Journal of Comparative International Management

A Regression Analysis on the Macroeconomic Variables Affecting Taiwan's Export Value to the US before and after 2008 Financial Crisis

Fong-Wen Tsai, Prosper Bernard, Jr., Michel Plaisent et Edward Y. H. Lin

Volume 17, numéro 1, september 2014

URI : https://id.erudit.org/iderudit/jcim17_1art04

Aller au sommaire du numéro

Éditeur(s)

Management Futures

ISSN

1481-0468 (imprimé)
1718-0864 (numérique)

Découvrir la revue

Citer cet article

Tsai, F.-W., Bernard, P., Plaisent, M. & Lin, E. Y. H. (2014). A Regression Analysis on the Macroeconomic Variables Affecting Taiwan's Export Value to the US before and after 2008 Financial Crisis. *Journal of Comparative International Management*, *17*(1), 43–65.

Résumé de l'article

The booming of international trade since 1980 has resulted in the sharp economic growth of Taiwan. It is therefore important to understand the influential factors and their impacts on Taiwan's international trade and export. This research adopts multiple regression method to identify the respective influential macroeconomic variables affecting the export values of Taiwan to the U.S. before and after 2008 financial crisis. It also analyzes the correlations among these macroeconomic variables. The results of this research indicate that, the first lag period of: (1) Taiwan industrial production index, (2) exchange rate of U.S. dollar to New Taiwan dollar, (3) US Interbank real call loan rate, and (4) U.S. industrial production index are influential macroeconomic variables affecting export values of Taiwan to the U.S. before 2008 financial crisis. After 2008 financial crisis, the influential macroeconomic factors are the first lag period of (1) exchange rate of U.S. dollar to New Taiwan dollar, (2) Taiwan's industrial production index, (3) Mainland China's consumer price index yearly increment, and (4) Taiwan'swholesale price index yearly increment (excluding service).

Journal of Comparative International Management
2014, Vol. 17, No. 1, 43–65

A Regression Analysis on the Macroeconomic Variables Affecting Taiwan's Export Value to the US before and after 2008 Financial Crisis

by

Fong-Wen Tsai
University of Quebec in Montreal, Canada

Prosper Bernard Jr.
City University of New York, U.S.A.

Michel Plaisent
University of Quebec in Montreal, Canada

Edward Y. H. Lin
National Taipei University of Technology, Taiwan
Royal Roads University, Canada

The booming of international trade since 1980 has resulted in the sharp economic growth of Taiwan. It is therefore important to understand the influential factors and their impacts on Taiwan's international trade and export. This research adopts multiple regression method to identify the respective influential macroeconomic variables affecting the export values of Taiwan to the U.S. before and after 2008 financial crisis. It also analyzes the correlations among these macroeconomic variables. The results of this research indicate that, the first lag period of: (1) Taiwan industrial production index, (2) exchange rate of U.S. dollar to New Taiwan dollar, (3) US Interbank real call loan rate, and (4) U.S. industrial production index are influential macroeconomic variables affecting export values of Taiwan to the U.S. before 2008 financial crisis. After 2008 financial crisis, the influential macroeconomic factors are the first lag period of (1) exchange rate of U.S. dollar to New Taiwan dollar, (2) Taiwan's industrial production index, (3) Mainland China's consumer price index yearly increment, and (4) Taiwan'swholesale price index yearly increment (excluding service).

Introduction

In addition to currency exchange rate which is considered the major factor that affects the export and import commodity price and volume and, in turn, affects the competitiveness of a nation, there are many other factors that still need to be considered. In the studies of global economy, Mundell (1963) and Fleming (1962) developed a popular Mundell-Fleming model by adding the balance of payment curve into the IS-LM model proposed by Hicks and Hansen in 1937 to analyze the factors that affect the import/export of a nation under open economy (Sachs, 1980). Their studies found that, other than

exchange rate, factors such as income level, consumer price index, interest rate, currency supply, etc. all contribute to the export of a country.

Asseery and Peel (1991) developed a long-term export function based on the research work of Gotur (1985). The independent variables in this function include foreign income, export commodity price, and fluctuation of currency exchange rate, among others. Using the two stage estimation approach developed by Engle and Granger (1987), it is found that there is a positive relationship between the commodity price and export volume. On the other hand, the exchange rate appears to be more significant on the export volume only for the short term.

In and Sgro (1998) studied the export volume of Singapore and South Korea using the export growth model to analyze the change in export volumes and the major factors affecting these changes. They found that exchange rate, income level, and both foreign and domestic commodity prices have more significant impact on the export volume of Singapore than on the export volume of South Korea.

Cheong, Mehari, and Williams (2005) adopted the export data from British manufactured goods to explore the impact of currency exchange rate fluctuation on trade volume and price competitiveness using GARCH model. The result shows that when there is a currency exchange rate fluctuation, British export companies would reduce instead of increase the trade volume. Exchange rate usually exhibits a positive relationship with the export price. However, such relationship becomes negative when applied to British trade volume.

Using ARCH model, Grier and Smallwood (2006) studied nine developed countries (namely, Australia, Canada, Denmark, Japan, Norway, Sweden, Switzerland, UK and USA) and nine developing countries (namely, Argentina, Brazil, India, Korea, Mexico, Peru, South Africa, Thailand and Turkey) to explore the effects of exchange rate fluctuation, foreign income level, real currency exchange rate and income fluctuation on export volume. The results show that currency exchange rate fluctuation has more negative impact on most developing countries. It has no significant impact on the developed countries. On the other hand, income fluctuation has significant positive relationship on the export volume of most less developed countries. Such relationship, although significant, can go either way for the developed countries.

Saang Joon (2008) uses error correction model to study the trade volume change as a result of currency exchange rate change between China’s RMB and US dollar. He also added the currency exchange rate of the third countries in the model. The results show that currency exchange rate fluctuation has significant negative impact on China’s export volume to the U.S. but not on the U.S. export volume to China. In addition, foreign income level has a greater impact on the export volume than real currency exchange rate.

Nishimura and Hirayama (2013) uses the ARCH model to investigate the effect of China’s RMB and Japanese Yen volatility on Japan-China trade with special emphasis on the impact of the reform of the RMB exchange rate regime implemented on July 21, 2005. They also utilize the daily data from January 2002 through December 2011 to examine both short-run and long-run effects of this volatility on exports of each country to the other through ARDL approach. The results indicate that Japan's exports to China are not affected by the exchange rate volatility, whereas China's exports to Japan are negatively

influenced during the reform period. It appears that the exchange rate has a significant impact on Chinese exports, but it has no influence on Japanese exports.

Grier and Smallwood (2013) studied the effects of uncertainty on trade by introducing a model that combines a reduced form vector autoregression for the growth rates of exports, foreign income, and the real exchange rate with a multivariate GARCH model. Using the data for both developed and emerging countries, they find that RER uncertainty negatively impacts trade for several less developed countries. We also find that real exchange rate uncertainty tends to be associated with a real currency appreciation.

Soleymani and Chua (2014) investigated the impact of Malaysian ringgit and China's RMB volatility on Malaysian trade with China using the disaggregated bilateral trade data by industry over the period of 1985–2010. They found that the exchange rate volatility has short-run effects on some import/export models. However, the effects may shift from short-run to long-run in some industries. Their research indicates that the exchange rate uncertainty has a positive effect on majority of these industries in regards to the trade between Malaysia and China.

Several researchers have conducted research on this topic in Taiwan. Their key findings are summarized as in Table 1.

