The Implication of the Exchange Rate Floor in Current Times:
The Swiss Experience

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Shuangshuang Chen

Department of Economics

University of California, Berkeley

Berkeley, CA 94704

chenshuangshuang@berkeley.edu

Under the supervision of Professor Barry Eichengreen

ABSTRACT

The economy of Switzerland has always surprised us with its strong export performance and low inflation rate, even during the Great Recession of 2008 and the European debt crisis. As a result, the monetary policies taken by the Swiss National Bank were carefully studied by many previous researchers. One featured policy was the exchange rate floor. With the announcement of the exchange rate floor, both in 1978 and in 2011, the Swiss National Bank became committed to limit the exchange rate fluctuations above a floor barrier measured by the number of Swiss Franc per Deutsche Mark (1978) or the number of Swiss Franc per Euro (2011). The effect of the exchange rate floor has been under debate for many years. This paper uses regression models to analyze its effect on Switzerland's export sector and inflation in current and subsequent periods. I conclude that this strategy was successful in the past and took on substantial role in improving the performance of the Swiss export sector while having minimal impact on inflation. My analysis is also in favor of its continuing performance in the near future.

Key words: Exchange rate floor, Export, Inflation, Swiss National Bank.

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1. Introduction

The announcement of the exchange rate floor of DEM/CHF (number of Swiss Franc per Deutsche Mark) in 1978 was considered a significant event after Switzerland adopted a floating exchange rate in 1973. The adoption of the floor successfully brought up the DEM/CHF exchange rate. However, during the 4-year period after the adoption of the floor, Switzerland experienced high inflation, which reached 7.4% in 1981. Some people argued that the exchange rate floor led to the economic problems in subsequent periods. In the current period, due to Switzerland's large current account surplus and low inflation rate, CHF is again treated as a safe haven. Between 2008 and 2011, CHF appreciated sharply against Euro (EUR) and against US Dollar (USD). This appreciation made the Swiss National Bank (SNB) believe that it posed "an acute threat to the Swiss economy" and carried "the risk of a deflationary development". Thus, on September 6, 2011, the SNB said in its press release that it would "no longer tolerate a EUR/CHF exchange rate below the minimum rate of CHF 1.20", and thus it would "enforce this minimum rate with the utmost determination" and would "buy foreign currency in unlimited quantities" (SNB, 2011).

The exchange rate floor announced in 2011 was a revisit of 1978's strategy. The possible outcomes of this strategy can thus be drawn from 1978's experience. The desirable outcome that the SNB wants to achieve is the end of CHF appreciation; however, it might have to sacrifice the current low inflation. The goal of this paper is to explore the possible consequences of the exchange rate floor with regression analysis, and to use the outcomes of 1978's exchange rate floor strategy to predict possible future outcomes of the similar strategy adopted in 2011. The paper finds that real effective exchange rate negatively affects export value, while currency depreciation has little effect on inflation. 1978's strategy was successful in a sense that it ended the appreciation of CHF, which further led to a better-performed Swiss export sector. The paper also finds that the inflation in the 1980's could not be attributed to the exchange rate floor adopted in 1978.

The paper is organized as follows. The next section introduces the historical background of Switzerland's monetary policy including the exchange rate floor in 1978. Section 3 provides some literature on the elasticity of exports and Quantity Theory of Money. Section 4 introduces two models, one discussing the effect of real effective exchange rate on export sector performance, and the other analyzing the relationship between money supply growth rate and inflation. Section 5 compares the situation in 1978 with that of the current period, and proposes the possible future outcomes of the exchange rate floor adopted in 2011. Section 6 analyzes the factors that bring down the exchange rate of CHF.

2. Historical Background and Motivation

The exchange rate floor announced in 2011 aroused much attention and heated discussion. In fact, prior to the announcement of the floor, the SNB intervened the foreign exchange market a few times in an attempt to end the appreciation of CHF, but without much success. In 2010, the SNB incurred losses of 21 billion francs after intervening in the currency markets to keep the Swiss franc from rising (Schober, 2011). However, the worsening of the European debt crisis continued to drive investors to save-haven currencies like CHF. The SNB failed to prevent CHF from appreciating.

The story seemed to be different this time around. The strong language in the SNB's statement seemed to convince the of the bank's determination. According to Alessandro Bee, currency strategist with Bank Sarasin, "the SNB is now completely committed. There is no going back. They will do everything to defend this. They have to resist the pressure. Otherwise, they can just close the SNB" (Ball, 2011). The surprise move prompted CHF to fall 8.2 percent against EUR in a matter of minutes and to lose 8.8 percent against USD (Garnham & Simonian, 2011). The market confidence in the SNB's commitment came from the fact that a central bank has more power to drive its currency down than to push it up since it can print unlimited amount of its currency to purchase foreign currencies if it wants to.

However, imposing floor carries inflation risks. The central bank cannot target both their exchange rate and inflation, and for Switzerland, the monetary base is almost 50% of GDP (the equivalent figure for America is 18%) ("Francs for nothing," 2011). A surge in monetary base might lead to higher inflation. Since the SNB took a similar action by imposing a floor on DEM/CHF back in 1978, it is worthwhile to look at the SNB's monetary policy history and to understand what happened before and after 1978 in order to better understand the current situation.

The SNB was established in 1907. Since then, it has been conducting the country's monetary policy as an independent central bank. Its primary goal is to ensure price stability, while taking due account of economic developments (Swiss National Bank).

Before 1973, Switzerland was in a fixed exchange regime. However, at the end of 1960s, the world was experiencing high inflation, and the SNB was not able to shield the domestic economy from high foreign inflation due to its commitment to the peg. Switzerland seemed to have suffered from inflation imported by both a direct price effect from abroad and by a liquidity effect from balance-of-payments surpluses (Allen, 1980). As a result, in 1973, the SNB switched to a floating exchange rate in an effort to control the high inflation in the country. At the end of

1974, the SNB adopted monetary targeting and set up targets for annual M1 growth rates as shown in Table 1.

Table 1. Annual monetary targets of the SNB between 1975 and 1979 (Rich, 2003)

Target for	Target Variable	Target (%)	Outcome (%)	Comments
1975	M1	6	4.4	Subsidiary monetary-base target
1976	M1	6	7.7	Subsidiary monetary-base target
1977	M1	6	5.5	
1978	M1	6	16.2	
1979	-	-		

With monetary targeting, the SNB successfully brought down the inflation rate from near 12% at the end of 1973 to around 1% at the beginning of 1978, as shown in Figure 1 below.

