following sections will present the different approaches individually, including the assumptions that the different methods have, and the results will be presented and applied on Siemens figures afterwards.

4.3.1 Variance-Covariance method

In variance-covariance method, an assumption is that Siemens’ USD and RMB collective positions is a linear combination of the changes in the individual USD and RMB positions. This means that the joint USD and RMB currency returns are dependent on the individual USD and RMB currency returns. Another assumption is that the joint currency returns follows a normal distribution. Thus, the VaR in percentage can be calculated using the following equation:
\[ \text{VaR} \% = \mu + CV \times \sigma \]

where \( \mu \) is the weighted mean of Siemens total USD and RMB currency returns, \( CV \) is the critical value of a one-sided test following the normal distribution, and \( \sigma \) is the standard deviation of Siemens currency returns on the joint USD and RMB positions. The standard deviation is a weighted transformation of the variance-covariance matrix for Siemens individual USD and RMB positions, where the currencies are weighted in accordance with the estimated cash flow exposure. With a USD net cash flow exposure amounting to 1.660 million EUR and a RMB net cash flow exposure of 272 million EUR, the USD currency return weights approximately 86% and the RMB 14% of the joint currency return. The same weight applies to the mean of Siemens total USD and RMB currency returns.

To convert the Siemens VaR % into their USD and RMB exposure measured in EUR, the VaR % must be multiplied with Siemens total USD and RMB currency exposure measured in EUR.

\[ \text{VaR} = TCE \times (\mu + CV \times \sigma) \]

where \( TCE \) represent Siemens total currency exposure from USD and CNY measured in EUR.

### 4.3.1.1 Descriptive statistics

The variance-covariance method assumes normal distribution. To test whether normality is present, the characteristics of the weighted currency returns are audited.

In figure 11 a histogram of the daily returns since 1999 is displayed along with some descriptive data.

![Histogram of daily returns since 1999](image)

**Figure 11, Histogram of daily returns since 1999**

<table>
<thead>
<tr>
<th>Series: DAY</th>
<th>Sample 3735</th>
<th>Observations 3735</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>1.67e-05</td>
<td></td>
</tr>
<tr>
<td>Median</td>
<td>0.000000</td>
<td></td>
</tr>
<tr>
<td>Maximum</td>
<td>0.045988</td>
<td></td>
</tr>
<tr>
<td>Minimum</td>
<td>-0.029827</td>
<td></td>
</tr>
<tr>
<td>Std. Dev.</td>
<td>0.006370</td>
<td></td>
</tr>
<tr>
<td>Skewness</td>
<td>0.116645</td>
<td></td>
</tr>
<tr>
<td>Kurtosis</td>
<td>5.246613</td>
<td></td>
</tr>
<tr>
<td>Jarque-Bera</td>
<td>793.9508</td>
<td></td>
</tr>
<tr>
<td>Probability</td>
<td>0.000000</td>
<td></td>
</tr>
</tbody>
</table>
As can be seen of the graph and table in figure 11, the skewness of the weighted returns is slightly positive, meaning that the weighted returns are right tailed. The kurtosis is higher than 3, which can also be seen as the peak of the distribution is higher than a standard normal distribution. From the Jarque-Bera test with a P-value of 0.00 it can definitively be concluded that normality is not present in the currency returns. This is in accordance with the conclusion of a study conducted in 2010 where long-term memory of the daily changes was found and normal distribution of EUR/USD returns rejected\(^72\), and with other studies concluding that currency returns are not normally distributed, but rather leptokurtic\(^73\). Due to the large sample of 3.735 weighted returns, we might be able to ease the requirement of normality\(^74\).

In figure 12 a histogram of the monthly returns since 1999 is displayed along with some descriptive data.

![Histogram of monthly returns since 1999](image)

As can be seen of the figure 12, the skewness of the weighted returns is negative, meaning that the weighted returns are left tailed. The kurtosis is a bit higher than 3, which can also be seen as the peak of the distribution is a bit higher than a standard normal distribution. Both factors deviate from the standard normal distribution, but only to a smaller extend. Looking at the Jarque-Bera test with a P-value of 0.17 it can be concluded that normality cannot be rejected at a 95% confidence level.

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\(^74\) Brooks, Introductory Econometrics for Finance, page 162
confidence level. Normality can therefore be assumed, although the weighted returns are far from being a perfect example of a normal distribution.

4.3.2 Historical simulation method

The approach to this method is to run Siemens’s foreign exchange rate exposure against a set of historical exchange rates, and in that way yield a distribution of losses. The VaR can then be found by computing a percentile corresponding to the confidence level you want, e.g. 95% or 99%. The steps in calculating Siemens historical VaR can be expressed as follows:

1. Obtaining historical exchange rate data (the data must be long term sufficiently\(^75\))
2. Computing currency return, weighted in accordance with Siemens exposure in the USD and RMB respectively
3. Derive VaR at different percentile’s corresponding to different confidence levels.

Thus, the assumption behind the historical simulation method is that history repeats itself in regards to the exchange rate distributions, and an advantage of the historical simulation method is that returns do not have to follow the normal distribution\(^76\).

Historical Value at Risk has been calculated for the EUR/USD and EUR/RMB monthly currency returns, weighting the currencies in accordance with the estimated cash flow exposures, as it was the case with the variance-covariance method. So also here USD currency return weights approximately 86% and the RMB 14% of the joint currency return.

The historical VaR has been calculated using data from the three periods; January 1981- April 2013, January 1999 – April 2013 and last July 2009 – April 2013. The monthly returns are shown as a scatter plot to the left side in figure 13, where the horizontal axis represents observations ordered by date starting from January 1981 and ending April 2013. A six month’s moving variance

\(^76\) Exchange rate risk measurement and management: Issues and approaches for firms, M.Papaioannou, IMF Working Paper 06/255, 2006, page 5-6
graph is presented at the right side of in figure 13, showing the development in variance throughout the years.

From the plots of the weighted returns, the variance in the returns does not seem to change systematically over time. The six months moving variance graph supports this as the moving variance does not seem to have a specific pattern over time, and the linear trend line of the moving variance has a slope close to zero. Clearly the variance changes throughout the period with peaks around early nineties and around 2007-2009 where the crisis was influencing financial markets, but no trend is present, and that certain periods should be better at predicting the future variance than others is therefore difficult to argue. For this reason, we have chosen to apply equal weights to the monthly currency returns throughout the period instead of doing an exponential historical VaR where emphasis is on latter returns over former ones.

**4.3.3 Monte Carlo simulation**

The last model used to estimate cash flow effects of volatile exchange rates is a Monte Carlo simulation. The program Crystal Ball for Excel has been used to conduct the simulations. As in the prior VaR analysis, the combined US Dollars and Chinese Yuan cash flow estimation measured in euro has been used. The Monte Carlo simulation conducts a number of trials based on a standard deviation and mean return defined by the user. The Monte Carlo simulations conducted in this analysis are based on data obtained from three different periods, like in the other VaR analyses. Considering the large sample size, the simulation has been based on a normal distribution even though the data does not fit the distribution perfectly.
In the simulation 5,000 trials has been run in order to get a sufficient data set. More trials could have been run, but increasing the trials from 5,000 to 10,000 would not have made any difference. A Monte Carlo simulation will create a different set of data each time it is simulating, as it draws 5,000 random numbers based on the mean and standard deviation that has been put in. This means that the VaR based on the simulation would be altered if the simulation was repeated, but 5,000 trials should assure fairly similar results every time. As a result, only minor and insignificant differences in outcomes would be expected. As a precaution, the simulations was run a number of times to check if the VaR levels changed significantly, but as expected this was not the situation.

In the Monte Carlo simulations, the same standard deviations and mean returns from the variance-covariance analysis has been used, and the monthly standard deviation has been converted to a yearly measure by multiplying the monthly standard deviation with the square root of 12. In figure 14 below the output from one of the Monte Carlo simulations is shown.

![Figure 14, Output from Monte Carlo simulation](image)

Figure 14 shows how the trials from the simulation are distributed and the potential loss with a 95% certainty. Crystal Ball always indicate a two sided test, which means that the simulation has been set to a certainty level of 90% in order to obtain the critical value for a one sided test. In the
example the maximum loss on a monthly basis will be no more than 95.4 million Euro with 95% certainty. The distribution also shows the potential gain from exchange rate changes, but from a risk management perspective this is not a primary focus. The number shows the potential upside Siemens can potentially gain in case of a favourable development in exchange rates, so the number might be of some interest in determining whether to pursue a normal hedging strategy by minimizing variance or to pursue an opportunistic hedging strategy by adding flexibility to take advantage of exchange rate fluctuations. This will be elaborated further in later sections.

4.3.4 VaR analysis data
We have calculated a series of different VaR levels using different sets and combinations of data:

<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Returns</td>
<td>Daily &amp; Monthly</td>
</tr>
<tr>
<td>Confidence levels</td>
<td>95% &amp; 99%</td>
</tr>
<tr>
<td>Methods</td>
<td>Variance-Covariance, Historical Simulation, Monte-Carlo Simulation</td>
</tr>
<tr>
<td>VaR time horizons</td>
<td>Daily VaR, Monthly VaR, Yearly VaR</td>
</tr>
</tbody>
</table>

Table 5, Basis for VaR calculations

The different datasets, returns, approaches, confidence levels and VaR horizons has produced a total of 54 VaR levels expressed both as percentages and euro values. A full presentation of the different VaR levels can be seen in appendix 3, along with statistical output from variance-covariance calculations, such as the variance-covariance matrix.

In the following, we will continue using the VaR levels calculated using data from the period January 1999 – April 2013, as this time horizon exclude the time where the euro did not actually exist as a functioning currency, and still include a time horizon long enough to grasp over different macroeconomic cycles and that provides a fairly large set of data, equivalent to 3.735 daily returns and 172 monthly returns. Our focus will be limited to monthly and yearly VaR levels, as performing short term risk management activities from daily VaR levels is to comprehensive and not the scope of this thesis. We have used standard deviations of monthly returns to estimate the standard deviation of yearly returns by multiplying by the square root of time – in this case the square root of 12 as there is 12 months in a year. The conversion of standard deviations using the square root of time stem from the classical idea of finance, that standard deviation tends to increase with the
square root of time\textsuperscript{77}. The arguments to estimate yearly returns from monthly returns rather than from daily returns are that monthly returns better fits a normal distribution, as was presented in the section about descriptive statistics, and that the multiplication factor is much smaller and therefore has less risk of being significantly biased.

4.3.5 VaR levels

VaR levels, calculated as described in the previous section, are presented in table 6.

<table>
<thead>
<tr>
<th>Data since 1999</th>
<th>95%</th>
<th>95%</th>
<th>99%</th>
<th>99%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Monthly VaR levels</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variance-Covariance method</td>
<td>5,11%</td>
<td>98,77</td>
<td>7,22%</td>
<td>139,43</td>
</tr>
<tr>
<td>Historical Simulation</td>
<td>5,08%</td>
<td>98,13</td>
<td>6,84%</td>
<td>132,24</td>
</tr>
<tr>
<td>Monte Carlo Simulation</td>
<td>4,94%</td>
<td>95,37</td>
<td>6,82%</td>
<td>131,69</td>
</tr>
<tr>
<td>Yearly VaR levels</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Variance-Covariance method</td>
<td>17,63%</td>
<td>340,60</td>
<td>24,92%</td>
<td>481,46</td>
</tr>
<tr>
<td>Historical Simulation</td>
<td>17,59%</td>
<td>339,94</td>
<td>23,71%</td>
<td>458,10</td>
</tr>
<tr>
<td>Monte Carlo Simulation</td>
<td>18,92%</td>
<td>365,51</td>
<td>25,87%</td>
<td>499,93</td>
</tr>
</tbody>
</table>

Table 6, Overview of different VaR levels

As can be seen, yearly VaR levels range between 340 – 366 million euros with a confidence level of 95%, while the same VaR levels range from 458 – 500 million euros on a 99% confidence level. To put these figures into perspective, a comparison of the VaR levels with some of Siemens’ key figures have been conducted in table 7.