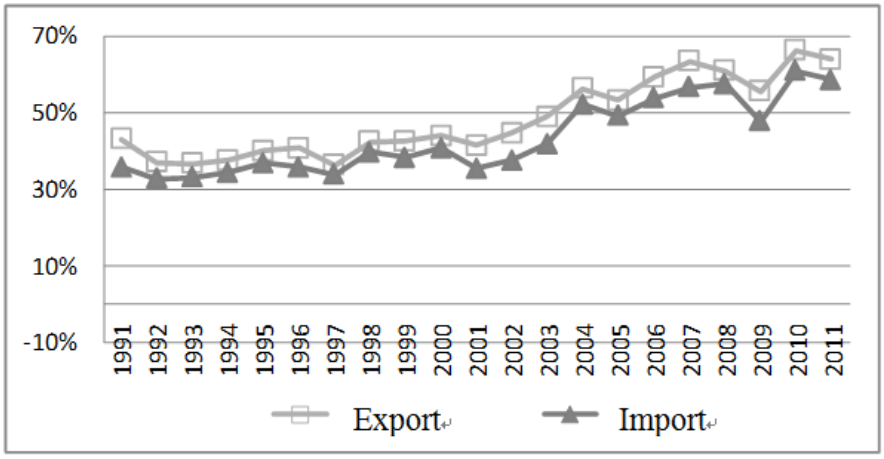
Table 1: Research Results from Scholars in Taiwan

Researchers	Research Methods	Research Results
Xiong, Y. Z. (1995)	One-tailed Hypothesis Test; Covariance Test; Error Modification Model	Short-term importers cannot rule out the influence of exchange rate fluctuation due to contract restrictions; Long-term importers would use domestic products to substitute the imported products to avoid risk. Regardless of long term or short term, there is no significant impact of currency exchange rate fluctuation on Taiwan's export volume.
Yang, M. J. (2002)	Multiple Regression; Chow-Test	Currency exchange rate, China's GDP, Taiwan's WPI, Taiwan's investment in China have positive impact on the export from Taiwan to China; Exchange rate, Taiwan's GDP, Taiwan's WPI have positive impact on the import from China to Taiwan.
Wang, H. R. (2005)	SVAR Model; Multiple Regression; GARCH Model	Currency exchange rate is influenced by the change of foreign asset held by Central Bank. In the long run, it is influenced more by Taiwan's export. Currency exchange rate fluctuation and the expectation of exchange rate change from the market have significant impact on Taiwan's export volume.
Huang, J. R. (2009)	One-Sided Hypothesis Test; Cause-Effect Test; ARCH and GARCH Models	Currency exchange rate fluctuation, income level and relative CPI in Taiwan have significant impact on the export volume of the US and China's export volume.
Huang, L. R. (2011)	One-Sided Hypothesis Test; Covariance Test; Error Modification Model; GARCH Model	Regardless of long term or short term, currency exchange rate has significant impact on Taiwan's export volume. It has less impact on Taiwan's import volume. Income levels have positive impact on both Taiwan's import and export volume.
Ke, S. H. and Jiang, C. Z. (2011)	Multiple Regression	Currency exchange rate, US real income and price of exported goods have significant impact on Taiwan's export to the US. Exchange rate, Taiwan's real income and imported commodity price have significant impact on Taiwan's imported volume.

Research Motivation

Taiwan's economy is export oriented. Based on the data from Statistic Taiwan, 2011 Gross Domestic Product (GDP) in Taiwan reached 466.88 billion US dollars. Both imported products and exported products occupied more than 60% of GDP. There is also an increasing trend in both export and import as shown in Figure 1.

Figure 1: Percentage of Taiwan's Import and Export in GDP



As the "shadow economy", Taiwan lacks natural resources and suffers from the limitations of a small domestic market. As a result, Taiwan has to rely heavily on international trade for its economic growth. The geographic location and the rapid growth of international trade have made an understanding of the key factors affecting the international trade and export important. To those countries that rely on trade, currency exchange rate is no doubt an important factor on the import and export of a country. Numerous studies have been conducted in this direction. However, there must be other factors in economy which could contribute to the change in import and export values.

The financial crisis caused by the subprime problem in the U.S. housing market at the end of 2008 has greatly affected world economy. It had led to the contraction of the economy, setback of trade volume, and an increase of unemployment rates. Based on the data released by the Ministry of Economy of Taiwan, the financial crisis of 2008 was no doubt the darkest moment in Taiwan's economic growth. Moreover, it has fundamentally changed the pattern of Taiwan's export.

United States has been the largest trading partner of Taiwan. The export value of goods from Taiwan to the U.S. during January, 1991 to August, 2012 stood at $1,071 billion US dollars, accounting for 15.762% of Taiwan's total export value during this period. It is therefore beneficial and important to study the macroeconomic variables that can affect Taiwan's export value to the U.S. The comparison of these variables before and after 2008 financial crisis can also provide useful insights into the behavior of these variables in differing economic contexts.

The purpose of this research is to explore the difference of such macroeconomic variables, particularly the role of currency exchange rate in such change. We also use the derived fitted regression

model after 2008 financial crisis to forecast Taiwan's export value to the U.S. during September to December of 2012 to assess its predictability.

Methods

Using multiple regression, this research identifies and studies the change of macroeconomic variables that affect Taiwan's export to the U.S. before and after 2008 financial crisis. We use MINITAB statistical software to conduct the analysis on two sets of data. The first set of data contains 47 monthly data for the period from January 2005 to December 2008. The second set of data contains 43 monthly data from January 2009 to September 2012.

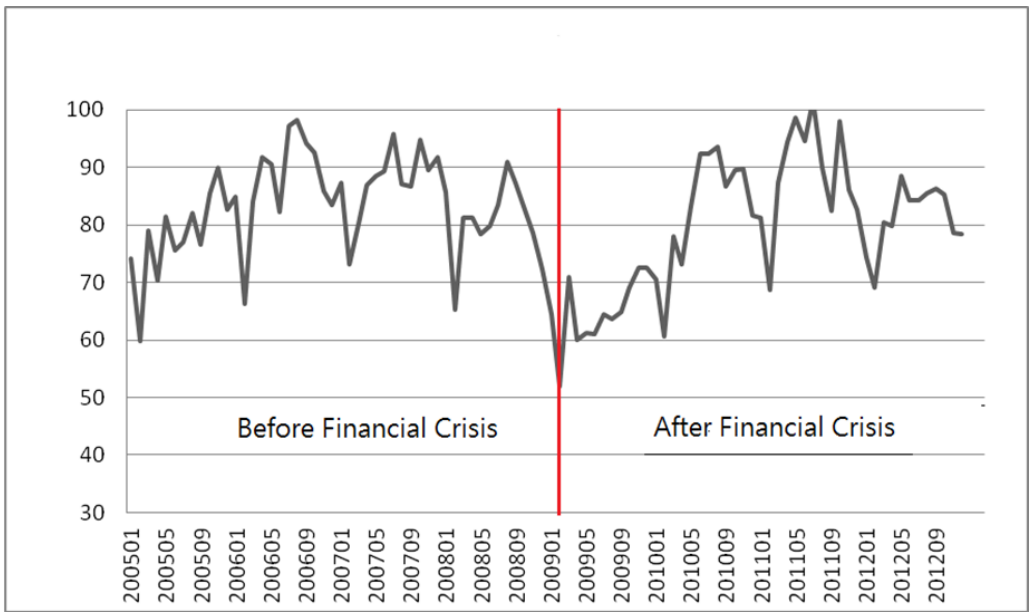
Construction of Regression Model

Dependent and Independent Variables

The dependent variable in the regression model is the value of Taiwan's export to the U.S. in billion New Taiwan dollars. We shall denote this dependent variable as EXUS. The trend of EXUS from 2005 to 2012 is depicted in Figure 2. We shall divide Figure 2 into two periods. The first one is from January of 2005 to December of 2008 which represents the period before 2008 financial crisis. The second one is from January of 2009 to September of 2012 which represents the period after 2008 financial crisis. Data for EXUS is drawn from Taiwan Economic Journal database (*http://www.tej.com.tw/twsite/*).

Note that although the financial crisis occurred in 2008, taking into consideration of the lag effect on export, we set January 1, 2009 as the cutoff point.

Figure 2: Trend of Taiwan's Export Value to the U.S. (2005-2012) in Billions of New Taiwan Dollars



To explore the behavior of the macroeconomic variables that may affect EXUS before and after 2008 financial crisis, we first identify the following candidates as independent variables and define them as below:

E_{US} : Exchange Rate of One US dollar to New Taiwan Dollars.

It is anticipated that EX_{US} will increase as E_{US} increases because higher E_{US} represents the devaluation of New Taiwan dollars which increases Taiwan's export competitiveness in price.

r_{US} : US Interbank Real Call Loan Rate.

It is anticipated that EX_{US} will increase as r_{US} increases because higher r_{US} represents higher cost of loan among US banks which will restrict the capital flow and result in weak import into the US.

IPI_{US} : US Industrial Production Index.

It is anticipated that EX_{US} will increase as IPI_{US} increases because higher IPI_{US} represents the growth of US economy which requires more imported electronic components from Taiwan.

$IPIY_{US}$: US Industrial Production Index Yearly Increment.

It is anticipated that EX_{US} will increase as $IPIY_{US}$ increases because higher $IPIY_{US}$ represents the continuous growth trend of US economy which requires more imports from Taiwan.

WPI_{TW} : Taiwan Wholesale Price Index (excluding service).

It is anticipated that EX_{US} will increase as WPI_{TW} decreases because lower WPI_{TW} represents lower material cost which will cut down commodity price and benefit Taiwan's export.

IPI_{TW} : Taiwan Industrial Production Index.