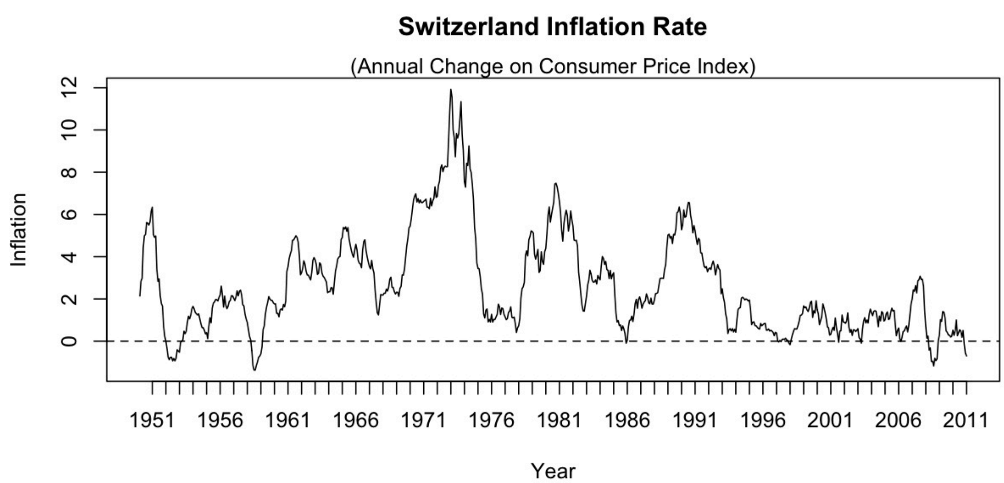

Figure 1. Inflation rate between 1951 and 2011

The low inflation caused large amounts of capital to flow into Switzerland. Between January 1973 and September 1978, CHF appreciated 44% against DEM and 134% against USD.

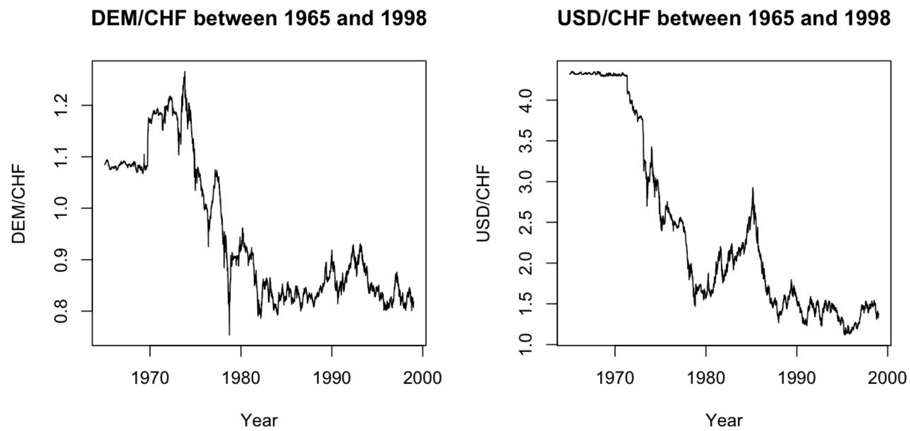

Figure 2. (a) DEM/CHF and (b) USD/CHF between 1965 and 1998.

At the same time, the export sector and the overall economy of Switzerland were performing well. Table 2 below illustrates Switzerland's export growth compared to other countries between 1973 and 1978.

Table 2. Cross-country comparison of exports of goods and services (annual % growth)

Country	1973	1974	1975	1976	1977	1978
Japan	5.2	23.1	-1.0	16.6	11.7	-0.3
Switzerland	7.9	1.0	-6.6	9.3	9.7	3.7
United Kingdom	12.3	7.3	-2.9	9.1	6.9	1.9
United States	18.8	7.9	-0.6	4.4	2.4	10.6
OECD Members	11.5	7.4	-2.7	9.3	6.0	5.9
World	11.3	6.3	-2.8	9.8	5.5	5.5

Source: Global Financial Data

Switzerland's exceptional export performance in 1977 resulted in intense appreciation pressure on CHF. As of September 30, 1978, the exchange rates of DEM/CHF and USD/CHF were 0.80 and 1.55 respectively. The overvaluation of CHF drove the SNB to worry about the country's export sector and economic growth. Therefore, in October 1978, the SNB announced an exchange rate floor, aiming to limit the DEM/CHF exchange rate above 0.8.

After the announcement of the floor, CHF depreciated against DEM and USD in later years. Theoretically, depreciation would cause an increase in export since the Swiss products became less expensive, especially in the short-run, when the price elasticity is likely to hold. However, the effect of the exchange rate floor on export was questioned since the Swiss export sector was performing well even with an overvalued currency.

Moreover, the inflation rate of Switzerland increased from 0.4% in October 1978 to 7.3% in October 1981. This phenomenon raised the question of whether this increase in inflation could be attributed to the exchange rate floor. There were many possible factors that the exchange rate floor could lead to higher inflation. First, if the SNB fulfilled its commitment to the floor by increasing the money supply, it might lead to high inflation. Second, if CHF depreciation stimulated exports, foreign reserves of the SNB would increase. The increase in foreign reserves meant an increase in money supply and thus resulted in demand-pull inflation. These two reasons were directly related to the money supply.

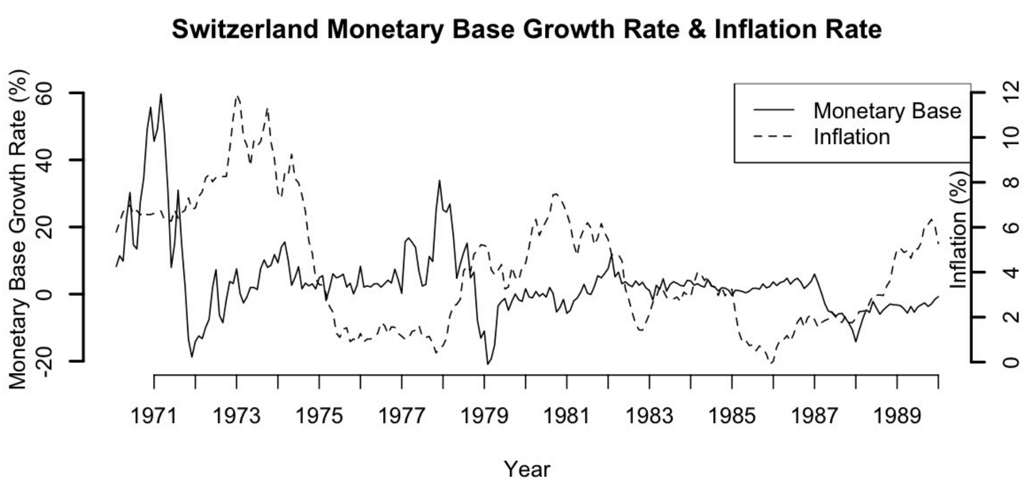

Figure 3. Switzerland’s monetary base growth rate and Inflation rate between (1971-1990)

In fact, as shown in Figure 3 above, the monetary base did increase in 1978. Whether this increase led to a higher inflation was analyzed quantitatively in Section 4.3 and quantitatively in Section 5.3. The third possible reason for an increase in inflation was related to an increase in import prices. The percentage by which import prices rise when the home currency depreciates by 1 percent is known as the degree of pass-through from the exchange rate to import prices (Krugman, Obstfeld & Melitz, 2011). Since imports were also part of the basket used to measure the price level, measures of inflation based on the basket would also rise (Hafer, 1989). A larger pass-through coefficient would result in a larger effect of depreciation on inflation. This pass-through effect is discussed in detail in Section 5.3.