<table>
<thead>
<tr>
<th>Siemens, million EUR</th>
<th>Monthly range, 95%</th>
<th>Monthly range, 99%</th>
<th>Yearly range, 95%</th>
<th>Yearly range, 99%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Net USD &amp; RMB exposure</td>
<td>1.932</td>
<td>5.08% - 5.11%</td>
<td>6.82% - 7.22%</td>
<td>17.59% - 18.92%</td>
</tr>
<tr>
<td>Siemens net income</td>
<td>4.590</td>
<td>2.14% - 2.15%</td>
<td>2.87% - 3.04%</td>
<td>7.41% - 7.96%</td>
</tr>
<tr>
<td>Siemens total equity</td>
<td>31.302</td>
<td>0.31% - 0.32%</td>
<td>0.42% - 0.45%</td>
<td>1.09% - 1.17%</td>
</tr>
</tbody>
</table>

Table 7, VaR levels compared to income and equity

Table 7 shows that the possible losses are far from insignificant, but that they however are not at a level that can threaten the very existence of Siemens, even on a yearly basis. This needs to be considered when assessing the immediate necessity for hedging.

\textsuperscript{77} http://www.investopedia.com/articles/04/101304.asp
4.3.6 Alternative volatility measures

There is a number of different ways to calculate volatility, but as this is not the primary scope of the thesis, not all volatility measures will be covered. In this section we give a short presentation to some alternative approaches that can be used in different situations though. As both the exchange rate markets and the situation of Siemens are constantly changing, having knowledge of different volatility measures can quickly become relevant.

4.3.6.1 Volatility pooling

In financial data, like exchange rates, volatility clustering or volatility pooling can often be found\(^78\). This means that there is a tendency for volatility to appear in clusters, where large returns (both positive and negative) are often followed by other large returns, and similarly where small returns have a tendency of being followed by other small returns.

There are more ways to test for volatility clustering in a sample, but due to the scope of the thesis we have only conducted a heteroskedasticity test. The test has been made in E-views, and is based on daily returns in EUR/USD since 1981. As it can be seen from table 8 we can conclude that the test clearly rejects the null hypothesis of homoscedasticity or constant variance in the returns.

<table>
<thead>
<tr>
<th>Heteroskedasticity Test: ARCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>F-statistic</td>
</tr>
<tr>
<td>Obs*R-squared</td>
</tr>
</tbody>
</table>

Table 8, Heteroskedasticity test EURUSD daily

Many volatility measures operate with an assumption of constant variance. When working with financial data this assumption might not be satisfied, as was the case in the daily returns in EURUSD since 1981. Creation of models likes ARCH and GARCH that accounts for heteroskedasticity is possible.

4.3.6.2 ARCH and GARCH models

ARCH and GARCH models are good examples of models that accounts for heteroskedasticity. Creation of these models is quite comprehensive and finding an ideal model requires performing a

\(^{78}\) Brooks, Introductory Econometrics for Finance, page 380
number of other tests as part of the process. Due to this and the scope of the thesis, the tests will not be conducted. In a situation of financial turmoil, however, the historical volatility measures might not be sufficient anymore. In this case financial managers need to be aware of the limitations to normal volatility measures assuming constant variance and the increased risks the higher exchange rate fluctuations bring. For short term exchange rate risk management in volatile markets, or in case of increased volatility in exchange rates in the future, ARCH and GARCH models might be necessary.

4.3.6.3 Implied volatility

Another way to measure volatility is to look at prices in the market for certain financial instruments. An example could be looking at options for EUR/USD and do backward calculations to obtain the volatility justifying the price of the option in the market. The backward calculations can be done because all other parameters in calculating the price can be defined with certainty. Implicit volatility is an average of all traders’ expectations about the volatility for a future period, so it will tell how traders expect volatility to develop and if i.e. the EUR/USD exchange rate is going to be more or less volatile than the average of the past.

Implicit volatility is important for financial managers, as it is the volatility used to price the financial instruments that could be used to hedge exposure to foreign exchange positions and future cash flows. Implicit volatility could also be used as a parameter in conducting the Monte Carlo simulation, where the financial managers can obtain an indication of how much risk they may expect on their foreign currency cash flows in a future period, if the implicit volatilities are good estimators for future volatility.

4.4 Measuring operating exposure

“Measuring the long-term exposure requires an understanding of the structure of the markets in which the company and its competitors operate. We should examine for all market players their flexibility to change sales markets, product mix, sourcing and technology”79.

79 Moffet & Karlsen, Managing Foreign Exchange Rate Economic Exposure, page 159
In this section an analysis of operating exposure will be performed. Operating exchange rate exposure will be measured as the influence unexpected exchange rate movements can have on the future cash flows and market value of Siemens. The analysis will include factors such as sales prices, cost curves and elasticity of demand. The aim of the analysis is to give an idea of how unfavourable exchange rate movements can deteriorate profits and market value of a company. Focus of the analysis is on the impacts that stems from the US and Chinese market operations, which means the effects of altered exchange rates on the German market is excluded.

Creating a model that reflects all market characteristics is an impossible task and requires information unavailable to us. Therefore a number of simplifications have been made:

- We only have one product, which has one price on each market
- Price discrimination between the US and Chinese is possible – i.e. no arbitrage
- Costs incurred in a country do not change in that country’s currency when exchange rates move - i.e. costs incurred in the US do not change in USD nominated value if the euro increases or decreases.

In table 9 price, cost and quantity functions are presented along with a valuation model based on a simple DCF method. The numbers illustrated in table 9 in the columns “US” and “China” reflects a 10% increase in the EUR over the USD and RMB.

<table>
<thead>
<tr>
<th>Price in foreign currency</th>
<th>US</th>
<th>China</th>
</tr>
</thead>
<tbody>
<tr>
<td>( P_{t+1} = P_t + \left( \frac{C.eur_t}{Q_{t+1}} \times FX_t \times \Delta FX \times pt \right) ), where</td>
<td>10,27 USD</td>
<td>101,73 RMB</td>
</tr>
<tr>
<td>( P_{t+1} ) = New sales price in USD or RMB</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( P_t ) = Initial sales price in USD or RMB</td>
<td>10,10 USD</td>
<td>100 RMB</td>
</tr>
<tr>
<td>( C.eur_t ) = Total initial EUR cost</td>
<td>5.516 EUR</td>
<td>883 EUR</td>
</tr>
<tr>
<td>( FX_t ) = Initial EUR/USD or EUR/RMB spot rate</td>
<td>1,3024</td>
<td>8,12</td>
</tr>
<tr>
<td>( \Delta FX ) = % change in EUR/USD or EUR/RMB</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>( pt ) = % pass through of extra cost.</td>
<td>0,47</td>
<td>0,47</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cost in foreign currency</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
</tr>
</tbody>
</table>
As can be seen, the value of the company is determined by the value of future cash flows, which again are determined by price, cost and quantity functions. Assumptions made in this example are described below.

Price is a function of the original price set, and a cost increase or decrease depending on the euro development. The original price set is therefore assumed to have been optimal under the former market conditions. Pass through of the cost increase or decrease has been determined by maximising profits from price, quantity and cost functions. Initial sales prices are randomly selected, but margins are selected to reflect those of Siemens.
Costs are a function of a variable unit cost in a foreign currency (USD of RMB) that does not change when quantities changes, and fixed costs in euros that alters units costs when quantity changes. Costs in foreign currencies are assumed to be materials and labour costs, and these are therefore variable. Costs in euros are assumed to be R&D, administration etc. and are therefore fixed. At original prices in our calculations example, as shall be elaborated on later, 60% of costs stem from the foreign country and 40% from the EU. Initial cost prices in both foreign currencies (USD and RMB) and EUR are randomly selected, but with margins reflecting those of Siemens.

Quantity is a function of the number of goods originally sold, the price increase from exchange rates movements and elasticity of demand. Elasticity of demand is set to 2 to reflect that Siemens operate in a competitive environment. Initial quantities are randomly selected, but distribution between the US and China reflects the 2012 cash flows with 86% coming from the US and only 14% from China. This will of course be altered over the estimation period due to different growth rates.

The valuation model is a classic DCF. We have assumed a 10 year budgeting period, where the annual growth rate has been set to 2,2% in the US and 7,8% in China. The numbers stems from the World Bank and IMF and is based on growth in 2012 and predictions for 2013 and 2014. For the terminal period we operate with a continuing growth rate of 2% for both countries. The discount rate has been set to 8%, as Siemens use a discount rate of 7-8,5% in their impairments tests. In our estimation of cash flows the effects of deprecations, investments, taxes etc. has not been considered for simplicity reasons.

Because of the high correlation between the USD and RMB described in the section “Exchange rate fundamental analysis”, it is assumed that the USD and RMB will develop similarly toward the euro.

80 Siemens annual report 2012, page 118
81 http://data.worldbank.org/indicator/NY.GDP.MKTP.KD.ZG
82 Siemens annual report 2012, page 168
From the functions and numbers shown in table 9 and described above, calculation of exchange rate movements can be made. Table 10 presents the negative impact an increase in the euro will have on cash flows from foreign operations and the impact it can have of Siemens market capitalization using the DCF model.

<table>
<thead>
<tr>
<th>Development in exchange rates</th>
<th>0,0%</th>
<th>2,0%</th>
<th>4,0%</th>
<th>6,0%</th>
<th>8,0%</th>
<th>10,0%</th>
<th>12,0%</th>
<th>14,0%</th>
<th>16,0%</th>
<th>18,0%</th>
<th>20,0%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Negative percentage change in value of future CF from subsidiaries</td>
<td>0,0%</td>
<td>8,0%</td>
<td>15,9%</td>
<td>23,6%</td>
<td>31,0%</td>
<td>38,2%</td>
<td>45,1%</td>
<td>51,8%</td>
<td>58,2%</td>
<td>64,4%</td>
<td>70,4%</td>
</tr>
<tr>
<td>Negative effect on Siemens’ market cap</td>
<td>0%</td>
<td>2,28%</td>
<td>4,52%</td>
<td>6,71%</td>
<td>8,84%</td>
<td>10,86%</td>
<td>12,85%</td>
<td>14,75%</td>
<td>16,56%</td>
<td>18,36%</td>
<td>20,07%</td>
</tr>
<tr>
<td>Pass through</td>
<td>1</td>
<td>1</td>
<td>0,781</td>
<td>0,586</td>
<td>0,469</td>
<td>0,391</td>
<td>0,335</td>
<td>0,293</td>
<td>0,26</td>
<td>0,234</td>
<td></td>
</tr>
</tbody>
</table>

Table 10, Measuring operating exposure

Table 10 should be interpreted as a rise in EURUSD and EURRMB of e.g. 10%, i.e. the euro appreciating, would have a negative impact on the entire discounted cash flow from foreign operations in US and China of 38,2%, and a negative impact on market capitalization of 10,88%. A full overview of calculations can be seen in appendix 4.