It is anticipated that EX_{US} will increase as IPI_{TW} increases because higher IPI_{TW} represents higher production activities which will contribute to the increase of Taiwan's export.

$WPIY_{TW}$: Taiwan Wholesale Price Index Yearly Increment (excluding service).

It is anticipated that EX_{US} will increase as $WPIY_{TW}$ decreases because lower $WPIY_{TW}$ represents the continuous decreasing trend of material costs in Taiwan which will increase Taiwan's competitiveness in commodity price and trigger strong export from Taiwan.

$INCOME_{US}$: US Disposable Personal Income.

It is anticipated that EX_{US} will increase as $INCOME_{US}$ increases because higher $INCOME_{US}$ represents strong purchasing power in the U.S. which will create higher demands in the U.S. market and requires more exports from Taiwan.

EX_{CH} : Value of Export from Taiwan to Mainland China.

It is anticipated that EX_{US} will increase as EX_{CH} increases because higher EX_{CH} represents stronger trading activities between Taiwan and Mainland China. Since more and more

goods produced by Taiwan companies are now manufactured in Mainland China, this will add to the value of exports from Taiwan.

$CPIY_{CH}$: Mainland China Consumer Price Index Yearly Increment.

It is anticipated that EX_{US} will increase as $CPIY_{CH}$ decreases because lower $CPIY_{CH}$ will encourage the export value from Mainland China. Since most goods produced by Taiwan companies are manufactured in Mainland China, this will also add to the value of exports from Taiwan.

$M2_{CH}$: Mainland China Money Supply.

It is anticipated that EX_{US} will increase as $M2_{CH}$ increases because higher $M2_{CH}$ will devaluate RMB, the currency of Mainland China, and increase China's competiveness in export. Since most goods produced by Taiwan companies are manufactured in Mainland China, this should increase the export value from Taiwan.

Data associated with above independent variables are taken from AREMOS database at Taiwan Economic Data Center (*http://net.aremos.org.tw/table.html*). Taking into account that it takes time for the above independent variables to take effect on dependent variable, EX_{US}, we shall allow one time period lag of these independent variables to match with EX_{US}.

Correlations among Variables

The Person correlation coefficient matrices among all variables before and after 2008 financial crisis are shown in Table 3 and Table 4, respectively. Note that notation "h" after the numbers in matrix entries represents high correlation between the pair of variables ($0.7 < r \leq 1$) whereas notation "m" after the numbers in matrix entries represents medium correlation between the pair of variables ($0.3 < r \leq 0.7$). Based on Table 2 and Table 3, it appears that high correlations exist in more cases in Table 3 than those in Table 2.

Table 2: Person Correlation Matrix among Variables before the 2008 Financial Crisis

	EX_{US}	E_{US}	r_{US}	IPI_{US}	$IPIY_{US}$	WPI_{TW}	IPI_{TW}	$WPIY_{TW}$	$INCOME_{US}$	EX_{CH}	$CPIY_{CH}$
E_{US}	0.318m										
r_{US}	0.493m	0.505m									
IPI_{US}	0.35m	-0.011	0.688m								
$IPIY_{US}$	0.099	0.104	0.711h	0.559m							
WPI_{TW}	0.311m	-0.278	-0.173	0.385m	-0.458m						
IPI_{TW}	0.609m	-0.234	0.209	0.618m	0.071	0.701h					
$WPIY_{TW}$	0.363m	-0.242	0.404m	0.724h	0.228	0.624m	0.65m				
$INCOME_{US}$	0.206	-0.176	-0.169	0.344m	-0.554m	0.896h	0.522m	0.462m			
EX_{CH}	0.496m	-0.227	0.090	0.601m	-0.123	0.848h	0.908h	0.65m	0.733h		
$CPIY_{CH}$	-0.003	-0.467m	-0.216	0.531m	-0.170	0.791h	0.639m	0.495m	0.707h	0.754h	
$M2_{CH}$	0.155	-0.152	-0.365m	0.137	-0.726h	0.886h	0.437m	0.287	0.941h	0.654m	0.687m

Table 3: Person Correlation Matrix among Variables after the 2008 Financial Crisis

	EX'$_{US}$	E'$_{US}$	r'$_{US}$	IPI'$_{US}$	IPIY'$_{US}$	WPI'$_{TW}$	IPI'$_{TW}$	WPIY'$_{TW}$	INCOME'$_{US}$	EX'$_{CH}$	CPIY'$_{CH}$
E'$_{US}$	-0.676$_m$										
r'$_{US}$	-0.317$_m$	0.552$_m$									
IPI'$_{US}$	0.636$_m$	-0.852$_h$	-0.435$_m$								
IPIY'$_{US}$	0.76$_h$	-0.731$_h$	-0.205	0.758$_h$							
WPI'$_{TW}$	0.733$_h$	-0.901$_h$	-0.573$_m$	0.881$_h$	0.835$_h$						
IPI'$_{TW}$	0.824$_h$	-0.793$_h$	-0.268	0.696$_m$	0.831$_h$	0.824$_h$					
WPIY'$_{TW}$	0.638$_m$	-0.554$_m$	-0.312$_m$	0.519$_m$	0.879$_h$	0.716$_h$	0.647$_m$				
INCOME'$_{US}$	0.601$_m$	-0.786$_h$	-0.199	0.905$_h$	0.675$_m$	0.728$_h$	0.613$_m$	0.393$_m$			
EX'$_{CH}$	0.756$_h$	-0.65$_m$	-0.196	0.523$_m$	0.788$_h$	0.739$_h$	0.92$_h$	0.698$_m$	0.438$_m$		
CPIY'$_{CH}$	0.793$_h$	-0.839$_h$	-0.463$_m$	0.725$_h$	0.852$_h$	0.849$_h$	0.728$_h$	0.8$_h$	0.664$_m$	0.637$_m$	
M2'$_{CH}$	0.609$_m$	-0.861$_h$	-0.447$_m$	0.965$_h$	0.72$_h$	0.885$_h$	0.757$_h$	0.473$_m$	0.861$_h$	0.587$_m$	0.647$_m$

Selection of "Best" Independent Variables

This research adopts the "Best Subsets Regression" to select the "best" set of independent variables. This is done by firstly conducting the simple linear regression of dependent variable on each of the candidates of independent variables. Based on the principle of "smaller standard error, and larger adjusted coefficient determination", an independent variable is chosen. A multiple regression of dependent variable on this chosen independent variable and another independent variable other than the chosen independent variable is conducted one at a time. The procedure repeats until the best set of independent variables is obtained.

Best Set of Independent Variables before 2008 Financial Crisis

Using the data before 2008 financial crisis (January 2005 to January 2009), Table 4 shows the simple linear regression of EX_{US} on each of the candidate independent variables discussed in previous section. The results show that $IPIY_{US}$ (Adj-R^2 = 0%), $INCOME_{US}$ (Adj-R^2 = 2.6%), $CPIY_{CH}$ (Adj-R^2 = 0%) and $M2_{CH}$ (Adj-R^2 = 1.8%) have no significant impact on EX_{US}. On the other hand, it appears that IPI_{TW} generates the smallest S value of 6.7084 accompanied with the largest Adj-R^2 value of 35.7%.

Table 4: Simple Linear Regression of EX_{US} on Each of Initial Independent Variables before 2008 Financial Crisis

Simple Linear Regression Model	S	Adj-R^2	Remarks
$EX_{US(t)} = -14.5 + 3.04\ E_{US\,(t-1)}$	8.0188	8.1%	
$EX_{US(t)} = 72.7 + 2.84\ r_{US\,(t-1)}$	7.3577	22.7%	
$EX_{US(t)} = -25.9 + 1.10\ IPI_{US\,(t-1)}$	7.9210	10.4%	
$EX_{US(t)} = 83.2 + 0.233\ IPIY_{US\,(t-1)}$	8.4151	0%	$IPIY_{US}$ *p-value* = 0.503

$EX_{US(t)} = -90.4 + 37.5 \ln (WPI_{TW(t-1)})$	7.9999	8.6%	
$EX_{US(t)} = 31.3 + 0.51\ IPI_{TW\ (t-1)}$	6.7084	35.7%	
$EX_{US(t)} = 80.3 - 0.70\ WPIY_{TW\ (t-1)}$	7.8811	11.3%	
$EX_{US(t)} = -40.7 + 53.4 \ln (INCOME_{US\ (t-1)})$	8.2586	2.6%	$\ln (INCOME_{US})$ *p-value* = 0.142
$EX_{US(t)} = -12.8 + 19.3 \ln (EX_{CH\ (t-1)})$	7.0179	29.6%	
$EX_{US(t)} = 83.5 - 0.01\ CPIY_{CH\ (t-1)}$	8.4567	0%	$CPIY_{CH}$ *p-value* = 0.985
$EX_{US(t)} = -11.8 + 9.10 \ln (M2_{CH\ (t-1)})$	8.2887	1.8%	$\ln (M2_{CH})$ *p-value* = 0.176

We then conduct multiple regression of EX_{US} on IPI_{TW} and another independent variable from the set of $\ln (EX_{CH})$, r_{US}, $WPIY_{TW}$, IPI_{US}, $\ln (WPI_{TW})$ and E_{US}. The results of these multiple regression are shown in Table 5.