3. Literature Review

3.1 Price Elasticity of Demand for Exports

Many previous efforts were devoted into analyzing trade elasticity. For the depreciation of the domestic currency to reduce the external deficit, the sum of export and import price elasticities (in absolute terms) must be greater than 1:

$$\varepsilon_x + \varepsilon_m > 1,$$

where ε_x is the price elasticity of demand for exports and ε_m is the price elasticity of demand for imports. This is known as the Marshall-Lerner condition. Hooper, Johnson, and Marquez showed (2000) that among G-7 countries, with exception for France and Germany, price elasticities for exports and imports satisfy the Marshall-Lerner condition. Tressel and Arda (2011) used similar methods but focused on analyzing Switzerland's price elasticity of exports between 1980 and 2011. They found that the real effective exchange rate negatively affected the same period's export volume. However, few papers have investigated the price elasticity of export of

Switzerland for the period before 1980. In fact, the data for the export at constant prices before 1980 are missing. As a result, the regression analysis in Section 4.2 uses the data of export at different prices and uses a similar formula used by Tressel and Arda (2011).

3.2 Quantity Theory of Money

An important theory that relates money supply and inflation is the quantity theory of money, descending from Copernicus and restated by Milton Friedman (Friedman, 1956). According to the theory, the following equation is satisfied:

$$MV = PQ, \qquad \text{(Equation 1)}$$

where M is the money in circulation, V is the velocity of money in transactions, P is the price level, and Q is the real income. After taking first derivatives of both sides of Equation 1 with respect to time t, we get

$$V\frac{dM}{dt} + M\frac{dV}{dt} = Q\frac{dP}{dt} + P\frac{dQ}{dt} \quad . \qquad \text{(Equation 2)}$$

Since MV=PQ, dividing the left side of Equation 2 by MV and dividing the right side of Equation 2 by QP gives: $\frac{dM/M}{dt} + \frac{dV/V}{dt} = \frac{dP/P}{dt} + \frac{dQ/Q}{dt}$, which is equivalent to

$$\frac{dP/P}{dt} = \frac{dM/M}{dt} + \frac{dV/V}{dt} - \frac{dQ/Q}{dt} \quad . \qquad \text{(Equation 3)}$$

Assuming that the velocity of money is constant over time, as Milton Friedman did, Equation 3 shows that the price level growth rate equals the money supply growth rate minus the real income growth rate. In other words, inflation is heavily affected by money supply growth rate and real GDP growth rate if this equation holds.

Real income growth rate can be approximated by real GDP growth rate. However, in reality, GDP data are available only quarterly rather than monthly. As a result, unemployment rate is used in my model. Okun's law postulates a negative relationship between change in unemployment rate and real GDP growth rate (Sögner & Stiassny, 2000), given by the equation:

$$w(U^{*} - U) = (Y - Y^{*}) / Y^{*} \quad , \qquad \text{(Equation 4)}$$

where U is the unemployment rate, Y is the real GDP, U* is the natural unemployment rate, and Y* is the potential real GDP. Since U* and Y* are hard to estimate in reality, the "growth rate version" of Okun's Law is used, and the relationship is (Cahill, 2006):

$$\frac{dY}{Y} = -wdU + \frac{dY^{*}}{Y^{*}} \qquad \text{(Equation 5)}$$

Assuming that the potential output is constant over time, we obtain the following equation:

$$\frac{dY}{Y} = -wdU \qquad \text{(Equation 6)}$$

Equation 6 indicates a negative relationship between inflation rate and change in unemployment rate. Combining Equation 3 and 6 gives an equation indicating positive relationships between inflation rate and money supply growth rate and between inflation rate and change in unemployment rate.

$$\frac{dP/P}{dt} = f\left(\frac{dM/M}{dt}(+), \frac{dU}{dt}(+)\right) \qquad \text{(Equation 7)}$$

The above equation is used as the foundation for analyzing the relationship between inflation and money supply growth rate in Section 4.3.

4. Methodology and Regression Analysis

4.1 Data Description

The yearly export and real effective exchange rate data are obtained from the World Bank website. The monthly closing values of CHF/DEM, CHF/EUR, CHF/USD exchange rates and the monthly CPI, M1 money supply, and monetary base data are obtained from Global Financial Data. Exports are measured at different prices. The real effective exchange rate is an index of an inflation-adjusted exchange rate used to measure a country's currency value relative to its trading partners. In the short run, currency appreciation causes this index to rise. The CPI base year is 2005. M1 money supply and monetary base are measured in millions of Swiss Francs.

4.2 The Effect of Exchange Rate on Export Sector

The main driving force for the SNB to adopt an exchange rate floor was to prevent the negative impacts that an overvalued currency could have on the Swiss export sector. The SNB's concern was well founded. Historically, Switzerland has been actively involved in trading with other nations, and its main trading partners are European countries, US, and Canada. The following graph shows Switzerland's export and import as percentage of GDP.

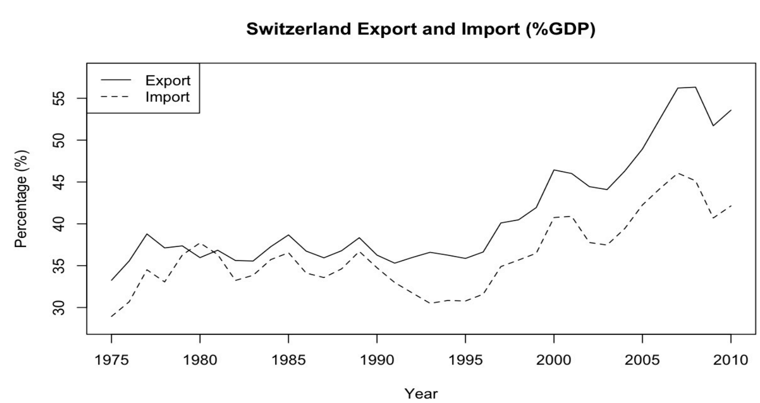

Figure 4. Switzerland export and import as percentage of its GDP

Even as early as 1975, Switzerland's annual export reached near 35% of its nominal GDP, and this number has been increasing over time. Another important fact that Figure 4 conveys is that Switzerland ran an export surplus for long periods of time, and the gap between export and import widened in recent years. Due to the significant contribution of export to GDP, if, as the SNB concerned, currency appreciation would negatively impact the performance of the export sector, this appreciation would negatively affect Switzerland's overall economic growth as well.