From prior calculations, it is estimated that approximately 28,5% of cash flows are generated in the US and China. Assuming Siemens’ market value is made up of future earnings alone, 28,5% of the market capitalisation stems from cash flows from operations in the US and China. Combining these 28,5% with Siemens total market capitalisation and the percentage impairment on foreign cash flows in table 10 allows for calculation of the impairment an increasing euro has on market capitalisation. The calculation below is in case of a 10% appreciation of the EUR over the USD and RMB:

\[
71.037^{83} \text{ mio. euro } \times 28,5\% \times 38,2\% = 7.734 \text{ mio. EUR}
\]

As the calculation above reveals an increase in euro of 10% against USD and RMB would reduce the value of Siemens by 7,7 billion euro or 10,88% of total market value. The range from 2-20% increase in euro equals a range of 2,28%-20,07% in erosion of Siemens total market value, which

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83 Market value of 30. july 2013
in terms of euro would be from 1,62-14,26 billion euro. As can be seen from the figures, potential impairment from operating exposure is rather large. The larger effect compared to e.g. VaR analysis is due to the infinite time horizon in this calculation, whereas VaR was limited to monthly and yearly basis.

The calculations illustrate how company value can be eroded from exchange rate movement. The example above excluded the effect exchange rate movements can have on Siemens operations in Germany. Intuitively a decrease in USD over the euro would reduce competitiveness of Siemens’ total business, including the German market, against USD based competitors. The total effect the operating exposure will therefore be larger than estimated here. If the competitiveness in Germany would have a 1:1 effect as the one in the US and China, the effect on the total future cash flows would be similar to those of the US and China, and the effect on market capitalisation would therefore be similar to the negative percentage change in cash flows.

As mentioned earlier, the model is simplified and contains quite a few assumptions that do not necessarily hold. However, focus is on percentage impact exchange rate movements have on company value, and the model can easily be fitted to suit other companies with other figures. A company like Siemens could make the model to fit more precisely by substituting numbers with real ones and adding parameters to the ones included in the example.

4.5 Alternative Approaches to measurement
Over time a number of different methods have been developed with the aim to measure firms’ exposure as accurate as possible. We will review some of these models and where relevant perform analyses and use the methods on the Siemens case.

4.5.1 Stock market approach
One approach to measure foreign exchange rate exposure for listed companies is to use the stock market as a tool. A study based on 8 large Danish companies was conducted, finding that regressing their stock returns on exchange rate returns led to significant coefficients for more than half of them. Some degree of direct correlation between exchange rates and firm value must

\[ Aabo, Exchange rate Exposure and Strategies of Industrial Companies, page 381 \]
therefore be expected. The study further contained interviews with the financial managers of the companies, revealing that management focus was actually to hedge cash flows rather than maximizing market value of the company.

The approach presented some problems though. Running a regression on the stock price of the Danish company Bang & Olufsen against the GBP resulted in a coefficient of 1.7. A relatively large and positive coefficient was expected as B&O stated that Great Britain is their single most important market based on sales. However, a coefficient of 1.7 means that they are selling GBP equal to an amount of 1.7 times their market value. This would in nature be very problematic, as a financial partner hardly would accept such a contract\textsuperscript{85}. The reasons for the extreme values are multiple, but as this is not the aim of the thesis they will not be reviewed.

Running a regression analysis with monthly EUR/USD currency returns from the period 2000-2013 as the independent variable and Siemens stock price as the dependent variable\textsuperscript{86} resulted in a negative coefficient, indicating that a euro increase over the dollar will have negative impact on Siemens stock price. The result is in line with Siemens using the euro as functional currency and has net cash inflow in USD\textsuperscript{87}. The coefficient of EURUSD comes out at -0.093 indicating that a strengthening of the euro by 1% would implicate Siemens to deliver an abnormal return of -0.093% compared to the Dax index. After all the coefficient is insignificant and the poor statistical result is also backed by $R^2$ of only 0.002\textsuperscript{88}, indicating that’ Siemens’ abnormal return is poorly explained by movements in EUR/USD rate. The stock market approach is therefore not applicable as a method of measuring risk for Siemens.

\subsection*{4.5.2 Other approaches}
Shapio (1975), Dumas (1978) and Hodder (1982) worked with some models with similar characteristics. Hodder’s model consisted of four different parts that influenced a company’s exposure to exchange rates; domestic price related exposure, foreign real asset exposure, inflation

\begin{itemize}
  \item Aabo, Exchange rate Exposure and Strategies of Industrial Companies, page 385
  \item Appendix number 5
  \item Siemens Annual report 2012, page 122
  \item Appendix number 5
\end{itemize}
related exposure and the firm’s fully exposed foreign borrowing exposure\textsuperscript{89}. As many other models, these models would be rather hard to implement for a multinational company like Siemens, as they have so many businesses and operations in a lot of countries making it hard to control all the information. These models are often simplifications with firms only having operations in two countries and two markets.

Tufano (1996), Levi (1994), Allayannis and Ihrig (2001), Marston (2001) and Bodnar et al. (2002) also contributed to the area with different approaches to measure a corporation’s exposure against unforeseeable moves in FX rates. Even though a consensus about an optimal model is not reached there is some agreement among the different contributions on what parameters are affecting a company’s FX exposure\textsuperscript{90}. Below we have listed some of the most important factors\textsuperscript{91}:

- Nature of the firm’s activities
- Import and export structure
- Involvement in foreign operations
- Competitors currency
- Competitiveness of input and output market

There are many implications when measuring and managing risk, which should be taken into consideration when interpreting the results. Most methods use historical data as base for making decisions for the future. An example is the VaR analysis using a historical standard deviation to predict the future exposure of the cash flows. If new altered conditions rule in the future, historical data is useless in best case or directly misleading in worst case. The measurements are based on the assumption that exchange rates follow a normal distribution, even though this is hardly the case. The financial crisis has clearly revealed that this is not the case and that extreme, low tailed outcomes cannot be ruled out. In these situations losses can supersede estimations. Exchange rate movements cannot be predicted and factors such as political interventions can alter conditions overnight. Precaution is therefore required for companies operating under financial

\textsuperscript{89} Muller et al., Foreign Exchange risk exposure: Survey and suggestions, page 388
\textsuperscript{90} Muller et al., Foreign Exchange risk exposure: Survey and suggestions, page 390
\textsuperscript{91} Muller et al., Foreign Exchange risk exposure: Survey and suggestions, page 390
turmoil or volatile governments. Also estimated cash flows could also be altered, e.g. due to altered demand conditions, new competitors, new technologies and so forth. This would alter future cash flows, and thereby the need for hedging.

4.6 Part conclusion

The purpose of this section was to answer the second main question:

What are the exchange rate risks for a German company doing business in the US and China, and how can they be measured?

Siemens face different foreign exchange rate risks; transaction risk, operating risk, translation risk and indirect risks, which can be considered included in operating risk. While operating risk is assessed most important, transaction risk is still an important measure to address.

Siemens’ USD and RMB exposure to transaction risk has been estimated by quantifying future one year USD and RMB cash flows from their annual report 2012. As Siemens has orders reaching one year into the future, one year cash flows seems to be an appropriate estimator for their contractual obligations. Quantification of their future cash flows reveals significant exposure to the USD while a less significant exposure to the RMB.

To measure Siemens’ exchange rate risk, VaR analyses has been performed by applying the three different approaches; variance-covariance, historical method and Monte Carlo simulation. Each method has its pros and cons, but calculated VaR levels do not differ significantly from each other regardless which method is applied. The yearly VaR levels range from 458 – 500 million euros on a 99% confidence level, equivalent to approximately 11% of Siemens’ 2012 net income or approximately 1,5% of the 2012 book value of their equity. We must emphasize that the measures are based on assumptions that might not be satisfied, and as such are subject to errors.

Operating risk is hard to measure as it rests on many parameters that are difficult to quantify. Some of the crucial parameters in determining operating risk are; elasticity of demand, competition in the market, competitors cost bases, composition of costs and pricing policy. Measuring operating risk from a number of assumptions showed that operating exposure can
have significant impact on Siemens market capitalisation. Operating risk is therefore important to address in developing hedging strategies.

5 Managing exchange rate risk

In the prior sections has focused on assessing the markets in which Siemens operate and measuring their risk and exposure in the currencies they operate in. In this section, the third and last main question from the problem statement will be answered:

*How can exchange rate risks be managed?*

Basically exchange rate hedging are activities performed by corporations to protect themselves from unpredicted developments in exchange rates. The activities can be different in both scale and character, depending on how company’s exchange rate exposure and how risk averse the management of the company is. Hedging activities can be split into two categories as described in table 11.

<table>
<thead>
<tr>
<th>Hedging</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Financial</strong></td>
<td>Financial hedging include make use of financial instruments, which is financial products offered by e.g. banks, to mitigate or eliminate exchange rate uncertainty.</td>
</tr>
<tr>
<td><strong>Natural</strong></td>
<td>Natural hedging is performed on a more strategic level, where activities are planned in a way that reduces the exchange rate exposure of a company.</td>
</tr>
</tbody>
</table>

Table 11, Hedging alternatives

This section will start by introducing how hedging has been conducted in recent years, both by Siemens and in general. After this, the two different approaches to hedging; financial and natural, will be thoroughly analysed. Analysis of financial hedging will include a review of different financial instruments, their prices and coverage and usability for different hedging purposes. Natural hedging will include both hedging from a marketing and production point of view, and suitability for Siemens will be analysed as well. The different methods will be recapped and suggestions for hedging in Siemens will be made. Finally, the section will end by reviewing some of the basic implications companies need to consider before entering hedging activities.
5.1 Financial and natural hedging through time

This section will provide knowledge about the development in hedging for both for Siemens and in general. The section should serve as a source of material to reflect on and compare to when reading the coming sections on hedging possibilities and when companies manage foreign exchange rate risk.

The Bank for International Settlements (BIS) makes a number of detailed reports on the activity in the foreign exchange market. Their findings clearly reveal that the size of the market has increased dramatically in the past years, with a growth, in the daily global foreign exchange market turnover, from 1.527 billion US dollars in 1998 to 3.981 billion US dollars in 2010\textsuperscript{92}. Financial hedges are easily quantified, but natural hedging is much harder to quantify. Natural hedging is therefore investigated through empirical studies prior made in the area.

Figure 15 show that non-financial customers, which are governments and corporations, have increased their use of financial instruments regarding foreign exchange.

![Figure 15, Foreign exchange market turnover by counterparty, BIS](image)

As it can be seen from figure 15, it is especially in the period from 2004-2007 we see a significant increase. The number in 1998 was 266 billion dollars per day and this number has increased to 533

\textsuperscript{92} BIS, Triennial Central Bank Survey, Report en global foreign exchange market activity in 2010
billion dollars in 2010, which corresponds to an increase of 100.38%. There has been a slight decrease in the number from 2007-2010 of 10%, which, according to BIS, is because of the slowdown in the overall economy.\footnote{The $4 trillion question: what explains FX growth since the 2007 survey?}

The downturn in corporations use of financial derivatives from 2007-2010 because of economic conditions also supports the findings from Allayannis and Olek, who concluded that corporations use financial derivatives to hedge foreign exchange risk and not for speculating purposes.\footnote{George Allayannis Eli Ofek, Exchange rate exposure, hedging, and the use of foreign currency derivatives, page 23} Siemens has since 2003 incorporated a passage in their annual report stating that units under Siemens are prohibited from taking any speculative positions in foreign currencies.

In 2002 Siemens state that a 10% parallel increase in euro against other currencies would cause a reduction in their known future cash flow of 79 mio. euro.\footnote{Siemens annual report 2002, page 84} This number was reduced to 38 mio. euro in 2006,\footnote{Siemens annual report 2006, page 146} which could indicate that Siemens has intensified their focus on reducing risk from exchange rate movements. They do not specify the number after 2006. In 2007 Siemens starts to give up numbers for the aggregated value of their foreign currency contracts.