Table 5: Multiple Regression of EX_{US} on IPI_{TW} and Other Independent Variables before 2008 Financial Crisis

Fitted Regression Model (Two Independent Variables)	*S*	*Adj*-R^2
$EX_{US(t)} = 34.5 + 0.537\ I\ PI_{TW\ (t-1)} - 1.2 \ln (EX_{CH\ (t-1)})$	6.7816	34.3%
$EX_{US(t)} = 29.8 + 0.443\ IPI_{TW\ (t-1)} + 2.20\ r_{US\ (t-1)}$	5.9822	48.9%
$EX_{US(t)} = 28.6 + 0.541\ IPI_{TW\ (t-1))} - 0.111\ WPIY_{TW(t-1)}$	6.7723	34.5%
$EX_{US(t)} = 42.2 + 0.532\ IPI_{TW\ (t-1)} - 0.131\ IPI_{US\ (t-1)}$	6.7767	34.4%
$EX_{US(t)} = 127 + 0.628\ IPI_{TW\ (t-1)} - 23.2 \ln (WPI_{TW\ (t-1)})$	6.6714	36.4%
$EX_{US(t)} = -129 + 0.605\ IPI_{TW\ (t-1)} + 4.65\ E_{US\ (t-1)}$	5.4447	57.6%

Table 5 shows the multiple regression of EX_{US} on IPI_{TW} and Independent variable E_{US} generates the smallest S value of 5.4447, with the largest Adj-R^2 value of 57.6% when included with independent variable E_{US}.

Based on this, we conduct the multiple regression of EX_{US} on IPI_{TW}, E_{US} and one independent variable from $\ln (EX_{CH})$, r_{US}, $WPIY_{TW}$, IPI_{US}, and $\ln (WPI_{TW})$. The results of these multiple regression are shown in Table 6.

Table 6: Multiple Regression of EX_{US} on IPI_{TW}, E_{US} and Third Independent Variable before 2008 Financial Crisis

Fitted Regression Model (Three Independent Variables)	*S*	*Adj*-R^2
$EX_{US(t)} = -99.8 + 0.561\ IPI_{TW\ (t-1)} + 3.8\ E_{US\ (t-1)} + 0.877\ r_{US\ (t-1)}$	5.4075	58.3%

$EX_{US(t)} = -69.2 + 0.672\ IPI_{TW\,(t-1)} + 4.54\ E_{US\,(t-1)} - 13.5\ ln\ (WPI_{TW\,(t-1)})$	5.4595	57.4%
$EX_{US(t)} = -128 + 0.595\ IPI_{TW\,(t-1)} + 4.67\ E_{US\,(t-1)} + 0.037\ WPIY_{TW\,(t-1)}$	5.5048	56.7%
$EX_{US(t)} = -96.3 + 0.688\ IPI_{TW\,(t-1)} + 4.85\ E_{US\,(t-1)} - 0.474\ IPI_{US\,(t-1)}$	5.4120	58.2%
$EX_{US(t)} = -112 + 0.776\ IPI_{TW\,(t-1)} + 4.77\ E_{US\,(t-1)} - 7.51\ ln\ (EX_{CH\,(t-1)})$	5.4607	57.4%

Table 6 shows the multiple regression of EX_{US} on IPI_{TW}, E_{US} and a third Independent variable generates the smallest S value of 5.4075, with the largest $Adj\text{-}R^2$ value of 58.3% when incorporated with independent variable r_{US}.

This drives us to carry on with the multiple regression of EX_{US} on IPI_{TW}, E_{US}, r_{US} and a fourth independent variable from $ln\ (EX_{CH})$, $WPIY_{TW}$, IPI_{US}, and $ln\ (WPI_{TW})$. The results of these multiple regressions are shown in Table 7.

Table 7: Multiple Regression of EX_{US} on IPI_{TW}, E_{US}, r_{US} and Fourth Independent Variable before 2008 Financial Crisis

Fitted Regression Model (Four Independent Variables)	*S*	*Adj*-R^2	Remarks
$EX_{US(t)} = 113 + 0.765\ IPI_{TW\,(t-1)} + 2.14\ E_{US\,(t-1)} + 3.43\ r_{US\,(t-1)} - 1.90\ IPI_{US\,(t-1)}$	4.7331	68.0%	
$EX_{US(t)} = -77.4 + 0.596\ IPI_{TW\,(t-1)} + 3.86\ E_{US\,(t-1)} + 0.761\ r_{US\,(t-1)} - 6.0\ ln\ (WPI_{TW\,(t-1)})$	5.4607	57.4%	$r_{US\,(t-1)}$ *p-value* = 0.327、$ln\ (WPI_{TW\,(t-1)})$ *p-value* = 0.732
$EX_{US(t)} = -91.8 + 0.684IPI_{TW\,(t-1)} + 3.97\ E_{US\,(t-1)} + 0.781\ r_{US\,(t-1)} - 5.19\ ln\ (EX_{CH\,(t-1)})$	5.4471	57.6%	$r_{US\,(t-1)}$ *p-value* =0.276、$ln\ (EX_{CH\,(t-1)})$ *p-value* = 0.566
$EX_{US(t)} = -92.4 + 0.579\ IPI_{TW\,(t-1)} + 3.45\ E_{US\,(t-1)} + 1.15\ r_{US\,(t-1)} - 0.18\ WPIY_{TW\,(t-1)}$	5.4434	57.7%	$r_{US\,(t-1)}$ *p-value* = 0.165、$WPIY_{TW\,(t-1)}$ *p-value* = 0.534

The results in Table 7 above show that the multiple regression of EX_{US} on IPI_{TW}, E_{US}, r_{US} and a fourth independent variable generates the smallest S value of 4.7331, with the largest $Adj\text{-}R^2$ value of 68.0% when included with independent variable IPI_{US}. It is also noted that the incorporation with other independent variables all carries with high *p-value*s indicating these regression models are less insignificant.

On the safe side, we continue to conduct the multiple regression of EX_{US} on IPI_{TW}, E_{US}, r_{US}, IPI_{US} and a fifth independent variable from $ln\ (EX_{CH})$, $WPIY_{TW}$, and $ln\ (WPI_{TW})$. The results of these multiple regression are shown in Table 8.

Table 8: Multiple Regression of EX_{US} on IPI_{TW}, E_{US}, r_{US}, IPI_{US} and Fifth Independent Variable before 2008 Financial Crisis

Fitted Regression Model	*S*	*Adj*-R^2	Remarks
$EX_{US(t)} = 117 + 0.748\ IPI_{TW\,(t-1)} + 2.32\ E_{US\,(t-1)} + 3.34\ r_{US\,(t-1)} - 1.98\ IPI_{US\,(t-1)} + 0.127\ WPIY_{TW\,(t-1)}$	4.7761	67.4%	$E_{US\,(t-1)}$ *p-value* = 0.052、$WPIY_{TW\,(t-1)}$ *p-value* = 0.635
$EX_{US(t)} = 127 + 0.576\ IPI_{TW\,(t-1)} + 1.61\ E_{US\,(t-1)} + 3.94\ r_{US\,(t-1)} - 2.16\ IPI_{US\,(t-1)} + 9.13\ ln\ (EX_{CH\,(t-1)})$	4.7263	68.1%	$E_{US\,(t-1)}$ *p-value* = 0.184、*ln* $(EX_{CH\,(t-1)})$ *p-value* = 0.295
$EX_{US(t)} = 59.3 + 0.649\ IPI_{TW\,(t-1)} + 1.44\ E_{US\,(t-1)} + 4.57\ r_{US\,(t-1)} - 2.35\ IPI_{US\,(t-1)} + 27.7\ ln\ (WPI_{TW\,(t-1)})$	4.6404	69.2%	$E_{US\,(t-1)}$ *p-value* = 0.216、*ln* $(WPI_{TW\,(t-1)})$ *p-value* = 0.106

The results in Table 8 above show that the last two multiple regression models of EX_{US} on IPI_{TW}, E_{US}, r_{US}, IPI_{US} combined respectively with *ln* (EX_{CH}) and *ln* $(WPI_{TW\,(t-1)})$ both generate the *p-value*s higher than 0.1, indicating that these regression models are less insignificant. Although the *p-value*s of the first multiple regression models of EX_{US} on IPI_{TW}, E_{US}, r_{US}, IPI_{US} combined with $WPIY_{TW}$ are less than 10%, taking into consideration that *Adj*-R^2 of this regression model is 67.4% which is less than the *Adj*-R^2 value of 68% which resulted from regression of EX_{US} on IPI_{TW}, E_{US}, r_{US} and IPI_{US}, we decided not to choose this regression model.