When analyzing the impact of exchange rate on export sector, I first adopt the following regression model:

$$Export_t = \beta_0 + \beta_1 \times EX_t + \beta_2 \times CPI_t + \varepsilon_t \text{ ,} \qquad \text{(Equation 8)}$$

where $Export_t$ denotes the total annual export value in Year t, EX_t indicates the real effective exchange rate, and CPI_t is one way to represent the annual price level. Ideally, I would want to use export volume, or export at a constant price. However, due to the lack of data before 1980, export value, or export at different prices are used. The domestic price level could thus have either positive or negative impact on export. On one hand, a higher price makes the domestic goods less competitive and results in a decrease in total export volume. On the other hand, however, the higher price also means more earnings for each export unit. The relationship between CPI and Export depends on whether the volume or the price effect dominates. Table 3 below summarizes the regression results.

Table 3. Regression results of Equation 8

Input Variable	Slope Estimate
Real Effective Exchange Rate	-3.5869 **
	(1.11300)
CPI	4.5695 ***
	(0.3705)
N=36; R-squared=0.8588; F-statistic=100.3	

The regression results confirm the SNB's belief: a higher relative real effective exchange rate negatively impacts the Swiss export sector performance. However, clear pattern is observed in the residual plot of the regression (left plot of Figure 5), which suggests that Equation 8 might not be an appropriate underlying model. The observed pattern could be explained by the fact that the relationship between CPI and export is not linear, as shown in the right plot of Figure 5 below.

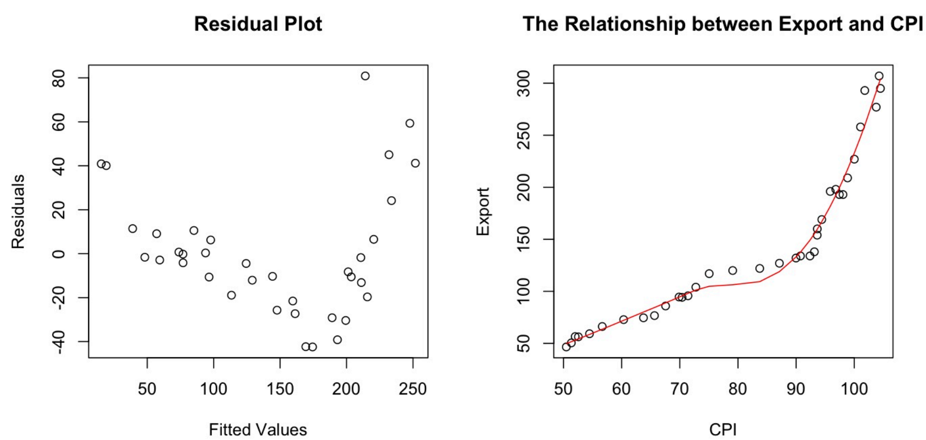

Figure 5. (Left) Residual plot and (Right) Plot of Export vs. CPI with loess curve fitted

Rather than linear, the functional relationship between export and CPI looks more quadratic. Therefore, I add the term $(CPI_t)^2$ to the original regression.

Furthermore, I would like to see if the exchange rate has any effect on the Swiss export sector in subsequent years; therefore, regression analysis with lags is also done. The revised form of regression now becomes:

$$Export_{t+i} = \beta_0 + \beta_1 \times EX_t + \beta_2 \times CPI_{t+i} + \beta_3 \times (CPI_{t+i})^2 + \varepsilon_t \text{ ,} \qquad \text{(Equation 9)}$$

where i denotes the number of years' lag. The regression results are displayed in Table 4 below:

Table 4. Regression results of Equation 11

Input Variable	Slope Estimate		
	0 Year Lag (i=0)	1 Year Lag (i=1)	2 Year lag (i=2)
Real Effective Exchange Rate	-1.97601 *	-1.17892	0.15131
	(0.87873)	(0.93248)	(0.96740)
CPI	-9.39975 ***	-9.62096 **	-10.39608 **
	(2.58333)	(2.73214)	(2.89759)
CPI^2	0.08732 ***	0.08700 ***	0.08999 ***
	(0.01606)	(0.01716)	(0.01834)
Number of Observations (N)	36	35	34
R-squared	0.9266	0.9131	0.9003
F-statistic	134.7	108.5	90.35

Note: number of * denotes level of significance: * p-value < 0.05; ** p-value < 0.01; *** p-value < 0.001

According to the results displayed in Table 4, while the real effective exchange rate negatively affects the export performance of the same year with statistical significance, its effect on subsequent years is negligible. Neither slope estimate of the real effective exchange rate in the regression analysis with 1-year or 2-year lag is significant at 5% significance level, a usual cut-off used to decide whether the change in endogenous variable is indeed caused by exogenous variables or due to chance error. The slope estimates of CPI_t and $(CPI_t)^2$ of regressions at lag 0, 1, and 2 are all significant at 1% significance level. Since CPI values for the period I analyze are mostly less than 100, the negative slope estimate of CPI_t dominates the positive slope estimate of CPI_t^2. As a result, volume effect rather than price effect dominates. This is consistent with many other researchers' findings (Bhagwati, 1978).

I notice that, however, there are some limitations of my slope estimates. Equation 8 tries to explain the change in export caused by the change in real effective exchange rate. But export can in turn affect real effective exchange rate. If the export of Switzerland increases due to reasons other than the real effective exchange rate, e.g., lower tariffs in destination countries, investors might become more confident in CHF, which could possibly lead to CHF appreciation. In fact, the appreciation of CHF in recent years was largely caused by risk-adverse investors' selection of save-haven currencies. Since nominal exchange rate appreciation is closely related to the increase in real effective exchange rate, especially for the short-run, export performance could positively affect the real effective exchange rate. That is too say, the estimated effect of real effective exchange rate on export in my model is in fact too small in magnitude.

4.3 The Effect of Money Supply Growth on Inflation

As shown in Figure 3 of Section 2, during the one-year period after the SNB adopted the exchange rate floor, the monetary base increased. The purpose of this section is to use regression models to assess whether the increase in money supply would lead to an increase in inflation. First, time series plots of CPI, monetary base, M1 money supply, and unemployment rate are obtained.