Figure 16, Siemens' total use of foreign exchange contracts

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\footnote{The $4 trillion question: what explains FX growth since the 2007 survey?} \footnote{George Allayannis Eli Ofek, Exchange rate exposure, hedging, and the use of foreign currency derivatives, page 23} \footnote{Siemens annual report 2002, page 84} \footnote{Siemens annual report 2006, page 146}
As it can be seen from figure 16 Siemens has lowered their use of financial contracts significantly since 2010. One reason could be that Siemens has become more efficient in their hedging management, i.e. increased cash flow pooling, or it could be due to increase use of natural hedging.

In a study undertaken by Fehle, he examines the use of financial hedging to hedge economic exposure and discretionary exposure. He wanted to explore the reasons for the firms to use financial hedging. He found out that most financial managers saw it as one their most important tasks to take care of hedging exchange rate exposure, furthermore he concludes that only a fraction of the firms has specified their economic exposure, but only hedges their discretionary exposure. These findings reveal that companies are very interested in their FX exposure, but they find it difficult to quantify and manage their total exposure.

A study by Choi and Jiang on US companies reveals that in 2000 24,3% of multinational companies and 6,3% of non-multinational companies disclosed operational hedging strategies, while 79,2% of MNCs and 51,6% of non-MNCs reported use of financial derivatives to hedge foreign exchange risk. This could indicate that the use of financial hedging has been more widely used than natural hedging, at least for US companies. With respect to our findings in the measurement of foreign exchange risk it is very important to offer some attention to economic exposure and natural hedging.

As it can be seen from this section, Siemens has moved towards more use of natural hedging. Findings also indicate that financial hedging is the preferred way to manage exchange rate risk for companies. The substantial value that lies in the area preludes for a more efficient approach to both measurement and management of exchange rate risk by corporations. This thesis could prove helpful for a lot of corporations in their search for measure and managing tools.

97 Fehle, Panel Evidence on Corporate Hedging
98 Choi and Jiang, Does multinationality matter? Implications of operational hedging or the exchange risk exposure.
5.2 Financial hedging

In this section financial instruments will be described and a comparison of the alternatives will be conducted using the exposure calculated when measuring the risk in the former section.

Financial hedging basically involves entering a financial contract that will rise/fall and offset a fall/rise in the value of an operating position. In their financial report 2012, Siemens state that “certain currency risks ... are hedged on a Company wide basis using derivative financial instruments”99, and that the hedging instruments “foreign currency exchange contracts, foreign currency put and call options and stop-loss orders” are available for their entities according to their company-guideline100. Financial hedging therefore seems to be an important tool for Siemens.

There are five main ways to use financial hedging, which are shortly described here:

- Forward contracts
- Futures
- Options
- Swaps
- Money market hedge

5.2.1 Forwards and futures

Buying futures and entering forward contracts both involves buying a foreign currency at a certain time in the future at a pre-specified exchange rate. The forward rate is determined by the spot rate +/- forward points, which are calculated based on interest rate differentials between the currencies. Forward contracts are individually negotiated contracts between two parties, normally a bank and a non-financial company. They are named “Over The Counter” (OTC) contracts due to their tailor made nature. Forward contracts are favoured by corporations because of their flexible nature, but also because they are not marked to market on a daily basis unlike futures. A forward is cleared at the expiration date, where the covered cash flow from operation should be sufficient to cover the settlement. For these reasons focus will be on forward contracts over futures in this

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99 Siemens annual report 2012, page 122
100 Siemens annual report 2012, page 204
thesis. Siemens also state in their 2002 annual report that their typical tool for hedging foreign exchange rate risk is forward contracts\textsuperscript{101}.

5.2.2 Options

A currency option is a right, but not obligation, to buy or sell currency at a pre-specified price at an execution date or timeframe. Currency options are characterized by their skewed distribution of payment.

Currency hedging with options can be ideal for companies who are interested in limiting their downside while maintaining upside, and who are willing to pay a premium for it. Hedging with options is costly and the risk of losses is higher, but this comes with the chance to make a larger profit if the currencies move in favour of the company. Options could be useful for companies, which are in a bidding process, as an option gives them a right but not an obligation. If they do not get the order they will only suffer a loss equal to the premium paid and they have the chance to make money on the option at the same time.

5.2.3 Swaps

A currency swap is a constellation of trading cash flows in different currencies with a counterpart (typically a bank). The swap can include or exclude a principal amount at the beginning of the swap period. If the structure of the swap is only to exchange the principal it reminds of a forward contract. Swaps are good at hedging on-going cash flows in foreign currencies. If a company e.g. enters a contract about 12 monthly purchases of raw material in exchange for paying a foreign currency at the time of deliverance, the company can hedge the position by entering a swap agreement involving 12 monthly cash flow exchanges at the current spot rate. In this way the company fix the amount they have to pay in their own currency to the current spot rate. Swaps can be expanded to include interest rates, but this will not be elaborated further here.

5.2.4 Money market

Hedging in the money market involves a company taking up a loan in foreign currency and immediately exchanging the proceeds to their main currency. The idea is that the loan will be

\textsuperscript{101} Siemens annual report 2002, page 126
repaid by future cash flows in the foreign currency, thereby offsetting the incoming cash flow by instalments and interest payments on the loan. A money market hedge reminds of a currency swap with immediate swaps of principals and without including interest rates in the swaps, as they alter the currency of a series of cash flows. The money market hedge can therefore be used in the same manner.

Money market hedge can cover a single transaction or a number of transactions and in the latter case it is called matching, which in practice can be very difficult.

Siemens use of money market hedge has altered over the years. Back in 2002 they had US debt of 1,145 billion US dollars, which was 13,37% of total debt. In 2012 they have debt in US dollars of 7,4 billion US dollars, which at the time amounted to 34,83% of total debt.

5.2.5 Comparison of the alternatives

In the following section, the different financial hedging tools will be compared and the implications connected with the reviewed. Specific suggestions will be given based on findings from the former sections, especially the section on exchange rate fundamentals.

In table 12 the costs associated with the hedges are shown in euro based on a cash flow transaction of 179.180.142 USD (monthly free cash flow from US) exchanged to euro in 90 days. Maximum losses and profits are based on EURUSD movements of +/- 5%, which equals three month standard deviation. The column “no change” can be interpreted as the cost of each hedge.

<table>
<thead>
<tr>
<th></th>
<th>Max loss</th>
<th>No change</th>
<th>Max profit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unhedged</td>
<td>-6.918.152</td>
<td>-</td>
<td>6.918.152</td>
</tr>
<tr>
<td>Option</td>
<td>-4.170.547</td>
<td>-1.403.286</td>
<td>5.514.866</td>
</tr>
<tr>
<td>Money market</td>
<td>-363.609</td>
<td>-363.609</td>
<td>-363.609</td>
</tr>
<tr>
<td>Forward contract</td>
<td>-77.818</td>
<td>-77.818</td>
<td>-77.818</td>
</tr>
</tbody>
</table>

Table 12, comparison of financial hedging tools

As it can be seen from table 12 no hedge will of course be the cheapest, but the range of outcomes is rather wide. The option hedge is based on a strike at 1,3284, which is 2% away from

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102 Siemens annual report 2002, page 114
103 Siemens annual report 2012, page 173
the spot rate. The choice of strike could be up for discussion, but it will be a matter of the risk the corporation is willing to take and what premium they are willing to pay. The option price stems from Saxobank’s trading system. The price indicated as cost of the option is an aggregated amount for both the price of the option and the cost paid to the financial counterparty.

The cost of the option with commission included is 1.827.640 USD, which correspond to 1.403.286 EUR. This is the price Siemens has to pay to get the insurance that their loss will be limited to 2% plus this cost.

In the money market hedge commission cost are not considered. The borrowing rate in USD is based on the average yield on investment grade bonds, which is 3,25%. The interest rates Siemens are paying on their US dollar debt, which is 3,36%\textsuperscript{104} could have been used, but this is an average of all their debt in US and some of it are loan agreements from years back where the interest level were higher than today. So in order to make an assessment of the money market hedge, calculations are based on the investment grade bond yields which are present today. The investment grade yields are used in calculations, both as lending and deposit rate. Again the average interest rate Siemens is paying on their European debt could have been used, but using present bond yields are found more appropriate.

The cost, commission included, of a forward hedge is 78.264 EUR. As the price of a forward contract is primarily determined by interest rate differentials, the cost of such a hedge is relatively low at the time, because of the low interest rates levels and spread in both US and Europe.

In figure 17 the coverage of the different financial instruments is illustrated.

\textsuperscript{104} Siemens annual report 2012, page 173
If an anticipation of exchange rates developing favourable is held, options would be a good alternative to an unhedged position as it limits the downside but retain upside. Siemens has disclosed that their politic about cover ratio is that it must be between 75-100%. This means that leaving it all unhedged is not a possible solution for Siemens. Buying options could therefore be a solution. Options would also be ideal, if Siemens are in a bidding process for an order.

Money market hedge could be ideal if Siemens has opportunities to use the proceeds from US dollar to substitute for euro denominated debt. In practice it would require the euro debt to be flexible, as it would probably be too expensive to make a lot of extra ordinary repayments on ordinary loans. An account with overdraft facilities could be ideal, as it would be costless to make transactions in and out of the account. In order to keep down the cost of a money market hedge, at least if it should be used continually, the corporation has to have a flexible borrowing account in the foreign currency, as the cost of making new loans or issue bonds on a continues basis would be too costly. This could have implications on the borrowing rate, as it must be assumed that the interest rate would be higher on an overdraft account than on bonds, which would make the money market hedge less attractive. As the money market hedge is based on borrowing rates for the corporation, it will also be a matter of which credit rating the corporations have. A lower rated company will suffer from higher interest rates on their loans than a higher rated company. This means that money market hedge in many cases will be more attractive for a highly rated company than for a lower rated one. In order to assess whether to use money market hedge or not, the corporation therefore has to consider their options and interest rates. Siemens has an Aa3 –
outlook stable rating from Moody’s and they consider it to be very positive and even increase their competitiveness against competitors to have such a high rating\textsuperscript{105}.

In table 13 the yields on corporate bonds are stated in US, Germany and China.

\begin{center}
\begin{tabular}{|l|c|}
\hline
Investment grade bonds yield & \\
\hline
US & 3.25\% \\
Germany & 2.21\% \\
China & 5.17\% \\
\hline
\end{tabular}
\end{center}

Table 13, Investment grade bond yields\textsuperscript{106}

These can be used by Siemens to compare the alternative interest rates in the countries they are operating in. Siemens has no debt in Yuan and, besides reasons previously mentioned, the higher interest rate compared to Germany could be a reason for this. If Siemens is unable to use the proceeds from a Chinese loan to substitute euro denominated debt, the alternative of placing the money in deposit account with low interest rates would prove costly. On the other hand, Siemens could use the proceeds in the daily operations of the business, which would make their wacc an appropriate rate of comparison, making the money market hedge more attractive.

Based on information from the annual reports of Siemens over the last 11 years, it is clear that Siemens, to a certain degree, want to hedge the main part of their cash flows from foreign operations. Forward contracts are simple and can be made with relatively low costs on a continuous basis, so with the forward points presently seen in the market forward contracts are indeed a good solution for eliminating risk rather cheaply.

As stated earlier in the thesis, exchange rates cannot be predicted by fundamentals, but interest rate spread seems to have significant impact on currency rates. As also mentioned in the section on exchange rate fundamentals, economic indicators suggest that the US economy are in better shape than the European, which could indicate that the Federal Reserve will hike interest rates

\textsuperscript{105} Siemens annual report 2012, page 19
\textsuperscript{106} http://www.bloomberg.com/markets/rates-bonds/corporate-bonds/
http://asianbondsonline.adb.org/china/data/bondmarket.php?code=Credit_Spread_Corp_vs_Govt
http://www.tradingeconomics.com/china/government-bond-yield
before the ECB. In this scenario a US dollar appreciate over the euro must be anticipated, given the calculated correlation of 0.6 between the interest rate spread and the EUR/USD exchange rate. In that scenario, no hedge is favourable as Siemens benefits from a strengthening of the US dollar. If a policy of 75-100% hedging is retained by Siemens, using options to maintain upside would be preferable.