Based on this, we conclude that the best set of macroeconomic variables affecting Taiwan's export value to the U.S. before 2008 financial crisis are: IPI_{TW} (Taiwan Industrial Production Index), E_{US} (Exchange Rate of one US dollar to New Taiwan dollars), r_{US} (US Interbank Real Call Loan Rate), and IPI_{US} (US Industrial Production Index). The fitted regression model for before 2008 financial crisis is therefore:

$$EX_{US(t)} = 113 + 0.765\ IPI_{TW\,(t-1)} + 2.14\ E_{US\,(t-1)} + 3.43\ r_{US\,(t-1)} - 1.90\ IPI_{US\,(t-1)}$$

Best Set of Independent Variables after 2008 Financial Crisis

If we adopt the best set of macroeconomic variables affecting Taiwan's export value to the U.S. before 2008 financial crisis to fit Taiwan's export value to the U.S. after 2008 financial crisis, we would obtain the results as in Table 9. We observe from Table 9 that *p-value*s of $E_{US\,(t-1)}$ and $r_{US\,(t-1)}$ are greater than 0.3 whereas *p-value* of IPI_{US} is greater than 0.5. This is an indication that the best set of independent variables for the prediction of EX_{US} before 2008 financial crisis is not suitable for the prediction of EX_{US} after 2008 financial crisis.

Table 9: Multiple Regression of EX_{US} on the Best Set of Independent Variables Used before 2008 Financial Crisis

Fitted Regression Model	*S*	*Adj*-R^2	Remarks
$EX_{US(t)} = 62 + 0.352\ IPI_{TW\ (t-1)} - 1.89\ E_{US\ (t-1)} + 39.1\ r_{US\ (t-1)} + 0.308\ IPI_{US\ (t-1)}$	8.2508	59.8%	$E_{US\ (t-1)}$ *p-value = 0.366* $r_{us\ (t-1)}$ *p-value = 0.307* $IPI_{US\ (t-1)}$ *p-value = 0.571*

Despite the measures taken by Taiwan Government to recover from the economic setback after 2008 financial crisis, such as stimulating consumption, encouraging investment, and creating conditions for stable financial market to boost Taiwan's export, according to the studies by Taiwan researchers, E_{US}, currency exchange rate between US dollar and New Taiwan dollar, has become more important to countries depending heavily on exports. This is also supported from the change of coefficient of correlation between EX_{US} and E_{US} from 0.318 in Table 2 to –0.676 in Table 3. As a result, we will start with multiple regression of EX_{US} on E_{US} and another independent variable from the set of r_{US}, *ln* ($IPI'_{US\ (t-1)}$), $IPIY_{US}$, WPI_{TW}, IPI_{TW}, $WPIY_{TW}$, $INCOME'_{US}$, EX_{CH}, $CPIY_{CH}$ and *ln* ($M2_{CH}$). The results of these multiple regression are shown in Table 10.

Table 10: Multiple Regression of EX_{US} on E_{US} and Another Independent Variables after 2008 Financial Crisis

Fitted Regression Model	*S*	*Adj*-R^2
$EX_{US(t)} = 250 - 5.61E_{US\ (t-1)} + 23.6\ r_{US\ (t-1)}$	9.3131	32.4%
$EX_{US(t)} = -98 - 3.62\ E_{US\ (t-1)} + 63.8\ ln\ (IPI_{US\ (t-1)})$	9.2086	33.6%
$EX_{US(t)} = 142 - 2.02\ E_{US\ (t-1)} + 0.945\ IPIY_{US\ (t-1)}$	7.9430	47.8%
$EX_{US(t)} = -112 - 0.41\ E_{US\ (t-1)} + 1.88\ WPI_{TW\ (t-1)}$	8.6275	40.4%
$EX_{US(t)} = 28.1 - 0.47\ E_{US\ (t-1)} + 0.552\ IPI_{TW\ (t-1)}$	7.1771	55.3%
$EX_{US(t)} = 192 - 3.63\ E_{US\ (t-1)} + 0.698\ WPIY_{TW\ (t-1)}$	8.4481	42.4%
$EX_{US(t)} = 78 - 4.15\ E_{US\ (t-1)} + 0.013\ INCOME_{US\ (t-1)}$	9.2426	33.2%
$EX_{US(t)} = 118 - 2.5\ E_{US\ (t-1)} + 0.207EX_{CH\ (t-1)}$	7.7210	50%
$EX_{US(t)} = 77.4 - E_{US\ (t-1)} + 3.77CPIY_{CH\ (t-1)}$	7.7259	50%
$EX_{US(t)} = 19 - 3.71\ E_{US\ (t-1)} + 15.8\ ln\ (M2_{CH\ (t-1)})$	9.2544	33.1%

Table 10 shows the multiple regression of EX_{US} on E_{US} and IPI_{TW} generates the smallest *S* value of 7.1771 and the largest *Adj*-R^2 value of 55.3%.

Based on this, we conducted the multiple regression of EX_{US} on E_{US}, IPI_{TW}, and one independent variable from the set $CPIY_{CH}$, EX_{CH}, $IPIY_{US}$, $WPIY_{TW}$, and WPI_{TW}. The results of these multiple regression are shown in Table 11.

Table 11: Multiple Regression of EX_{US} on E_{US}, IPI_{TW} and A Third Independent Variables after 2008 Financial Crisis

Fitted Regression Model	*S*	*Adj*-R^2
$EX_{US(t)} = -78.2 + 2.96\ E_{US\ (t-1)} + 0.478\ IPI_{TW\ (t-1)} + 3.08\ CPIY'_{CH\ (t-1)}$	5.8723	66.4%
$EX_{US(t)} = 29.3 - 0.5\ E_{US\ (t-1)} + 0.539\ IPI_{TW\ (t-1)} + 0.0063 EX_{CH\ (t-1)}$	7.2658	54.5%
$EX_{US(t)} = 30.5 - 0.12\ E_{US\ (t-1)} + 0.437\ IPI_{TW\ (t-1)} + 0.396\ IPIY_{US\ (t-1)}$	7.0723	56.3%
$EX_{US(t)} = 31.7 - 0.32 E_{US\ (t-1)} + 0.482\ IPI_{TW\ (t-1)} + 0.326\ WPIY_{TW\ (t-1)}$	7.0575	56.4%
$EX_{US(t)} = -91 + 0.98\ E_{US\ (t-1)} + 0.499\ IPI_{TW\ (t-1)} + 0.743\ WPI_{TW\ (t-1)}$	7.1455	55.6%

Table 11 shows that the multiple regression of EX_{US} on E_{US}, IPI_{TW} and a third Independent variable generates the smallest *S* value of 5.8723 with the largest *Adj*-R^2 value of 66.4% when incorporated with independent variable $CPIY_{CH}$.

This drives us to carry on with the multiple regression of EX_{US} on E_{US}, IPI_{TW}, $CPIY_{CH}$ and a fourth independent variable from the set of $WPIY_{TW}$, $IPIY_{US}$, WPI_{TW}, and EX_{CH}. The results of these multiple regression are shown in Table 12.