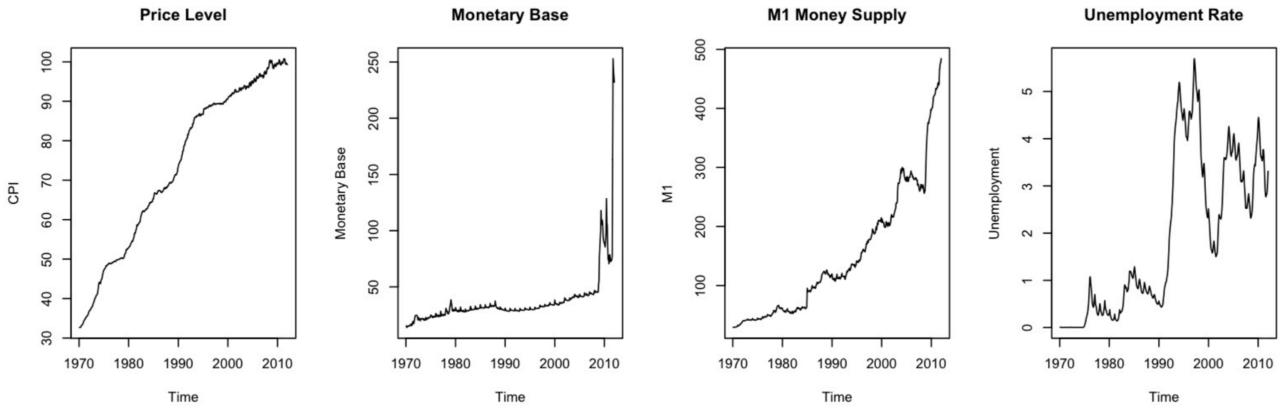

Figure 6. Time series pots of price level, monetary base, M1 money supply, and unemployment rate

All four variables increased in value over time, with unemployment rate fluctuating the most. The money aggregates had very dramatic increase around 2010 since the SNB injected liquidity into the financial system to prevent CHF from appreciating but without much success. If CPI is regressed directly on monetary base, M1, or unemployment rate, we might not get meaningful results, since CPI of time t depends on previous periods' CPI values.

Rather, as shown by in Section 3, inflation can be written as a positive function of both money supply growth rate and change in unemployment rate. Therefore, the primary model adopted is:

$$\frac{dP/P}{dt} = \beta_0 + \beta_1 \frac{dM/M}{dt} + \beta_2 \frac{dU}{dt} \quad \text{(Equation 11)}$$

Also, for any given variable X, $\frac{X_t - X_{t-1}}{X_{t-1}}$ can be approximated by $\log(X_t) - \log(X_{t-1})$. Thus, the following regression form is used:

$$\log(P_t) - \log(P_{t-1}) = \beta_0 + \beta_1 \times (\log(Mi_t) - \log(Mi_{t-1})) + \beta_2 \times (U_t - U_{t-1}) + \varepsilon_t \text{ , (Equation 12)}$$

where P is the price level, Mi denotes the money aggregate (M0 - monetary base; M1 - M1 money supply), U is the unemployment rate, and t-1 indicates 1 year before Year t. The use of one-year period is to exclude seasonal fluctuations. The following table summarizes the regression results.

Table 6. Regression results of Equation 12 (without time lags)

Input Variable	Slope Estimate
Monetary Base	-0.023153 ***
	(0.006298)
Unemployment	0.005098 **
	(0.001684)
N=492; R-squared=0.03918; F-statistic=9.97	
M1	-0.069632 ***
	(0.011567)
Unemployment	0.006925 ***
	(0.001691)
N=492; R-squared=0.08075 F-statistic=21.48	

From Table 6 above, it is clear that change in unemployment rate is positively correlated with inflation rate, though the effect is not very strong. A 1% increase in unemployment rate is associated with a 0.5%~0.7% increase in inflation. However, surprisingly, changes in both M0 and M1 supply lead to the movement of inflation rate in the opposite direction, which violates what my model (Equation 12) suggests. This could possibly be explained by the time difference. While the change in monetary base or M1 money supply is immediately measurable, it might take time for them have a significant impact on the actual price level. In addition, real-world data collection is subject to delay.

Considering the time lags, I revise my model as the following.

$$\log(P_{t+i}) - \log(P_{t+i-1}) = \beta_0 + \beta_1 \times (\log(Mi_t) - \log(Mi_{t-1})) + \beta_2 \times (U_t - U_{t-1}) + \varepsilon_t \text{, (Equation 13)}$$

where i=1,2,3, …, indicating the number of years' lag. The regression results are summarized in Table 7 below.

Table 7. Regression results of Equation 13 (with time lags)

Input Variable	Slope Estimate		
	1 Year Lag (i=1)	2 Year Lag (i=2)	3 Year lag (i=3)
Monetary Base	-0.009138	-0.026023 ***	-0.007350
	(0.006193)	(0.006233)	(0.006624)
Unemployment	0.012253 ***	0.013348 ***	0.005379 **
	(0.001625)	(0.001597)	(0.006189)
N	480	468	456
R-squared	0.1068	0.1444	0.02274
F-statistic	28.51	39.24	5.271
M1	-0.048336 ***	-0.041559 ***	0.047384 ***
	(0.011376)	(0.011641)	(0.012092)
Unemployment	0.013794 ***	0.013982 ***	0.003227
	(0.001643)	(0.001652)	(0.001712)
N	480	468	456
R-squared	0.1354	0.136	0.05221
F-statistic	37.36	36.6	12.48

Some take-aways from the regression results in Table 7 are summarized. First, the monetary base growth has almost no-effect on current and subsequent periods' inflation. The slope estimates are negative and have very small absolute values. Second, while negative relationships are observed between M1 supply growth and inflation at 1-year and 2-year lag, highly significant relationship exists at 3-year lag. The negative relationships can be attributed to the delay in data collection and chance error. The regression study conveys that it takes approximately three years for the growth in M1 money supply to affect the inflation. A 1% increase in M1 money supply of Year 1 is approximately associated with 0.047% increase in inflation of Year 3.

5. Discussion on the Implication of Regression Analysis

5.1 Similarities and Differences of the Two Periods

Despite the fact that more than thirty years have passed between when the SNB first adopted the exchange rate floor in 1978 and when this strategy was used again 2011, the two periods shared many similarities. From the beginning of both 1978 and 2011 to the months before the exchange rate floors were announced, CHF experienced very rapid appreciation against major currencies. The DEM/CHF exchange rate appreciated 19% between December 31, 1977 and September 30, 1978, while the EUR/CHF exchange rate appreciated 8% between December 31, 2010 and August 31, 2011. The rapid appreciation resulted in an overvalued CHF in both periods. According to the research done by Samuel Regynard (2008), the overvaluation of CHF relative to USD back in 1978 was similar to that in 1997. In 1997, the Big Mac prices in Switzerland and United States were $5.9 and $2.42 respectively, indicating a 144% overvaluation of CHF relative to USD. At the end of 2010, the Big Mac prices in Switzerland and United States were $6.19 and $3.73 respectively, indicating that CHF was 66% overvalued against USD.

In addition, in both years when the exchange rate floors were adopted, the inflation of Switzerland was low. The inflation of 1978 was only 0.73% and that of 2011 was -0.72%.