Use of money market hedge would result in more interest costs in US dollar and thereby reduce USD cash flow. In the light of the economic condition in the countries, like stated above, we find it likely that we will see interest hike in US before Europe. In such a scenario the yield spread between the countries would widen further making it less attractive to borrow in US and invest in Europe, and especially borrowing at a variable rate in USD could prove costly. On the other hand we have argued that the US dollar might be fundamentally overvalued, due to the enormous deficits on their current account. These deficits have been funded by foreigners, especially China, buying bonds in US. After all we do consider it more likely, in near future, that the increasing interest rates will weigh heavier creating upwards pressure on the US dollar against the euro and thus money market hedge should not be used in the current situation.

Regarding cash flows from China, we have seen a gradual increase in the USD/RMB exchange rate. As stated in the section on exchange rate fundamentals it is very likely that the RMB will increase further against the USD. As stated above we find it likely that USD will increase against EUR and this would of course also result in the Yuan increasing over the euro. Such a development would be beneficial for Siemens, as they have positive cash flows in Yuan Renminbi. China is considered to be an important driver of growth in the future and an ideal country to locate new productions sites in due to cheaper operating costs. There are some pitfalls in this scenario though, but these will be addressed in the section about natural hedging.

Operating risk was measured in a previous section, but as financial instruments are poor in hedging long term risk and unknown cash flows, no suggestions to hedging this will be made here. Studies in the area have shown that attempts to hedge operating exposure with financial instruments might actually introduce more cash flow volatility. The simple reason behind this is the fact that cash flows beyond known transactions are uncertain and the exchange rate
movements’ impact on future cash flows will be very hard to assess and hedge with financial instruments.\textsuperscript{107}

5.3 Natural hedging

Natural hedging takes place on a strategic level, where activities are planned in a way that reduces the exchange rate exposure of a company. From the statement in Siemens’ 2012 annual report: “Siemens’ financial risk management is an integral part of how to plan and execute its business strategies,”\textsuperscript{108} it can be concluded that Siemens focuses on a strategy approach to hedging.

From reviews of annual reports, it can be concluded that Siemens do not use the word “natural hedging” in their reports before 2010. This does not mean that Siemens was not aware of the possibilities and strengths of natural hedging until 2010. Already in their annual report of 2002, Siemens states that some of their foreign exchange rate risk is partly offset by production facilities abroad.\textsuperscript{109} In Siemens annual report of 2012, they state that “through adaptation of our production facilities during the recent past, we have improved our natural hedge on a global basis.”\textsuperscript{110} Siemens thereby focus on natural hedging and state that they have a made attempts to match cost and revenue in the recent years.\textsuperscript{111} This is also indicated by their use of derivatives for hedging currency risk, which has fallen from 2011 till 2012.\textsuperscript{112} It can also be seen from their Value at Risk (VaR) calculation on currency hedging. The VaR for currency hedging activities has fallen from 23 million euro in 2011 to 9 million euro in 2012, based on a confidence level of 99,5% and a ten days holding period.\textsuperscript{113} This could of course be due to lower volatility, but this can hardly account for such a large drop in the VaR level. The decrease in VaR could therefore indicate increased use of natural hedging in the recent years. Natural hedging therefore seems to be an area of growing focus for Siemens, indicating the importance of the topic.

\textsuperscript{107} Moffet & Karlsen, Managing Foreign exchange rate economic exposure, page 167
\textsuperscript{108} Siemens annual report 2012, page 203
\textsuperscript{109} Siemens annual report 2002, page 83
\textsuperscript{110} Siemens annual report 2012, page 114
\textsuperscript{111} Siemens annual report 2012, page 127
\textsuperscript{112} Siemens annual report 2012, page 200
\textsuperscript{113} Siemens annual report 2012, page 204
Natural hedging can take place in many areas and at different levels. Table 14 list the different strategies and methods we will include in our assessment of Siemens’ opportunities to incorporate natural hedging in their business.

<table>
<thead>
<tr>
<th>Strategy</th>
<th>Method</th>
<th>Involves</th>
</tr>
</thead>
<tbody>
<tr>
<td>Marketing</td>
<td>Market selection</td>
<td>Selecting markets where FX rates are favourable</td>
</tr>
<tr>
<td></td>
<td>Promotional strategy</td>
<td>Allocating marketing effort to the most profitable markets</td>
</tr>
<tr>
<td></td>
<td>Pricing policies</td>
<td>Setting prices according to FX rates, price elasticity and competition</td>
</tr>
<tr>
<td>Production</td>
<td>Diversify operations</td>
<td>Going into offsetting business, e.g. both import and export</td>
</tr>
<tr>
<td></td>
<td>Diversifying sources of input</td>
<td>Having suppliers from more countries, so that procurement can be made in the most favourable currency at all times</td>
</tr>
<tr>
<td></td>
<td>Facility location</td>
<td>Locating facilities, i.e. production plants, where revenue is generated to offset the income</td>
</tr>
<tr>
<td></td>
<td>A strategy of flexibility</td>
<td>Having plants and suppliers in more countries to be able take advantage of FX rate movements</td>
</tr>
</tbody>
</table>

Table 14, natural hedging

5.3.1 Marketing strategies for managing operating exposure

5.3.1.1 Market selection

Siemens can choose its markets in accordance with favourable exchange rates. The U.S. and China are the worlds’ two biggest economies\(^\text{114}\), and not being present on either of the two markets seems unrealistic for a company the size of Siemens. For this reason, market selection in full scale might not be a relevant choice. However, with their presence in the Chinese and U.S. markets Siemens still need to consider aspects of market selection in the light of fluctuating exchange rates. If either the USD or the RMB decreases to the EUR, price elasticity of demand can require Siemens to either lower their prices measured in EUR or to lose market shares in the U.S and China. Lowering prices would have negative impact on margins, which could potentially mean having to sell with losses. Losing markets shares on the other hand might be even more expensive in the long run, as regaining lost markets shares might be difficult and require many resources to

accomplish. Choosing strategy in a situation of an increasing EUR is therefore a choice between two evils. Given great reluctance of losing market shares, Siemens would probably be better off cutting margins in the short run, while assessing if the new exchange rates are caused by fundamental changes in the countries / areas, or if it merely based on market sentiment. In the former scenario, Siemens need to consider if fundamental changes in cost base is necessary to remain competitive and to maintain a profitable business. From fundamental analysis we have seen that the EUR/USD exchange rates are highly determined from spreads in central bank interest rates. If the EUR increase over the USD is caused by a ECB interest rate announcement, chances are that the Federal Reserve will make a similar announcement shortly after. Fundamental analysis also highlighted the undervaluation of the RMB, and an increasing EUR over the RMB should therefore not be a key concern for Siemens.

5.3.1.2 Promotional strategy
While full scale market selection is not an actual possibility, Siemens can change its promotional strategy to better fit new market conditions. E.g. if the USD increases over both the EUR and the RMB, Siemens can alter its marketing budget by allocating more money to marketing in the US where the goods can now be sold at more favourable prices measured in EUR. A pitfall of this strategy is that marketing efforts might have a delayed effect, which means that it might be difficult to react to short term exchange rates movements. For this reason the strategy works better on medium and long time horizons. However, aside of an expectation of the RMB strengthening in the future, we concluded that exchange rate movements hardly can be predicted. The question is therefore how efficient the promotional tool is in Siemens’ hedging strategy.

5.3.1.3 Pricing policies
When facing exchange rate fluctuations, Siemens faces the choice of either absorbing price changes themselves or to alter their prices to reflect the new exchange rates. To which extent price changes leads to changes in demand on the entire market depends on the price elasticity of demand, while the demand for Siemens products specifically also depend on competitors reactions to the exchange rate movements. Siemens must consider both the market demand effect (the general effect on the market) and a competitive effect (Siemen’s market share) when evaluating effects of introducing price changes.
5.3.1.3.1 Market demand effect

A higher elasticity of demand leads to a greater effect of price changes. As a general rule we expect that a high elasticity of demand makes Siemens more reluctant to introduce increases in prices in case of increasing EUR rate, while a low elasticity of demand on the opposite would encourage them to do so. Studies show that long-run elasticities are higher than short run elasticities\(^\text{115}\), which also necessitates considering the timing of price alterations. There are however more things to consider when assessing the possibilities of using pricing policy as a mean of adjusting to changes in exchange rates.

As informed in the description about Siemens in section 2.1.1, Siemens operates in the businesses Energy, Health Care, Industry and Infrastructure & Cities. The businesses are largely characterised by high levels of technology, engineering and therefore also R&D. With specialised production facilities and much money invested in R&D, economy of scale might only be achieved at high output levels. This can make it difficult for Siemens to increase prices as reaction to exchange rate changes, as a lower production could increase the unit cost, leaving the unit margin unaltered. Also the cost of altering production plans into a different output needs to be considered. In case of a favourable exchange rate movement, Siemens could consider lowering its prices to capture a larger market share, but if the cost of expanding production output is high, the economic incentive to do so might be confined.

To avoid the need for price alterations in response to exchange rate movements, Siemens could try to mitigate their exposure by invoicing their U.S. and Chinese customers in euros. There might be a big pitfall to this strategy though. If currency fluctuations leads to the euro increasing over the USD and RMB and the new rates are not immediately reflected in euro currency prices, Siemens is potentially exposed to economic risk as they might lose competitiveness\(^\text{116}\). If the euro on the other hand decreases, their customers will continue to purchase from Siemens at the lower prices measured in USD and RMB, and Siemens would therefore lose the potential upside. The

\(^{115}\)J.M. Campa, L.S. Goldberg, J.M. González-Mínguez, Exchange Rate Pass-Through to Import Prices in the Euro Area, Federal Reserve Bank of New York, Staff Report no. 219, 2005, page 21

\(^{116}\)B. Döhring, 2008, Hedging and invoicing strategies to reduce exchange rate exposure: a euro-area perspective, European Comission, page 4
approach of invoicing foreign customers in euros therefore has serious drawbacks, and might prove useless.

5.3.1.3.2 Competitive effect

In regards to pricing policy, the competitive effect is comprised by competitor substitution. If Siemens alter their prices, they are likely to either lose or gain market shares depending on the direction of the alteration. To which extend they will lose or gain market shares depends on several factors that we will review.

A higher seller concentration and homogenous products would mean price changes introduced by Siemens would have a greater effect on their market share\(^\text{117}\). Seller concentration and the degree of differentiation are therefore important factors to consider before deciding on price changes. As mentioned before Siemens’ businesses are largely characterised by high levels of technology, engineering and R&D. The business structure therefore probably presents high barriers of entry, and probably also a high level of differentiation. However, Siemens’ states that: “We operate in highly competitive markets, which are subject to price pressures and rapid changes: The worldwide markets for our products and solutions are highly competitive in terms of pricing, product and service quality, development and introduction time, customer service and financing”\(^\text{118}\), in their annual report, which indicates that only little or no pass through is possible. If Siemens has a large market share, they might be price leaders, which would increase the likeliness of them being able to pass exchange rate changes through to their customers. Higher global competition in the industries would on the other on a hand lead to less pass through.