Table 12: Multiple Regression of EX_{US} on E_{US}, IPI_{TW}, $CPIY_{CH}$ and Fourth Independent Variable after 2008 Financial Crisis

Fitted Regression Model	*S*	*Adj*-R^2	Remarks
$EX_{US(t)} = 2.6 + 1.05\ E_{US\ (t-1)} + 0.319\ IPI_{TW\ (t-1)} + 2.32\ CPIY_{CH\ (t-1)} + 0.119\ WPIY_{TW\ (t-1)}$	5.5361	68.9%	
$EX_{US(t)} = -120 + 3.7\ E_{US\ (t-1)} + 0.609\ IPI_{TW(t-1)} + 4.19\ CPIY_{CH\ (t-1)} - 0.54\ IPIY_{US\ (t-1)}$	5.7002	67.7%	$IPIY_{US\ (t-1)}$ *p-value* =0.071
$EX_{US(t)} = -67.1 + 2.84\ E_{US\ (t-1)} + 0.483\ IPI_{TW(t-1)} + 3.11\ CPIY_{CH\ (t-1)} - 0.076\ WPI_{TW\ (t-1)}$	5.9458	65.8%	$WPI_{TW\ (t-1)}$ *p-value* =0.893
$EX_{US(t)} = -86.4 + 3.16\ E_{US\ (t-1)} + 0.55\ IPI_{TW\ (t-1)} + 3.12\ CPIY_{CH\ (t-1)} - 0.0353\ EX_{CH\ (t-1)}$	5.9304	65.9%	$EX_{CH\ (t-1)}$ *p-value* =0.641 $IPI_{TW\ (t-1)}$ VIF=11.416

The results in Table 12 show that the multiple regression of EX_{US} on E_{US}, IPI_{TW}, $CPIY_{CH}$ and a fourth independent variable generates the smallest *S* value of 5.5361 with the largest *Adj*-R^2 value of 68.9% when incorporated with independent variable $WPIY_{TW}$. It is noted that the incorporation with other independent variables all carries with high *p-value*s for some of the variables indicating these regression models are less insignificant. We also found a high VIF value in the last fitted regression model indicating that a high degree of multi-collinearity among the predictors may exist.

We continued to conduct the multiple regression of EX_{US} on E_{US}, IPI_{TW}, $CPIY_{CH}$, $WPIY_{TW}$ and a fifth independent variable from $IPIY_{US}$, EX_{CH} and WPI_{TW}. The results of these multiple regression are shown in Table 13.

Table 13: Multiple Regression of EX_{US} on E_{US}, IPI_{TW}, $CPIY_{CH}$, $WPIY_{TW}$ and Fifth Independent Variable After 2008 Financial Crisis

Fitted Regression Model	*S*	*Adj*-R^2	Remarks
$EX_{US(t)} = -147 + 4.56\ E_{US\ (t-1)} + 0.597\ IPI_{TW\ (t-1)} + 4.87\ CPIY_{CH\ (t-1)} - 0.504\ WPIY_{TW\ (t-1)} - 0.18\ IPIY_{US\ (t-1)}$	5.5905	68.5%	$WPIY'_{TW\ (t-1)}$ *p-value* =0.119 $IPIY'_{US\ (t-1)}$ *p-value* =0.624
$EX_{US(t)} = -140 + 4.5\ E_{US\ (t-1)} + 0.467\ IPI_{TW\ (t-1)} + 4.98\ CPIY_{CH\ (t-1)} - 0.693\ WPIY_{TW\ (t-1)} + 0.0565\ EX_{CH\ (t-1)}$	5.5718	68.6%	$EX'_{CH\ (t-1)}$ *p-value* =0.483 $IPI'_{TW\ (t-1)}$ VIF=11.885
$EX_{US(t)} = -252 + 5.89\ E_{US\ (t-1)} + 0.549\ IPI_{TW\ (t-1)} + 4.89\ CPIY_{CH\ (t-1)} - 0.738\ WPIY_{TW\ (t-1)} + 0.639\ WPI_{TW\ (t-1)}$	5.5227	69%	$WPI'_{TW\ (t-1)}$ *p-value* =0.282 $E'_{us\ (t-1)}$ VIF=11.189

The results in Table 13 above show that all fitted regression models of EX_{US} on E_{US}, IPI_{TW}, $CPIY_{CH}$, $WPIY_{TW}$ incorporated respectively with $IPIY_{US}$, EX_{CH} and WPI_{TW} generate the *p-value*s higher than 0.1, indicating that these regression models are less insignificant. In addition, the VIF values of the last two fitted regression model are both high, signaling the possibility of high degree of multi-collinearity among the predictors.

Based on this, we conclude that the best set of macroeconomic variables affecting Taiwan's export to the US after 2008 financial crisis are: E_{US}, (Exchange Rate of one US dollar to New Taiwan dollars), IPI_{TW}, (Taiwan Industrial Production Index), $CPIY_{CH}$, (Mainland China Consumer Price Index Yearly Increment), and $WPIY_{TW}$ (Taiwan Wholesale Price Index Yearly Increment (excluding service)). The fitted regression model after 2008 financial crisis is therefore:

$$EX_{US\ (t)} = 2.6+1.05\ E_{US\ (t-1)} + 0.319\ IPI_{TW\ (t-1)} + 2.32\ CPIY_{CH\ (t-1)} + 0.119\ WPIY_{TW\ (t-1)}$$

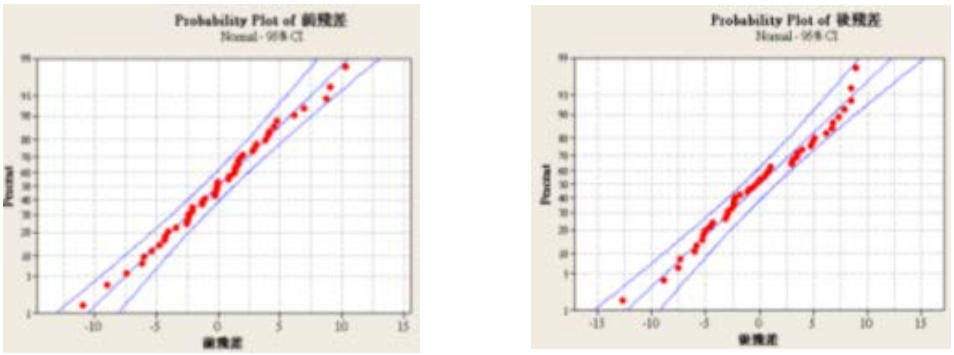
Validation of Fitted Regression Model

Normality Test

The left-hand-side of Figure 3 below shows the Normal Probability Plot of error residuals before 2008 financial crisis whereas the right-hand-side of Figure 3 shows the Normal Probability Plot of error residuals after 2008 financial crisis. We find all error residuals for both plots clustered close to a diagonal straight line from lower left corner to upper right corner. This is a indication that error residuals follow a normal distribution.

In addition, the results of the hypothesis test of "H0 : Error residuals follow normal distribution" against "HA : Error residuals do not follow normail distribution" produces the p-values before and after 2008 financial crisis of 0.955 and 0.504, respectively. Such large p-values provide further evidence that H0 cannot be rejected, and hence we can conclude that the error residuals should follow normal distribution assumption.

Figure 3: Normal Probability Plots of Error Residuals before and after 2008 Financial Crisis Residual Plot

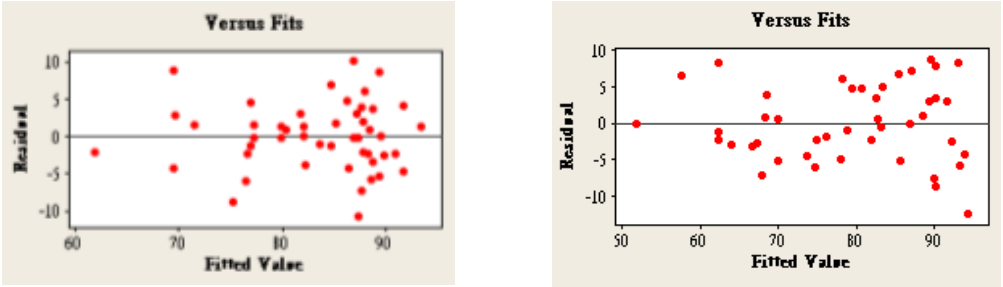


Residual Plot

The left-hand-side of Figure 4 below shows the residaul plot of error residuals before 2008 financial crisis whereas the right-hand-side of Figure 4 shows the residual plot of error residuals after 2008 financial crisis. We find that all error residuals for both plots seem to scatter randomly above and below the baseline of residual equals to zero. This is an indication that error residuals should satisfy the assumption of common variance for error residuals.

In addition, the results of the hypothesis test of "H_0 : Error residuals have common variance." against "H_A : Error residuals do not have common variance." reveal the *p-value*s before and after 2008 financial crisis are both greater than 0.1 which further confirms the common variance assumption for error residuals.

Figure 4: Residual Plots of Error Residuals before and after 2008 Financial Crisis Durbin-Watson Test



Durbin-Watson Test

It can be calculated that DW, the test statistic of Durbin-Watson test, for the fitted regression model before 2008 financial crisis is 1.9281, and 1.7370 for the fitted regression model after 2008 financial crisis. From Durbin-Watson Table, at α = 5% with 45 observations and four predictors, we have d_L = 1.34 and d_U = 1.72. Since both DW values are greater than d_U = 1.72, we conclude that there is no

first order autocorrelation among the residuals for both fitted regression models before and after 2008 financial crisis.