The situation in these two periods had differences as well. As shown by the bar chart below, while the 1978 period had relatively stable GDP growth, the 2011 period was characterized by volatility, with GDP growth rate fluctuating a lot due to the financial crisis.

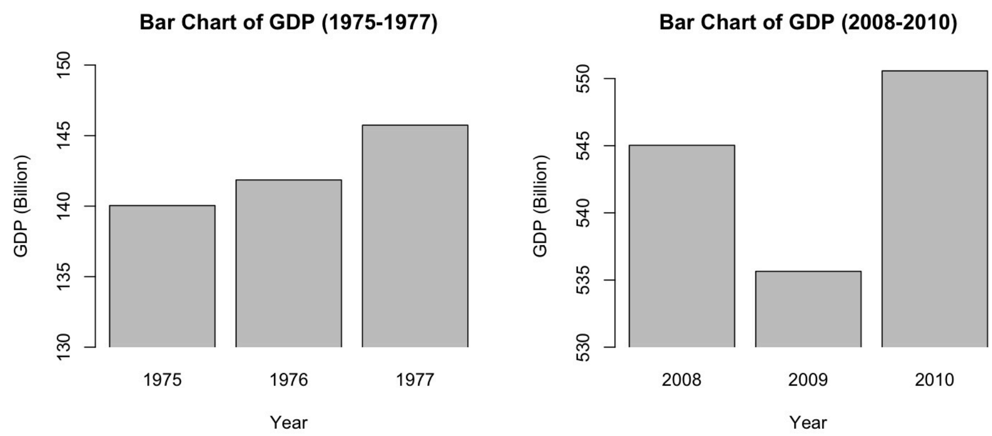

Figure 7. Bar Chart of GDP

Furthermore, export played a more important role in the Swiss economy in the current period than in the period of 1978. Compared with 1977, when export was 39% of GDP, the export reached 54% of GDP in 2010. The increasing significance of export sector in the whole economy justified the SNB's concern over the rising exchange rate of CHF.

5.2 Implication on Export and GDP

The rapid appreciation of the nominal value of CHF led to an increase in the real effective exchange rate in both periods. The real effective exchange rate increased from 84.94 in 1975 to 96.72 in 1978. With other variables held constant, the model (Equation 9 with i=0) predicts a 23.3 billion decrease in the Swiss total export during the three years. Similarly, the real effective exchange rate increased from 97.86 in 2008 to 107.50 in 2010, which is predicted to result in a 19 billion decrease in total export during the two years. However, while the growth rate of the Swiss export sector decreased significantly from 9.7% in 1977 to 3.7% in 1978, the current period's export growth rate was very high, reaching 8% in 2010. This exceptional export sector performance was inconsistent with what my model predicts. Auer and Saure (2011) provide a possible explanation. The unexpected export sector performance in 2010 could partially be attributed to the unique composition of the Swiss export basket. The Swiss export basket concentrated in sectors where demand contracted strongly during the crisis and rebounded subsequently. As a result, when the economy started to recover in 2010, the Swiss export sector had a boom year.

After the adoption of the exchange rate floor in 1978, the real effective exchange rate dropped from 96.72 in 1978 to 89.48 in 1981. 1978's strategy was successful in a sense that it successfully brought down the exchange rate and improved the performance of the Swiss export sector. My model delivers estimates that are consistent with those provided by other authors (Tressel & Arda, 2011), but it provides insight on export value rather than export volume. In reality, the increase in export value due to currency depreciation might be even larger due to the possible bias of my slope estimates. The same strategy in 2011 is likely to have similar impact in the current period. However, since 1978's CHF was more overvalued than 2011's CHF according to the Big Mac Index, the nominal exchange rate of CHF in the current period might not change as fast as before. Thus, the change in export due to the decrease in relative effective exchange rate might not be as significant as that in 1978. Nevertheless, due to the increasing significance of export sector in the overall economy, a similar change in export will likely to result in greater effect in the economy. In addition, with the current uncertainty of the European Debt Crisis, a strong export sector performance is especially important for the economic growth. As a result, the exchange rate floor strategy adopted in 2011 is likely to improve the performance of the Swiss export sector and help the Swiss economy fight against deflationary risks.

5.3 Implication on Inflation

My model predicts that monetary base growth has no significant impact on the inflation of current and subsequent periods; however, M1 money supply growth affects the inflation rate at a three-year lag. After the adoption of the ceiling in 1978, the monetary base grew from 27.5 million on September 30, 1978 to 29.3 million on September 30, 1979, while the M1 money supply increased from 57.7 million to 61.2 million in the same period. This increase in M1 money supply should be associated with approximately 0.12% increase in inflation with three-year lag according my model. However, while the inflation between September 1978 and September 1979 was 4.8%, the inflation between September 1981 and September 1982 reached 5.5%. This 0.7% increase in inflation could hardly be explained by the increase in M1 money supply. Further, the inflation rate peaked in 1981, which should be caused by the increase in M1 money supply between 1977 and 1978, the time before the adoption of the exchange rate floor. Therefore, the high inflation of the 1980s was likely to be caused by other factors. Stuart Allen (1980) showed that the historical inflation was also linked to domestic fiscal policy.

This is likely to be the current period's story as well. Between August 2011 and February 2012, the M1 money supply increased from 465.70 million to 481.96 million, which would only lead to a 0.07% increase in inflation with a 3-year lag. The impact is really small, and is unlikely to cause any significant change in the Swiss economy. Furthermore, the inflation as of February 2012 was near -1%. As a result, having a slightly higher inflation rate can even be more desirable.

Another source of inflation that my regression analysis doesn't discuss is the exchange rate pass-through. Theoretically, depreciation should result in the same percent of import price increase. In reality, however, the exchange rate pass-through coefficient is much smaller than 1.

One possible reason for this incomplete pass-through is international market segmentation, which allows imperfectly competitive firms to price to market by charging different prices for the same product in different countries (Krugman, Obstfeld & Melitz, 2011). According to the panel study done by Ilan Goldfajn and Sergio Werlang (2000), while the real exchange rate (RER) misalignment is the most important determinant of pass-through coefficient for emerging markets, the initial inflation is the most important variable for developed countries. The authors also showed that the pass-through coefficient is much lower for OECD members than non-OECD members. In addition, there is evidence that the pass-through coefficient has been decreasing due to the recent low inflation achieved by many countries (Taylor, 1999) and the reduction in the fraction of flexible-price firms in the economy (Takhatamanova, 2008). Based on their findings, the initial low inflation rate back in 1978 was likely to result in a low exchange rate pass-through coefficient. The current negative inflation environment and the fact that the exchange rate path-through coefficient has been decreasing over time are likely to result in an even lower pass-through coefficient of the current period. Last but not least, imports only make up part of the basket of goods purchased by consumers, and the rest of the basket is comprised of domestic goods. Alan Stockman (2004) showed that the import price increase does not have much effect on the price level since the import price increase leads to lower disposable income for domestic goods. As a result, the consumption of domestic goods decreases, and the price of domestic goods decreases as well. All of the findings imply that the current currency depreciation is unlikely to result in high inflation through the exchange rate pass-through effect in this case.