The cost structures of competitors should also be considered. If competitors have currency compositions close to Siemens they will be exposed to the same effect of exchange rate movements. In this situation reactions to exchange rate movements are likely to be similar, and therefore the competitive effect will be diluted. If they have a different cost structure on the other hand, reactions must be expected different, and a competitive effect must be anticipated. In theory companies can hedge the competitive effect by aligning their cost structure with those of

\(^{117}\) http://www.tandfonline.com/doi/pdf/10.1080/13504850802297962

\(^{118}\) Siemens annual report 2012, page 118
their main competitors. However, in practice it will be close to impossible. The first challenge is that a company like Siemens operates in four different main businesses, and their competitors will be different from one business to another. If Siemens where to align their cost structure with their competitors, they would have to sub optimise each business, probably compromising the company-wide optimal hedge. Second challenge is the likeliness of more competitors existing in each business, each having different cost structures. In the end exchange rate movements will alter their competitive situation against at least one competitor no matter how Siemens organise their cost structure.

5.3.2  Production strategies for managing operating exposure

From the statement in Siemens annual report 2012: “Foreign currency exchange rate exposure is partly balanced by purchasing of goods, commodities and services in the respective currencies as well as production activities and other contributions along the value chain in the local markets”\(^\text{119}\), it can be concluded that Siemens use sourcing of inputs and plant location as hedging tools. In the following we will elaborate on how to incorporate the strategies into a business, and which factors to consider before doing so.

5.3.2.1  Diversifying operations

Siemens could choose to go into operations that offset their present net cash flow of foreign currencies. As Siemens is exposed in the USD and RMB, Siemens could start an import business, selling products from the US and China in the euro area. This might lead to going into businesses where they have no core competences, and is therefore a doubtful method to use. For this reason we will not go further into this option.

5.3.2.2  Diversifying sources of input

By purchasing larger parts of raw material and semi-finished goods from the U.S. and China, or at least from companies that have cost base in USD and RMB, Siemens can offset parts of their USD and RMB net cash inflow. Due to a high correlation between the two currencies, Siemens can pursue country specific advantages and let currency nomination of costs be a secondary

\(^{119}\)Siemens annual report 2012, page 203
parameter, as long as they are aware that the correlation might change in the future. Siemens could also negotiate procurement contracts to be settled in USD and RMB with suppliers who do not have cost base in USD or RMB, but this strategy might have some drawbacks as suppliers would demand compensation for their risk, and in case of significant long term exchange rate movements, the new market conditions would end up being reflected in supplier prices.

5.3.2.3 Facility location

An obvious consideration when talking cost base is the location of production plants, administration offices, R&D centres etc. By locating all or some of their facilities in the U.S. or in China, Siemens can alter their cost base and thereby their currency exposure. But while locating facilities in specific countries to manage the cost base might eliminate parts of the currency exposure, the strategy can incur other significant costs.

There are many factors to consider when choosing location. Factors such as labour costs and infrastructure will probably be of importance when deciding locations for production plants, while the decision of where to place of R&D facilities should probably be based on the availability of relevant technical expertise. Low labour costs and high availability of technical expertise might not be readily available at the same place, which might lead to considerations of separating R&D facilities from production. Being in rather technical business areas, Siemens might need to choose R&D locations near the well accredited universities or science centres. Efficient R&D might also depend on integration with production, and separating the R&D and production facilities might lead to higher costs in systems for communication and information and infrastructure.

Also general economic factors must be considered. Siemens must for example be careful before moving production to China. As described in section 3.2 about Chinese monetary policy, the Chinese Yuan Renminbi is potentially undervalued and facing upward pressure. This could lead to an increase in the RMB over the EUR, in which case it would be unfavourable for Siemens to have a larger cost base in RMB. Also the inflation level in China surpasses that of the Eurozone and U.S. This means that higher increases in salaries and some costs must be expected in the years to come. As the PPP does not seem to hold, see section 3.5.1 on inflation, exchange rate movements cannot be expected to offset the higher inflation rates. The costs in RMB would therefore have a
negative impact on Siemens’ profits measured in euros. So in light of elevated risk of an increasing RMB, offsetting their net currency inflow from China might not be desirable at all.

To address the competitive effect, Siemens could locate facilities to mirror their competitors cost bases, but as mentioned earlier this might prove impossible for Siemens due to a large number of competitors in their four different businesses. And with the formerly mentioned considerations when choosing locations, choosing superior locations could bring competitive advantages superseding the competitive setback exchange rate movements might bring. While exchange rate risk is important, it is more important to keep focus on core business and not compromise the foundation of it.

In many instances, Siemens might not have an actual choice when deciding on plant location. A good example is their energy business where windmills are a part of their product portfolio. Gears and the control system might be produced and shipped to a final destination. On the other hand the tower and the wings needs to be produced very close to where they are meant to be put up, as the costs incurred when transporting them would be severe. Also areas such as administration can be hard to move, as local expertise might be necessary in handling local government requirements such as tax matters.

5.3.2.4 A strategy of flexibility

Natural hedging involves creating a flexible structure of the company, which makes it possible to exploit exchange rate movements effectively. In an optimal situation the firm should purchase input wherever it is cheapest, produce wherever it is cheapest, sell its products wherever they can achieve the highest price and so forth. This section will look closer at some of the aspects of adding flexibility to a corporation.

5.3.2.4.1 Flexibility in Sources of input

By building relationships with a number of suppliers located in the different currencies – some in both US, China and the euro area – Siemens might be able to utilize exchange rate fluctuations by always placing their orders at the suppliers located in a low-currency-rate country and therefore

120 Jeanette Capel, A Real option Approach to Economic Exposure Management, page 87
with the most favourable prices. The drawback of this strategy is the costs incurred in switching suppliers, and probably also an impairment of supplier relations due to a lack of supplier relationship management. To maintain relations to more suppliers, a corporation could guarantee them a minimum level of orders, but as only one of them can be the cheaper one, this would mean that the company pays too much for some inputs. In this situation, these costs can be considered as the costs of maintaining the flexibility. The fact that most commodities are priced in USD on the world market limits the extent to which Siemens can hedge using alternate suppliers, but as labour costs can be significant parts of the cost of goods, the strategy might still lead to potential savings.

Figure 18 illustrates how sourcing from multiple suppliers based in different currencies might prove beneficial. The bell curve is generated by simulating 20,000 normally distributed exchange rates, using the present EUR/USD rate (at 26th of April) as fix rate and a standard deviation derived from monthly EUR/USD rates since 2009. The linear costs curves represent the costs of buying materials from suppliers, assuming that the unit cost will not change regardless quantity purchased. In the example the monthly amount of procurement is equivalent of 20 million EUR at present exchange rate, and at the present exchange rate the cost of purchasing the goods from a euro area or US supplier is the same. The USD cost of buying in US is therefore $1.3024 \times 20,000,000 = 26,048,000$ USD, and the EUR cost equation of purchasing in US is $26,048,000/FX$. The intervals on the horizontal axis are the monthly standard deviation in the EUR/USD exchange rate.

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Jeanette Capel, A Real option Approach to Economic Exposure Management, page 101
As can be seen from figure 18 the intersect between the cost curves is at the present exchange rate EUR/USD 1,3024. Any exchange rate change will make purchasing from either the US or EU supplier more favourable than the other, as it will be a deviation from the present equilibrium.

If Siemens at the moment purchases from their euro supplier, an increase in the euro over the dollar will make it favourable to switch to the US supplier. The cost savings are represented by the green and red area to the right of the cost curve intercept. The opposite goes if the dollar strengthens over the euro. Here the cost savings by sticking to the euro supplier is represented by the green and red area to the left of the intercept. In this situation, the average saving from being able to switch from a euro based supplier to a USD based supplier amounts to approximately TEUR 410, while the average saving from being able to switch from a USD based supplier to a EUR based supplier amounts to approximately TEUR 470. The savings are calculated from the 20.000 simulated exchange rates, where the costs of buying from an EU and a US supplier are compared and the average saving calculated.

If switching costs of 1 million euros are introduced, thresholds need to be set up. In this example, thresholds are equivalent to +/- 1 standard deviation, meaning that Siemens will not switch supplier unless the exchange rate moves more than 1 standard deviation away from the intercept. Therefore, a switch will only occur when the exchange rates go beyond the EUR/USD exchange rate range of 1,2311 – 1,3737, which is indicated by the red-area in figure 18. As the bell curve is a
normal distribution probability curve, exchange rates will stay within the mentioned range approximately 68% of the time, given that the historical standard deviation is actually an unbiased estimator for the future exchange rate development. In this situation spending money on building relationships with more suppliers could easily become profitable. We assume an equal chance of both the EUR of USD rates to increase in value, and with a 32% probability one of the rates will increase enough to make a switch profitable. From the example we have made calculations showing that the average saving from being able to switch to a euro supplier from a US supplier is approximately 132 TEUR while the average saving of being able to a US supplier from a EU supplier is approximately 84 TEUR. If relationship management can be done cheaper than this, having flexibility in the sources of input is profitable. As this strategy serves as hedging of the positions that would have been with only one supplier, saved hedging costs could be added to the savings if found appropriate. The savings are calculated from the 20,000 simulated exchange rates, where the costs of buying from an EU and a US supplier are compared while including the restrictions about thresholds and switching costs.

As there are no indications that exchange rates are mean reverting, a change in the rates must normally be assumed to be permanent. Therefore the new exchange rate should serve as a new fix point in future assessments when choosing suppliers. This is illustrated by the red bell curve (EUR +5.6%) in figure 19, where the only difference from the blue bell curve is that is generated from a mean euro appreciation over the dollar of 5.6%, but the same standard deviation.
In this new situation is clearly favourable to purchase from a US supplier and the euro needs to depreciate a lot before a change of suppliers is favourable. In this latter example, spending money on building relations with EU suppliers might not be profitable, as the chances of the exchange rate moving into the “green zone” where both the euro supplier becomes more favourable and the switching costs are justified are small. For a switch to EU suppliers to be favourable, the EUR/USD rate must drop to 1.2311. As this point is two standard deviations away from the new mean, the probability of this happening is down to 2.5%. The advantage is therefore limited, and can probably not justify the cost of maintaining more supplier relationships. It should be noticed that the mean of the probability curve is a dynamic measure as mean reversion cannot be expected. Also the cost equilibrium is a dynamic measure, which can move separate from exchange rates e.g. if labour costs in one country increases and leads to price increases in one country over another.

5.3.2.4.2 Flexibility in plant location

As it is practically impossible to mirror competitors cost bases, Siemens could pursue an opportunistic strategy of adding flexibility to their production to take advantage of exchange rate fluctuations. By building production plants in several countries, Siemens can switch production
from one country to another when exchange rates moves from being in favour of production in one country to another. The possibility of producing in either e.g. the US or Germany is in effect a real option, and the option price is the establishment cost they spent making switching possible\(^{122}\). The costs are obvious, as the flexibility requires permanent excess production capacity. If economy of scale is only accomplished at high production levels, or if the cost of switching from one plant to another is high, the strategy might prove unprofitable. Moving production of Siemen’s more sophisticated products would be hard, and switching cost associated with it would be high. It is doubtful whether the skilled workers would be willing to travel to other countries and accept new wages, and it would be difficult to replace them. In addition, building more production facilities with advanced equipment is more expensive than building more production facilities with less advanced equipment.

Consider an example where a production plant in Europe is a necessity, but Siemens can choose also to build a production plant in the US. The assumptions behind the situation are presented in table 15.