F-Test

Table 14 shows the results of ANOVA of fitted regression model before and after 2008 financial crisis. Based on the high *F* statistics and the near zero *p-value*s before and after 2008 financial crisis, we would reject the null hypothesis of "$H_0: \beta_1 = \beta_2 = \beta_3 = \beta_4 = 0$" and conclude that the four predictors (ie., independent variables) in the fitted regression models, either before or after 2008 financial crisis, collectively are significant.

Table 14: Results of ANOVA of Fitted Regression Model

Before 2008 Financial Crisis

Source	DF	SS	MS	*F*	*p-value*
Regression	4	2326.47	581.6175	26.090	0.000
Error Residual	42	936.28	22.2924		
Total	46	3289.75			

After 2008 Financial Crisis

Source	DF	SS	MS	*F*	*p-value*
Regression	4	4384	1096.00	19.200	0.000
Error Residual	39	2226.2	57.0821		
Total	43	6610.2			

t-Test and VIF Test

Table 15 shows the information with regard to the coefficients of the fitted regression model before and after 2008 financial crisis. Based on the high *t* test statistics and the low *p-value*s (i.e., all less than 0.05) associated with each of the four independent variables in the fitted regression model before and after 2008 financial crisis, we would reject the null hypothesis of"$H_0: \beta_i = 0; \quad i = 1, 2, 3, 4$"and conclude that each of the four predictors (ie., independent variables) in the fitted regression models, either before or after 2008 financial crisis, is significant.

We also observe from Table 15 that the maximum value of *VIF*, either before or after 2008 financial crisis is less than 10. This is an idication that multicollinearity among the four predictors both before and after 2008 financial crisis is note severe.

Table 15: Information with regard to the Coefficients of fitted regression model

Before 2008 Financial Crisis

Regression equation:

$EX_{US\,(t)} = 113 + 0.765\ IPI_{TW\,(t-1)} + 2.14\ E_{US\,(t-1)} + 3.43\ r_{US\,(t-1)} - 1.90\ IPI_{US\,(t-1)}$

Predictor	Coefficient	St. Error of Coefficient	*t*	*p-value*	*VIF*
Constant	113	66.1	1.72	0.043	
$IPI_{TW\,(t-1)}$	0.765	0.094	8.13	0.000	1.849
$E_{US\,(t-1)}$	2.14	1.89	2.06	0.046	1.907
$r_{US\,(t-1)}$	3.43	0.9	3.81	0.000	3.587
$IPI_{US\,(t-1)}$	-1.9	0.502	-3.79	0.000	3.784
S = 4.73307		*R-Sq* = 70.7%		*Adj-*R^2 = 68.0%	

After 2008 Financial Crisis

Regression equation:

$EX_{US\,(t)} = 2.6 + 1.05\ E'_{US(t-1)} + 0.319\ IPI'_{TW\,(t-1)} + 2.32\ CPIY'_{CH\,(t-1)} + 0.119\ WPIY'_{TW\,(t-1)}$

Predictor	Coefficient	St. Error of Coefficient	*t*	*p-value*	*VIF*
Constant	2.62	67.52	2.92	0.006	
$E_{US\,(t-1)}$	1.05	1.786	3.52	0.001	5.003
$IPI_{TW\,(t-1)}$	0.319	0.119	6.39	0	3.363
$CPIY_{CH\,(t-1)}$	2.32	1.263	5.1	0	5.767
$WPIY_{TW\,(t-1)}$	0.119	0.3286	2.45	0.019	3.838
S = 5.5361		*R-Sq* = 72.3%		*Adj-*R^2 = 68.9%	

Inference on Best Fitted Models

Based on the previous regression results and analyses, we conclude that the significant macroeconomic variables affecting Taiwan's export value to the U.S. before 2008 financial crisis are:

- IPI_{TW} : Taiwan Industrial Production Index
- E_{US} : Exchange Rate of one US dollar to New Taiwan dollars

- r_{US} : US Interbank Real Call Loan Rate
- IPI_{US} : US Industrial Production Index

The best fitted multiple regression model based on these four macroeconomic variables, before 2008 financial crisis, can be derived as:

$$EX_{US}\,(_{t)} = 113 + 0.765\ IPI_{TW\,(t-1)} + 2.14\ E_{US\,(t-1)} + 3.43\ r_{US\,(t-1)} - 1.90\ IPI_{US\,(t-1)}$$

Based on the value of multiple coefficient of determination, $Adj\text{-}R^2$ = 68.0%, in Table 15, this model has 68% predictability for the period before 2008 financial crisis.

On the other hand, the significant macroeconomic variables affecting Taiwan's export to the U.S. after 2008 financial crisis are:

- E_{US} : Exchange Rate of one US dollar to New Taiwan dollars
- IPI_{TW} : Taiwan Industrial Production Index
- $CPIY_{CH}$: Mainland China Consumer Price Index Yearly Increment
- $WPIY_{TW}$: Taiwan Wholesale Price Index Yearly Increment (excluding service)

The best fitted multiple regression model, after 2008 financial crisis, based on these four macroeconomic variables can be derived as:

$$EX_{US(t)} = 2.6 + 1.05\ E_{US\,(t-1)} + 0.319\ IPI_{TW\,(t-1)} + 2.32\ CPIY_{CH\,(t-1)} + 0.119\ WPIY_{TW\,(t-1)}$$

Based on the value of multiple coefficient of determination, $Adj\text{-}R^2$ = 68.9%, in Table 15, this model has around 69% of predictability for the period after 2008 financial crisis.

Compared with the best fitted regression models before and after 2008 financial crisis, we have the following observations:

- The impact of US dollar to New Taiwan dollar exchange rate on Taiwan's export value to the U.S. before 2008 financial crisis is reduced to half after 2008 financial crisis. This is likely because such exchange rate has become more stable after 2008 financial crisis as the Government of Taiwan struggled to stabilize the fluctuation of New Taiwan dollar exchange rate against US dollar as part of the effort to recover from the economic setback that resulted from 2008 financial crisis.

- The impact of Taiwan's industrial production index on Taiwan's export to the US before 2008 financial crisis also reduces to about half after 2008 financial crisis. This is likely because after 2008 financial crisis, more and more companies in Taiwan's manufacturing sector have moved outside of Taiwan (mostly to China and some to Southeast Asian countries). As a result,

Taiwan's service sector has become more important after 2008 financial crisis.

- U.S. Interbank real call loan rate and U.S. industrial production index become insignificant after 2008 financial crisis. This is likely due to the sluggish U.S. industrial production and the low interest rate policy adopted by U.S. Federal Reserve Board as a measure to boost the U.S. economy after 2008 financial crisis.

- Mainland China consumer price index yearly increment becomes particularly significant after 2008 financial crisis. This is likely due to continuous strong growth of China's economy despite 2008 financial crisis. Such growth would inevitably trigger the inflation which is reflected on the consumer price index. Since after signing "Economic Cooperation Framework Agreement", the economic tie between China and Taiwan has further strengthened after 2008 financial crisis, a good portion of the increased economic activities in China is the result of products manufactured by Taiwanese companies. Many of these manufactured goods were exported to the US via Taiwan.

- Taiwan's wholesale price index yearly increment (excluding service) becomes significant after 2008 financial crisis. Since material cost is included in wholesale price, the increase of Taiwan wholesale price index yearly increment reflects the increase of material costs which is an indication of economic recovery. For a country where most of its GDP comes from export, such economic recovery represents the increase of Taiwan's export value to the US.

Predictability of Best Fitted Model

To conduct the test on the predictability of the fitted regression model after 2008 financial crisis, we use the derived fitted regression model to forecast Taiwan's export value to the US for September, October, November and December of 2012 and compare the results with the actual export values. The result is shown in Table 16. It can be seen that, despite some deviation for the forecasted export value for September and October of 2012, all forecasted export values fall in between the lower level and upper level of 95% confidence interval.