6. What Caused the Depreciation?

One year after the SNB announced the exchange rate floor in 1978, CHF depreciated approximately 10% against DEM. One question that people might ask was that without significant increase in money supply, how could the exchange rate of CHF come down? I believe that this depreciation could largely be attributed to the change of investors' expectations. The announcement of the exchange rate floor created very negative impact on the inventors' confidence in CHF. As we have observed, confidence has historically played a significant role in the foreign exchange market. For instance, during the Bretton Woods period, the confidence in USD was the foundation for the well functioning of the whole system. If the confidence in the dollar ebbed, foreign governments might stage a run on U.S. gold reserves, much like a run by depositors on a commercial bank, bringing the entire system crashing down (Bordo & Eichengreen, 1991). In this case, the exchange rate floor caused the investors to fear that if they continued investing in CHF and pushed the DEM/CHF beyond the point that the SNB set, the SNB would intervene the market. The change in expectation and confidence drove some investors to switch away from CHF. Without injecting too much liquidity into the system, the SNB successfully brought the exchange rate down.

A more complete picture of how investors' confidence changes after an exchange rate floor has been adopted can be drawn from Krugman's study (1991) on the target zones. If the honeymoon effect exists in the exchange rate within a band, the partial honeymoon effect should also be valid in Switzerland's case. According to Krugman (1991), the exchange rate behavior near the edges of the zone lies off the 45-degree line (shown in Figure 8), and this will affect exchange rate expectations further inside the zone as well. The repeated revisions of exchange rate expectations will lead to a relationship between (log of the) spot price of foreign exchange and velocity shocks that look like the S-shaped curve.

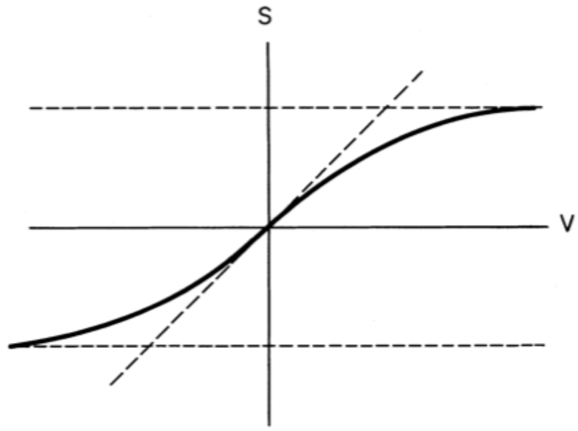

Figure 8. Graphical illustration of the honeymoon effect

In our case of the exchange rate floor, only the lower bound exists. The existence of the bound constrains the minimal point that the exchange rate can move beyond, which should affect the exchange rate behavior even when the exchange rate is above the floor. This is likely to result in a J-shaped curve: the actual exchange rate line lies above the 45-degree line at points close to the lower bound.

7. Conclusion

In this paper, I have studied the exchange rate floor announced in 1978 and 2011. Ideally, the SNB wants to prevent CHF from appreciating through the floor, leading to an increase in export while keeping inflation rate approximately the same. While the exchange rate of CHF against major currencies declined after the adoption of the floor in 1978, the floor's effect on export and inflation was unclear at first glance. As a result, two regression models are applied.

The model on export indicates a negative relationship between export and the same period's real effective exchange rate. Since nominal exchange rate and real effective exchange rate are closely related, especially in the short run, the deprecation of CHF after 1978 led to a decrease in the real effective exchange rate index, which in turn resulted in an increase in export, ceteris paribus. The similar strategy in 2011 is likely to have a smaller but similar impact on the Swiss export sector since CHF in 2011 was less overvalued than that in 1978. Nevertheless, due to the growing signifiance of the export sector in the overall economy, similar impact on the overall economic performance could still be expected.

The other model on inflation shows that increase in M1 money supply will, after 3-year lag, increase inflation rate. Further analysis shows that the 1980s' high inflation could neither be explained by the increase in M1 money supply nor higher import prices due to exchange rate pass-through effect. Similarly, the exchange rate floor in 2011 is unlikely to cause high inflation in the future, unless the SNB significant increases the M1 money supply. In the mechanism of how the exchange rate floor successfully brings down the exchange rate, I believe that investors' confidence rather than the increase in money supply plays an important role.

In conclusion, the positive effect on the export sector and the comparative small impact on inflation made the exchange rate floor strategy a success in the period of 1978, and the success story is likely to continue in current times.