<table>
<thead>
<tr>
<th>Variable costs - Cost per produced unit, including shipping costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>In euro area:</td>
</tr>
<tr>
<td>In the US:</td>
</tr>
<tr>
<td>1.000,00 EUR</td>
</tr>
<tr>
<td>1.231,05 EUR</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Fixed costs- Monthly cost of running production plants</th>
</tr>
</thead>
<tbody>
<tr>
<td>Production plant only in the euro area</td>
</tr>
<tr>
<td>6.000,000 EUR</td>
</tr>
<tr>
<td>Production plant in euro area when another in the US</td>
</tr>
<tr>
<td>4.000,000 EUR</td>
</tr>
<tr>
<td>Production plant in the US when another in the euro area</td>
</tr>
<tr>
<td>4.924,211 USD</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Switching costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>There are no switching costs for simplicity of the illustration.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cost equations in EUR</th>
</tr>
</thead>
<tbody>
<tr>
<td>FX = EUR/USD rate ; PO=Production output in units</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Production plant only in the euro area</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.000*PO+6.000.000</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Production plants both in the euro area and in the US</th>
</tr>
</thead>
<tbody>
<tr>
<td>Range EUR/USD 0-1,2311</td>
</tr>
<tr>
<td>1.000*PO+4.924.211/FX+4.000.000</td>
</tr>
<tr>
<td>Range EUR/USD 1,2311-∞</td>
</tr>
<tr>
<td>1.231,05/FX*PO+4.924.211/FX+4.000.000</td>
</tr>
</tbody>
</table>

Table 15, Assumptions behind natural hedging example

\(^{122}\) Jeanette Capel, A Real option Approach to Economic Exposure Management, page 89
The variable costs include all costs, such as materials, labour costs, indirect productions costs and shipping etc. The fixed costs include all fixed costs such as financing, depreciation and administrative costs etc. Fixed costs for only having a production plant in Europe is higher than if Siemens also builds one in the US, as no reserve capacity is needed, and some processes need not to be done twice anyway.

Figure 20 illustrates how having two production plants in under the assumptions informed in table 15 can be advantageous in light of fluctuating exchange rates.

The bell curve is generated similarly to the one in the section about flexible sources of input, and the intervals on the horizontal axis are also still the monthly standard deviation. The more linear curves are the cost curves at different production outputs for two different production strategies – production only in the euro area or production in both the euro area and US. The cost curves are the picturing of the cost equations presented in table 15. Looking at them it is clear that the cost curves are functions of both the level of production output and the EUR/USD exchange rate. From the cost equations it can be seen that production will take place in the euro area plant at an EUR/USD exchange rate under 1.23105, while production at an EUR/USD over 1.23105 will take place at the US plant.
Assuming that Siemens plans to produce exactly 32.509 units the coming month, having production plants in both the euro area and the US or only in the euro area have the exact same cost of 38.5 million EUR. Should the EUR increase over the USD, having 2 plants become more profitable, as the USD costs are constant while the EUR value of it are reduced. If the USD increases on the other hand, production will take place in Europe at the same variable unit cost as in the scenario with only a euro area plant, but the costs of having an extra plant in the US still has to be financed.

Also output affects the profitability of having an extra plant in the US. As the production price is cheaper at the current EUR/USD rate, a larger production will increase the value of producing in the US. On the contrary, a small production will reduce the benefit of having lower variable unit prices. If exchange rates dictates production in the euro area, output level has no say in extra costs as only fixed costs are different in that situation.

Looking at figure 20, the areas between the cost curves painted green represents the net cost savings by having a US production plant, while the red area represents the net extra costs. It is clear that the savings supersedes the costs at a production output at 32.509 units, while the opposite goes when production output are at 15.254 units and 9.503 units respectively. However, the bell curve represents the probability curve, and expectations of savings and costs must also be taken into consideration when assessing the profitability. From the example we have made calculations based on the 20.000 simulated exchange rates and the cost functions, indicating that the average saving from having a production plant in the US at an output of 32.509 units is approximately 61 TEUR. At production outputs of 15.254 units and 9.503 units the calculated average savings are TEUR -923 and -1.250 TEUR respectively. While the negative outcomes intuitively seems unfavourable, one must keep in mind that the cost of hedging Siemens monthly USD cash flows using an option amounts to TEUR 1.403 as shown in section 5.2 about financial hedging.

The example illustrates that larger price differences, larger production levels and higher exchange rate volatility increase the advantage of having flexibility in production. As both production level, cost price development, and exchange rate levels, volatilities and distribution may be unknown factors, there are great uncertainties associated with the calculations and conclusions. The results
of macroeconomic analysis must be included in the considerations to assess these factors, but this will be elaborated later in this thesis.

5.3.2.4.3 Considerations about flexibility

The speed with which Siemens can adjust their production to fit new exchange rates and take advantage of currency movements is of importance, as is the speed with which they can switch suppliers. It takes time to switch suppliers and make new production plans and therefore it will take some time to adjust, if foreign exchange rates change. We call this adjustment time and the lower the adjustment time, the better Siemens will be able to utilize exchange rate volatility by switching to cheaper production sites or cheaper sources of input\(^{123}\). Fast adjustment procedures therefore lower Siemens exchange rate risk and raise its cash flows.

In general we can say that more uncertainty increases the value of flexibility\(^{124}\). Siemens save money every time they change supplier or move production from one plant to another, and in more volatile markets this will happen more often. However, it is important to consider the cost associated with switching. If exchange rates change, it might seem beneficial to change production to another location or to switch sources of input immediately. In light of how volatile exchange rates can be, the consequence of reacting immediately can be constant switches forth and back, incurring switching costs every time. If a strategy of flexibility is implemented, Siemens should therefore set up thresholds triggering the changes in productions or sources of input. Changes in production or source of input should only be made if exchange rates move above or below certain points, where the costs of switching can be justified by the savings in exchange rate differences. The introduction of thresholds taking switching costs into account would involve a “wait and see” zone where they should not alter their production or purchase strategy. The higher the exchange rate volatility and adjustment costs, the further the thresholds should be set above / below the point where a change in production or sourcing of input initially seems profitable\(^{125}\).

\(^{123}\) Jeanette Capel, A Real option Approach to Economic Exposure Management, page 97
\(^{124}\) Jeanette Capel, A Real option Approach to Economic Exposure Management, page 101
\(^{125}\) Jeanette Capel, A Real option Approach to Economic Exposure Management, page 102
Adding flexibility limits downside while preserving upside. This way it both lowers risk and increases expected cash inflows. The costs of adding the flexibility must therefore be compared to both the money saved on alternative hedging activities and the probable value of an upside scenario.

5.4 Main considerations and implications of hedging
In this section main advantages and concerns about hedging possibilities are summarised, and suggestions to risk management given the current situations in markets and currencies are presented.

5.4.1 Pros and cons on financial hedging
Financial hedging offers a fairly simple way of eliminating exchange rate risk. Foreign currency cash flows can either be converted to home currency cash flow by forward contracts, swaps or money market hedge, or downside alone can be eliminated using options. Financial instruments does not need to be incorporated into the strategy of the corporation, but can be handled solely by the financial department as hedging needs arises. The simplicity of the instruments is one of the main strengths financial instruments have.

While financial hedges offers easy ways of hedging cash flows, banks or other financial partners charge commission when entering agreements. This means that companies has to pay money to reduce their risk, and chances are that they actually end up having paid money and at the same time lose an upside outcome of exchange rate movements. Also the necessity of knowing the money amount and time horizon in advance puts a limit to the use of financial instruments.

While the price and information required to use financial instruments is a clear downside, an even bigger concern is the lack of coverage. While financial instruments can cover potential losses on single transactions fully, they perform badly in hedging operating risks. Loss of competitiveness is not covered, and as was shown in the section “Measuring operating risk” this can be significant.

5.4.2 Pros and cons on natural hedging
For a multinational corporation management of exchange rate risks is not only a matter of financial decisions for the CFO. Natural hedging includes considerations about plant location and marketing strategy, and decisions about it should be part of a long term strategy incorporated by
top management. Many considerations about the markets the company operates in need to be considered, as placing a production plant in a country with high inflation or undervalued currency can deteriorate future earnings.

From the thesis we can conclude that operational risk can have a huge impact on a company’s cash flows and market value. We can also conclude that it is difficult to hedge, as offsetting cash flows does not mitigate the threat of competitors gaining competitive advantages in case of unfavourable exchange rate movements.

Adding flexibility both reduces the risk of unfavourable exchange rate movements lowering the value of cash flows from foreign operations. At the same time it eliminates the threat of competitors gaining competitive advantages. For this reason having flexibility seems to be the only way to fully hedge exchange rate risks, and a welcome side effect is raising expected cash flows by taking advantage of the exchange rate movements. However, cost of having flexibility might be significantly more expensive production or compromising core competencies by impairing R&D or quality of products or services. In this case the price tag might be insurmountable. Whether operational flexibility is profitable or not dependents on factors such as volumes produced, adjustment time, switching costs and exchange rate volatility. A clear recommendation of pursuing this strategy is therefore not possible to make.

While natural hedging offers long term hedging of unknown cash flows, it is not suitable for controlling short term risk, as there is some adjustment time and switching costs connected to with approach. Financial hedging on the other hand can hedge short term known cash flows due to their simplicity, but works poorly for long term hedging, and might be an expensive long term solution as well. We therefore consider the use of financial and natural hedging to be complements rather than substitutes, which is also in line with prior studies in the area.\textsuperscript{126}

In table 16 suggestions for Siemens use of financial and natural hedging are made on both long and short term basis.

\textsuperscript{126} Allayannis et al. Exchange rate hedging: Financial versus operational strategies, page 394
Table 16, Summary of hedging possibilities

<table>
<thead>
<tr>
<th>Hedging</th>
<th>Short term</th>
<th>Long term</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial</td>
<td>Hedge transaction risks using options to have downside protection, but not eliminating the expected increase in the USD and RMB over the EUR. Forwards offers a cheap way of hedging short term exposure, but eliminates upside potential. Alternatively it can be considered leaving cash flows from US and China unhedged to take advantage of expected increases in the currencies over the euro.</td>
<td>Financial instruments should not be used to hedge on a long term horizon. Using financial instruments to mitigate unknown cash flows might even create more volatility in earnings rather than lowering volatility.</td>
</tr>
<tr>
<td>Natural</td>
<td>Natural hedging can be used to offset revenue and costs, but due to adjustment time is not suitable for short term hedging. We expect high inflation in China and an appreciation of the Yuan, meaning that increasing production in China can lead to unexpected rise in costs in the short run.</td>
<td>Natural hedging should be used to create flexibility, making corporations able to take advantage of currency movements and thereby increase earnings. Reducing switching costs and adjustment time is a crucial part of making operational flexibility profitable. Firms must be careful not to compromise core competencies or quality of products and services in the process of adding flexibility to their organisation.</td>
</tr>
</tbody>
</table>

Due to the conclusions from exchange rate fundamental analysis, we see a strengthening of the US dollar over the euro in the coming years as a likely scenario. To take advantage of this we believe Siemens should consider hedging short term positions using options, or even leave some US dollar cash flow unhedged. Reasons not to do so could be the fundamental imbalance we see on the US balance of payment indicating that US dollar is fundamentally overvalued, but as we do not believe that this imbalance will disappear in near future, the imbalance is probably only an issue in a longer perspective.

We also see considerable chances that the Chinese Yuan could appreciate against both the US Dollar and the euro. Along with increasing inflation, this can erode the benefits of having cheap production in China. As described in section about exchange rate fundamentals, the Chinese economy is growing at a pace surpassing both US and Europe, and we expect that China’s part of Siemens revenue will increase in future. Over the coming years the spread between costs in China
and Europe and US is expected to converge. Production sites can be established in China to increase costs to offset growing revenues, but it should not be done solely to have low cost production on a long time horizon. China advantage of low cost is likely to be reduced with their high inflation, and alternatives should therefore be considered. We find it likely that a company of Siemens size could take advantage of a flexible production in some areas. They already have a setup with production in numerous countries all over the world, and therefore they already hold the knowledge necessary to operate in foreign countries. We believe that the costs associated with creating a flexible production will be surpassed by the potential increase in earnings and money saved on alternative hedging activities.