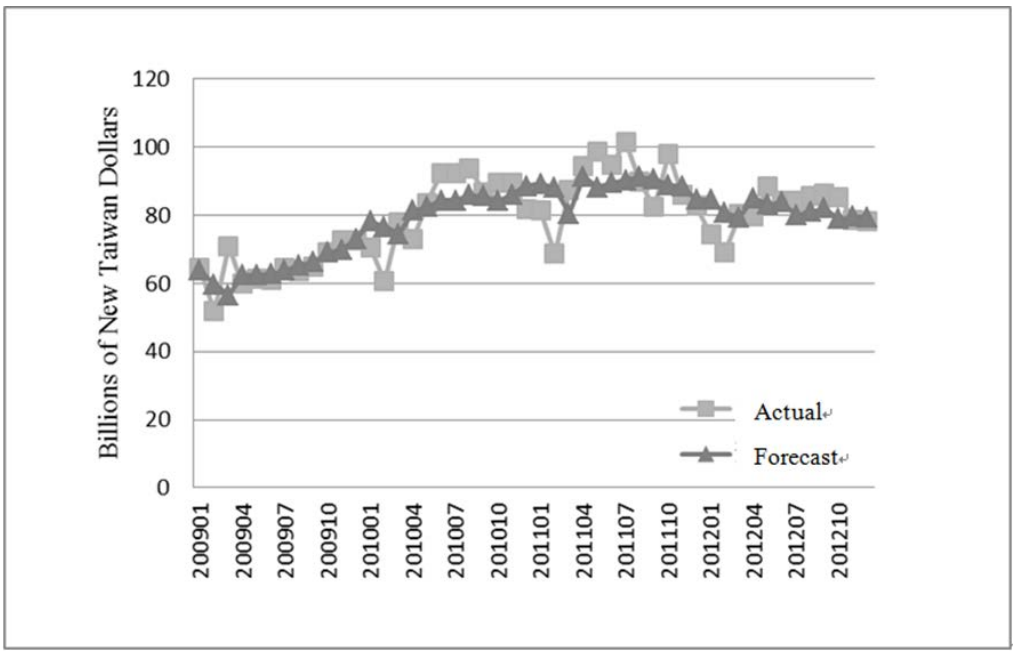
Table 16: Forecast Using Fitted Regression Model after 2008 Financial Crisis (Value in Billions of New Taiwan Dollars)

Year / Month	Actual	Forecast	Lower 95% Confidence Interval	Upper 95% Confidence Interval
2012 / 09	86.221	81.91	76.44	87.38
2012 / 10	85.356	78.79	71.87	85.71

2012 / 11	78.635	79.43	72.16	86.69
2012 / 12	78.337	79.31	72.17	86.44

Figure 5 shows the comparison of the fitted values calclulated using the fitted regression model and the actual export values from Taiwan to the U.S. after 2008 financial crisis. Calculation of mean squared errors reveals that this fitted regression model follows closely to the trend of actual export values.

Figure 5: Comparison of Fitted Values and Actual Trade Values After 2008 Financial Crisis (2009.01 to 2012.10)



Concluding Remarks

Due to the lack of natural resources and limited domestic market, export to the U.S. is vital to Taiwan's economy. Like most of the countries, the financial crisis of 2008 has made a great impact on Taiwan's export oriented economy and, therefore, changed the macroeconomic variables that affect Taiwan's export value to the U.S. This research conducted the multiple regression analysis to define the set of best predictors before and after 2008 financial crisis, and compared their differences and significances. Using the derived fitted regression model after 2008 financial crisis, we have also conducted the forecast on four month data to evaluate its predictability.

The results of this research reinforce the importance of currency exchange rate on Taiwan's export value to the U.S. which is proportional to trade volume both before and after 2008 financial crisis.

With the growing mobility of capitals moving in and out of Taiwan due to Internet banking and less government regulation, currency exchange rate of Taiwan is in danger of being distorted by the injection of "hot money". As a result, the role of the Central Bank of Taiwan will become more important in the future.

The industries in Taiwan are mostly capital and technology intensive. The fitted regression model after 2008 financial crisis indicates that, on average, one point increase in Taiwan's industrial production index will contribute around 0.319 billion of New Taiwan dollar (around 10.63 million US dollars) increase on the export value to the U.S. This indicates that the enhancement of Taiwan's industrial performance is vital to its export competitiveness.

The economic integration between Taiwan and China has increased to a point where China's consumer price index is beginning to affect Taiwan's export value to the U.S. Recent move of some of Taiwan's investments from China to Southeast Asia, particularly to Vietnam, may ease a little on this situation. This will have to be verified by future researches.

As the worldwide economy continues to grow after 2008 financial crisis, the costs of raw materials begin to escalate. This has made Taiwan's wholesale price index yearly increment one of the influential macroeconomic variables in the fitted regression model after 2008 financial crisis. Since most of Taiwan's materials are imported and, as a result, its price is also subject to the currency exchange rate of New Taiwan dollar. The balance between lowering down imported material costs and increasing the export value will become a difficult lesson for the Government of Taiwan.

From the international management point of view, the result of this research can provide, not only as a useful reference to the Government of Taiwan, it can also serve as a reference for the countries whose GDP depends heavily on the exports to the U.S. The methodology adopted by this research further demonstrates the applicability of multiple regression on the empirical analysis of time series data in an effort to find the cause-and-effect relationship between the dependent variable and its vital predictors.

References

English

Asseery, A. and Peel, D. A. 1991. The Impact of Exchange Rate Volatility on Export Growth: Some Theoretical Considerations and Empirical Results. *Journal of Policy Modeling* 9: 225-244.

Cheong, C., Mehari, T. and Williams, L. V. 2005. The Effects of Exchange Rate Volatility on Price Competitiveness and Trade Volumes in the UK: A Disaggregated Approach. *Journal of Policy Modeling.* 27(8): 961-970.

Engle, R. F. and Granger C. W. J. 1987. Co-integration and Error Correction: Representation, Estimation, and Testing. *Econometrica: Journal of the Econometric Society*. 55(2): 251-276.

Fleming, J. M. 1962. Domestic Financial Policies Under Fixed and Under Floating Exchange Rates. *Staff Papers, International Monetary Fund*. 9: 369-379.

Grier, K. B. and Smallwood, A. D. 2006. Uncertainty and Export Performance: Evidence from 18 Countries. *Journal of Money, Credit & Banking*. 39(4): 967-977.

Grier, K.B. and Smallwood, A.D. 2013. Exchange Rate Shocks and Trade: A Multivariate GARCH-M Approach. *Journal of International Money and Finance*, 37: pp. 282-305.

Gotur,. 1985. Effects of Exchange Rate Volatility on Trade." *IMF Staff Papers*. 32: 475-572.

In, F. and Sgro, P. 1998. Export Growth and Its Determinants: Some Evidence for South Korea and Singapore. *Applied Economics Letters*. 5(4): 225-30.

Mundell, R. A. 1963. Capital Mobility and Stabilization Policy under Fixed and Flexible Exchange Rates. *Canadian Journal of Economics and Political Science*. 29(3): 475-485.

Lee, W. S., Shimojo, S. and Doherty, J. P. 2003. Neural Computations Underlying Arbitration between Model-Based and Model-free Learning. *Neuron*. 81(3): 687-699.

Nishimura, Y., Hirayama, K. 2013. Does Exchange Rate Volatility Deter Japan-China Trade? Evidence from pre-and post-exchange rate reform in China, *Japan and the World Economy*, 25-26: pp. 90-101.

Sachs, C. 1980. Wages, Flexible Exchange Rates, and Macroeconomic Policy. *Quarterly Journal of Economics*. 94(4): 731-747.

Saang Joon, B. 2008. The Bilateral Real Exchange Rates and Trade between China and the U.S. *China Economic Review*, 19(2): 117-127.

Soleymani, A. and Chua, S.Y. 2014. Effect of Exchange Rate Volatility on Industry Trade Flows between Malaysia and China. *Journal of International Trade and Economic Development*, 23 (5): pp. 626-655.

Chinese

Huang, J. R. 2009. An Empirical Study of the Influence of Exchange Rate Fluctuation on Export and Import Trade. *Master Thesis*, National Chung Cheng University.

Huang, L. R. 2011. The Influence of Exchange Rate and Income Fluctuation on Taiwan's Export and Import Trade. *Master Thesis*, National Taipei University.

Ke, S. H. and Jiang, C. Z. 2011. A Correlation Analysis among Real Income, Relative Price, Exchange Rate and International Trade: Trade between Taiwan and the US. *Journal of Chinese Economic Research*, 9(2): 21-32.

Wang, H. R. 2005. The Exchange Rate of New Taiwan Dollar on Taiwan's Economic and Financial Activities. *Central Bank Quarterly*, 27(1): 13-45.

Xiong, Y. Z. 1995. The Influence of Currency Exchange Rate Fluctuation on Taiwan's Import and Export Volume. *Master Thesis*, National Chung Hsing University, Taiwan.

Yang, M. J. 2002. The Influence of Taiwan's Investment in China on Taiwan's Export Trade. *Master Thesis*, National Cheng Kung University, Taiwan.