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Appendix – R Code for Graph Generating and Regression Analysis

```
## Econ Senior Thesis

setwd("/Users/shuangshuangchen/Desktop/ECON Senior Thesis/DATA")

#### Create Plots of Exchange Rates, Inflation, and Money Supply

## Exchange Rates

CHFDEM <- read.csv(file="CHFDEM.csv", header=TRUE)
head(CHFDEM)
CHFDEM$Date <- as.Date(CHFDEM$Date, "%m/%d/%Y")

CHFUSD1 <- read.csv(file="CHFUSD1.csv", header=TRUE)
head(CHFUSD1)
CHFUSD1$Date <- as.Date(CHFUSD1$Date, "%m/%d/%Y")
par(mfrow=c(1,2))
plot(CHFDEM$Date, 1/CHFDEM$DEM, type="l", xlab="Year", ylab="DEM/CHF",
 main="DEM/CHF between 1965 and 1998")
plot(CHFUSD1$Date, 1/CHFUSD1$USD, type="l", xlab="Year", ylab="USD/CHF",
 main="USD/CHF between 1965 and 1998")

## Inflation and Money Supply

Inflation <- read.csv(file="Monthly Inflation.csv", header=TRUE)
head(Inflation)
plot(Inflation$Inflation, type="l", xlab="Year", ylab="Inflation", main="Switzerland Inflation
 Rate",xaxt="n")
axis(side=1, at=12*(1:61), labels=1951:2011)
mtext("(Annual Change on Consumer Price Index)")
abline(a=0, b=0, lty=2)

MoneySupply <- read.csv(file="Money Supply 1971-1990.csv", header=TRUE)
head(MoneySupply)
plot(MoneySupply$M0.growth[13:252], type="l", xlab="Year", ylab="", main="Switzerland
 Monetary Base Growth Rate & Inflation Rate",axes=FALSE, lty=1)
axis(side=1, at=12*(1:20), labels=1971:1990)
axis(2, ylim=c(-20,60), col="black", lwd=2)
mtext("Monetary Base Growth Rate (%)", 2, line=2)
par(new=TRUE)
plot(Inflation$Inflation[241:480], type="l", lty=2, xlab="", ylab="", axes=FALSE)
axis(4, ylim=c(-5, 12), col="black", lwd=2)
mtext("Inflation (%)", 4, line=-1)
legend("topright", c("Monetary Base", "Inflation"), lty=c(1,2))
```

```
#### Regression Analysis on Export

## Create the lag function

tslag <-
function(x, d)
{
  x <- as.vector(x)
  n <- length(x)
  c(rep(NA,d),x)[1:n]
}


## Read-in Data and Deal with Data

Reg2.Data <- read.csv(file="Regression 2.csv", header=TRUE)

Reg2.Data$Export <- Reg2.Data$Export/1000000000
Reg2.Data$Import <- Reg2.Data$Import/1000000000
Reg2.Data$GDP <- Reg2.Data$GDP/1000
head(Reg2.Data)

Export <- ts(Reg2.Data$Export, start=1975, freq=1)
Import <- ts(Reg2.Data$Import, start=1975, freq=1)
GDP <- ts(Reg2.Data$GDP, start=1975, freq=1)
CPI <- ts(Reg2.Data$CPI, start=1975, freq=1)
Real.EX <- ts(Reg2.Data$Real.EX, start=1975, freq=1)

Export.ratio <- Export/GDP*100
Import.ratio <- Import/GDP*100

## Export and Import Plots

plot(Export.ratio, lty=1, xlab="Year", ylab="Percentage (%)", main="Switzerland Export and
 Import (%GDP)", ylim=c(28, 58))
lines(Import.ratio, lty=2)
legend("topleft", c("Export", "Import"), lty=c(1,2))

## Regression

reg2.1 <- lm(Export~Real.EX+CPI, data=Reg2.Data)
summary(reg2.1)

## nonparametric fit
```

```
nonpara.CPI.fit <- loess(formula=Export~CPI, data=Reg2.Data)

par(mfrow=c(1,2))
plot(reg2.1$fitted.values,reg2.1$residuals, cex=1, xlab="Fitted Values", ylab="Residuals",
 main="Residual Plot")
plot(Reg2.Data$CPI, Reg2.Data$Export, xlab="CPI", ylab="Export", main="The Relationship
 between Export and CPI")
lines(Reg2.Data$CPI, nonpara.CPI.fit$fitted, col="red")

CPI.squared <- CPI^2

reg2.2 <- lm(Export~Real.EX+CPI+CPI.squared)
summary(reg2.2)

plot(reg2.2$fitted.values,reg2.2$residuals, cex=1, xlab="Fitted Values", ylab="Residuals",
 main="Residual Plot")

Export.lag1 <- tslag(Export, 1)
CPI.lag1 <- tslag(CPI, 1)
CPI.squared.lag1 <- CPI.lag1^2

reg2.3 <- lm(Export.lag1~Real.EX+CPI.lag1+CPI.squared.lag1)
summary(reg2.3)

Export.lag2 <- tslag(Export, 2)
CPI.lag2 <- tslag(CPI, 2)
CPI.squared.lag2 <- CPI.lag2^2

reg2.4 <- lm(Export.lag2~Real.EX+CPI.lag2+CPI.squared.lag2)
summary(reg2.4)

NetEX <- Reg2.Data$Export - Reg2.Data$Import
reg2.5 <- lm(NetEX~Real.EX+CPI+CPI.squared)
summary(reg2.5)


#### Regression Analysis on Inflation

Reg1.Data <- read.csv(file="Regression 1.csv", header=TRUE)
head(Reg1.Data)

## Time series plot of the original data

Reg1.Data$Date <- as.Date(Reg1.Data$Date, "%m/%d/%Y")
par(mfrow=c(1,4))
plot(Reg1.Data$Date, Reg1.Data$CPI, type="l", xlab="Time", ylab="CPI", main="Price Level")
```

```
plot(Reg1.Data$Date, Reg1.Data$M0, type="l", xlab="Time", ylab="Monetary Base",
 main="Monetary Base")
plot(Reg1.Data$Date, Reg1.Data$M1, type="l", xlab="Time", ylab="M1", main="M1 Money
 Supply")
plot(Reg1.Data$Date, Reg1.Data$Unemployment, type="l", xlab="Time",
 ylab="Unemployment", main="Unemployment Rate")

CPI <- ts(Reg1.Data$CPI, start=1970, freq=12)
M0 <- ts(Reg1.Data$M0, start=1970, freq=12)
M1 <- ts(Reg1.Data$M1, start=1970, freq=12)
Unemployment <- ts(Reg1.Data$Unemployment, start=1970)

CPI.diff <- diff(log(CPI),12)
M0.diff <- diff(log(M0),12)
M1.diff <- diff(log(M1),12)
Unemployment.diff <- diff(Unemployment,12)

## Regression analysis

reg1.1 <- lm(CPI.diff~M0.diff + Unemployment.diff)
summary(reg1.1)
reg1.2 <- lm(CPI.diff~M1.diff + Unemployment.diff)
summary(reg1.2)

CPI.lag12 <- tslag(CPI.diff, 12)

reg1.3 <- lm(CPI.lag12~M0.diff + Unemployment.diff)
summary(reg1.3)
reg1.4 <- lm(CPI.lag12~M1.diff + Unemployment.diff)
summary(reg1.4)

CPI.lag24 <- tslag(CPI.diff, 24)

reg1.5 <- lm(CPI.lag24~M0.diff + Unemployment.diff)
summary(reg1.5)
reg1.6 <- lm(CPI.lag24~M1.diff + Unemployment.diff)
summary(reg1.6)

CPI.lag36 <- tslag(CPI.diff, 36)

reg1.7 <- lm(CPI.lag36~M0.diff + Unemployment.diff)
summary(reg1.7)
reg1.8 <- lm(CPI.lag36~M1.diff + Unemployment.diff)
summary(reg1.8)

## Residual Check
```

```
par(mfrow=c(1,2))
plot(reg1.1$fitted.values,reg1.1$residuals, cex=1, xlab="Fitted Values", ylab="Residuals",
 main="Residual Plot")
qqnorm(reg1.1$residuals)
qqline(reg1.1$residuals)

par(mfrow=c(1,2))
plot(reg1.2$fitted.values,reg1.2$residuals, cex=1, xlab="Fitted Values", ylab="Residuals",
 main="Residual Plot")
qqnorm(reg1.2$residuals)
qqline(reg1.2$residuals)


#### More Plots and Analysis

## Bar Chart of GDP

par(mfrow=c(1,2))
barplot(Reg2.Data$GDP[1:3], names.arg=1975:1977, xlab="Year", ylab="GDP (Billion)",
 ylim=c(130, 150), xpd=FALSE, main="Bar Chart of GDP (1975-1977)")
barplot(Reg2.Data$GDP[34:36], names.arg=2008:2010, xlab="Year", ylab="GDP (Billion)",
 ylim=c(530, 551), xpd=FALSE, main="Bar Chart of GDP (2008-2010)")
```