5.4.3 Implications to hedging activities

The value of a firm is the net present value of all future cash flows, but due the uncertainty associated with predicting the future cash flows, uncertainty about the value of the firm also exists. By performing hedging activities, management can reduce uncertainty about future cash flows and thereby reduce the variance of the discounted cash flows. A question is if a reduction in variance of future cash flows is reason enough to manage exchange rate risks in a company? In the table 17 some pros and cons of performing hedging activities will be presented.

<table>
<thead>
<tr>
<th>Argument</th>
<th>Pro hedging</th>
<th>Con hedging</th>
</tr>
</thead>
<tbody>
<tr>
<td>Variance reduction</td>
<td>A reduction of the variance in the future cash flow will have positive impact on the net present value of the company, as a lower cost of capital in investment calculations can be justified when cash flows are more predictable.</td>
<td>By hedging the firm protects itself from losses from unfavourable exchange rate movements, but will often at the same time give up the opportunity of a gain in case of favourable movements in exchange rates. As hedging does not come for free, management has to ask themself if what is gained by entering hedging activities justify both the costs and giving up potential up-side outcomes.</td>
</tr>
<tr>
<td>Management vs. investor risk-management / Covenants</td>
<td>As hedged cash flows are less volatile than unhedged, unhedged corporations can easier hit certain thresholds triggering covenants. As this increases the risk of financial distress, hedging can be said to prevent financial distress. Investors cannot handle this risk themself, and</td>
<td>It can be argued that shareholders handle idiosyncratic risks better themselves. If investors believe exchange rate risks should be reduced, they can do it themselves by e.g. diversification. As exchange rate risk management does not increase future cash flows, but consumes firm resources, the net effect of hedging</td>
</tr>
</tbody>
</table>
therefore management should enter hedging. activities in this light will be a decrease in firm value.

| Stockholder base | Siemens is a euro-nominated stock, and investors purchasing the stock are aware of this. The motivation of buying a euro nominated stock might be based in euro prospects or it might be to diversify portfolios internationally. Regardless the motivation, stockholder expect euro-income, and hedging helps achieving this. | Being a listed and global company, Siemens probably has shareholders from many countries. While it for euro shareholder might be an advantage that Siemens hedges their income in euro, it might be a disadvantage for their foreign shareholders. Whether hedging their income is good or bad for investors is therefore questionable. |
| Equilibrium theory | Disequilibrium’s might occur, in which case corporations are in better positions to exploit the opportunities and make selective hedges, taking advantage of onetime situations where management has clear expectations about the direction of the market. | The equilibrium theory, used in many fields of finance, suggests that the market will always be in equilibrium and that the currency market is a zero sum game. This means that the overall value of hedging will also be zero, and that resources should not be allocated to hedging activities. |
| Agency theory | Management might have a comparative advantage over the single investor, because they have more insight and knowledge about the company. | Due to less diversification, management tends to be more risk averse than investors. Therefore they will not act rational in order to maximize the value of the firm. |

Table 17, implications on hedging

As can be concluded from table 17, whether hedging creates more value than the resources spent on hedging activities is not obvious from a theoretical point of view. From Siemens point of view though, we believe that the risks associated with exchange rate movements are significant, and can possibly deteriorate their foreign operations. While some investors might be diversified, we cannot assume this is the case for majority of shareholders, and therefore our assessment is that hedging is necessary.

5.5 Part conclusion

This part of the thesis aimed to answer main question number three:

*How can exchange rate risks be managed?*

Basically two approaches to hedging exchange rate risk exists; financial and natural hedging. In a historical perspective, both for Siemens and in general, it seems that financial hedging has
increased with the globalization. In recent years, natural hedging has gained more interest from Siemens and corporations in general. From this it can be concluded that hedging exchange rate risk is of increasing importance.

From analysis of the two different hedging methods, we find that the risks of single contracts or transactions or are optimally managed with financial instruments, while operating exposure and continuous transactions need to be managed through natural hedging.

Financial hedging tools bring a number of possibilities fitting different kind of approaches to hedging. The main structural differences in financial instruments are time horizons, limitation of upside and price. If clear expectations about future development are held, like with the undervalued RMB, options might be the preferred instrument as it only limits downside.

Natural hedging makes corporations able to offset revenue with costs, and even take advantage of exchange rate movements to increase profits if operational flexibility I incorporated. The advantage of having flexibility depends on factors such as exchange rate volatility, switching costs and economy of scale. It is important to remember that while natural hedging offers many advantages, companies must be careful not to compromise core competencies or the quality of products and services in the process of matching costs and revenues across borders.

In the current state of the economic regions; China, US and Europe, we see indications suggesting that the US Dollar and Chinese Yuan in particular could increase over the euro over the coming years. Furthermore we believe that higher inflation in China could lead to eradication of the lower costs connected with production in China. Establishing production facilities in China should therefore only be done if the advantages withstands even after an increase in the RMB and increased salary levels.

Exchange rate management is not limited to considering exchange rate developments. Factors such as an alteration of demand, competitive changes, new technologies, political intervention etc. need to be considered as well. These factors can both lead to exchange rate fluctuations on the macro level, but also an alteration of Siemen’s exchange rate exposure on the micro level. Both are equally important from the perspective of a company managing their exchange rate risk.
6 Conclusion

The main purpose of the thesis was to analyse the implications of exchange rates for companies doing business globally. Focus was on the currencies of the three biggest markets in the world; the US dollar, the Chinese Yuan Renminbi and the euro, and Siemens has been used for illustrative purposes and examples throughout the thesis.

The implications of exchange rates have been addressed by answering three main questions, which have been answered separately. For this reason separate conclusions will be presented here, followed by a joint conclusion to summarise the main points addressing the overall purpose of the thesis.

What are the characteristics of the currencies and markets Siemens operate in?

A historical review of the exchange rates was conducted, explaining the reasons behind major currency fluctuations in the past, and the historical monetary policies of the three economic regions; the Eurozone, the US and China.

Through an analysis of present monetary policies it could be concluded that while the Federal Reserve and the ECB does not intervene in exchange rates, the Peoples Bank of China peg the Chinese Yuan Renminbi primarily to the US dollar. Recent years the net effect of the peg has been an undervalued Yuan Renminbi towards both the US dollar and the euro. Due to significant upward pressure on the Yuan Renminbi and high debt levels in China, it is doubtful whether People’s Bank of China can maintain their peg at the current exchange rate. While neither the Federal Reserve nor the ECB intervenes directly in exchange rates, they have both implemented a loose monetary policy to stimulate economic growth making it even harder for PBoC to maintain the peg against the dollar. The euro and the US dollar are both floating currencies, and the exchange rate is mainly determined by the spread in interest rates set by the Federal Reserve and the ECB. A simple correlation calculation show a coefficient of 0,6 between the interest rate spread and the exchange rates.
Analysis of macroeconomic factors such as GDP levels and GDP growth, inflation and government debt levels reveals significant differences between China on the one side and US and the euro area on the other side. Higher GDP growth makes China an attractive market, while a higher inflation level and a potentially undervalued RMB raise the question of whether China can remain competitive as a low labour country in the long term. Government debt levels are very high for both the US and the euro area, and although it was not statistically proven the debt levels seem to have caused increased volatility in the exchange rates, where especially the euro debt crisis has been of interest recent years.

By calculating correlation coefficients and conducting multiple regression analyses, the explanatory power of macroeconomic factors on exchange rates was tested. Aside of ECB and Fed’s interest rate spread, correlation coefficients came out very small and statistically insignificant. Using macroeconomic factors as indication for future exchange rate development is therefore not possible. However, from the analysis of both monetary policies and macroeconomic factors, indications of an undervalued RMB and a strengthening of the US economy were found, suggesting that the RMB and USD might increase over the EUR in the near future.

What are the exchange rate risks for a German company doing business in the US and China, and how can they be measured?

The most important exchange rate risks associated with doing business in US and China is transaction and operating risk. While operating risk is very difficult to measure, transaction risk is quantifiable and therefore easier to make reliable measures of. The simple reason behind is that transaction risk is concerns known future cash flows while operating risk concerns unknown future cash flows.

Through estimations of Siemens cash flows from US and China it can be concluded that they have a significant exposure in both and the Chinese Yuan Renminbi, but the US dollar exposure is by far the largest one. On basis of their cash flows from US and China for the coming year, VaR analysis has been performed to measure their transaction risk. VaR measures were based on three different approaches; variance-covariance, historical method and Monte Carlo simulation. The
different methods did not differ significantly from each other and the one year exposure for Siemens were measured to be in the range of 458-500 million euros at a 99% confidence level. It must be emphasised that the measures assume normally distributed data, which might not be satisfied. The measures are based on historical data, and as history do not necessarily repeat itself, and in case of changing conditions the risk measures might prove useless.

Important drivers behind operating risk is considered to be factors such as; elasticity of demand, competition in the market, competitors cost bases, composition of costs and pricing policy. These factors differ from one corporation to another, which means that the measures must be adapted to fit a given corporation. We created a model taking elasticity of demand, pricing policy, costs and cost bases into account, and applied some figures to it to demonstrate how operating risk can affect cash flows and market capitalisation of a company. Through this operating risk proved to have significantly more impact on Siemens value than transaction risk. We must conclude that operating risk is very difficult to quantify though, which is supported by several studies earlier conducted by other people.

How can exchange rate risks be managed?

Exchange rate risk can be hedged using either by financial hedging or natural hedging. Corporations have found it important to hedge their exchange rate risk for years, but studies indicate they have had trouble in doing it properly. While financial hedging historically seems to have been the preferred method of hedging, natural hedging has gained more foothold in the recent years, both by Siemens and in general.

Financial hedging is a good tool for managing known transaction risks where cash flows are known, while it perform poorly in hedging operating where applying financial instruments can even increase cash flow volatility. Natural hedging can oppositely manage operating risk effectively, while short term transaction risks are difficult to hedge using this method.

By incorporating flexibility into procurement and production, natural hedging can allow for companies to take advantage of exchange rate movements in addition to mitigating risks. In order to assess whether flexibility will be profitable or not, factors like switching costs, adjustment time,
exchange rate volatility and economy of scale must be considered. In general operating flexibility is worth more, as uncertainty about exchange rates and other conditions increases.

In order to have a full picture of exchange rate management, fundamental conditions must be considered as well. The indications of increases in US dollars and Chinese Yuan over the euro should be considered in both long and short term management of exchange rate risk. Fundamental factors should also be considered when pursuing advantages through natural hedging, e.g. cost advantages in China could be eroded. It is important to remember that financial and natural hedging are complimentary rather than substitutes, and that both methods should be used simultaneously to address different risks.

**What are the implications of exchange rates for companies doing business globally.**

As was illustrated through risk calculations, exchange rate risks can have a huge impact on a company’s cash flows and market value. It is therefore important that companies consider the implications and take appropriate action. Hedging is far from an exact science though and a general recipe on how to hedge effectively cannot be made. The risk depends on the markets and currencies that a company operates in, and thorough knowledge about these factors is necessary to be able to address the risk in an effective manner. Companies must also have knowledge about both financial and natural hedging approaches, as the two hedging approaches are complimentary. Financial hedging is a great tool in short term hedging of known cash flows, while natural hedging proofs effective in long term hedging of unknown cash flows. Effective hedging therefore goes beyond the world of finance, as it must be incorporated into the general strategy of a company. It is therefore our advice that hedging is not fully delegated to the financial associates, but that top management is involved in creating viable solutions.
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Federal Reserve Bank of New York, no authors shown:
8 List of appendices

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Appendix 2: Calculations behind Siemens free cash flow from US dollar and Chinese Yuan

Appendix 3: Full list of VaR levels and overview of statistical output from variance covariance analysis

Appendix 4: Calculations behind economic/operating exposure

Appendix 5: Regression on Siemens and EURUSD