DETERMINANTS OF BILATERAL TRADE BETWEEN THE UNITED STATES AND JAPAN

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The Supervisory Committee certifies that this ***disquisition*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

MASTER OF SCIENCE

ABSTRACT

Walter, Jason Michael; M.S.; Department of Agribusiness and Applied Economics; College of Agriculture, Food Systems, and Natural Resources; North Dakota State University; March 2010. Determinants of Bilateral Trade Between the United States and Japan. Major Professor: Dr. Won W. Koo.

The objective of this study is to evaluate the effects of macroeconomic policy variables on bilateral trade between the United States and Japan. An auto-regressive distributed lag model is developed to estimate the effects of government economic policies on four commodity groups: agriculture; materials and chemicals; machinery and transport equipment; and manufactured goods.

Results indicate that monetary policy significantly affects U.S. and Japanese imports of manufactured goods and transport equipment. The results also show that changes in government expenditure have a significant long-run effect on U.S. imports of manufactured goods and Japanese imports of materials and chemicals, while the long-run effects of income and exchange rates are significant for most commodity groups.

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CHAPTER 1. INTRODUCTION

The effect of international trade on economic growth has become an increasingly important focus in development literature. The relationship between international trade and growth are of significant importance, since each country's production and consumption are affected by changes in trade. Foreign producers may be more efficient in the production of specific goods than domestic producers, and are able to export at a relatively lower price. Imports of foreign goods could result in a decrease in domestic production. Imports of foreign goods could be harmful to domestic producers, but good for domestic consumers. Domestic consumers can purchase imported goods at a lower price, relative to domestically produced substitutes.

Within certain industries, production may be complementary between foreign and domestic producers. Production in each country can be specialized, allowing each country to focus on production of specific parts of an industry. This intra-industry exchange will bring more efficient domestic and foreign production, resulting in decreases in relative price in both markets.

National income is an important factor determining a country's consumption of domestic and foreign goods. Increases in income not only allow countries to import more foreign goods, but also to consume more domestically produced goods. If domestic income rises relative to foreign income, domestic consumption of imports would rise and lead to an increase in foreign production. Growth of domestic income may indirectly increase imports of foreign goods and thereby affect foreign income.

Fiscal and monetary policies play an important role in influencing aggregate demand, and can have a substantial role in the business cycle. The effects of government expenditures on production may be minimal depending on the purchases made. If government expenditures replace private expenditures, overall consumption composition remains unchanged. Government expenditures can permanently alter resource allocations and gross domestic product (GDP) structure, if expenditures are allocated differently then would be by the private market (Devarajan et al. 1996). Monetary policy is considered by many economists to be the main driving force behind aggregate demand (Ahmed 1998).

Monetary policy influences expenditures by adjusting the availability of capital. Expansionary monetary policy lowers the cost of capital, and thus increases aggregate demand by making capital more available. On the other hand, contractionary policy is used to reduce aggregate demand by decreasing the amount of capital in the market and raising capital costs. Changes to government expenditures and monetary policy will have an underlying affect, not only on consumption, but also on GDP (Day and Yung 2009).

As foreign and domestic markets intertwine, exchange rates determine the relative price of goods and services between countries. The exchange rate is determined by the relative demand of foreign and domestic currencies. If foreign investments or products become more appealing, domestic consumers will trade domestic currency for foreign currency or vice versa. This will lead to an appreciation of foreign currency relative to domestic currency, and alter the prices of foreign goods and services for domestic consumers. As domestic currency depreciates, the relative price of domestic goods and services decreases for foreign consumers, and may increase foreign demand for domestic products.

Specific Problem

The United States and Japan are the two largest economies in the world (The World Bank 2008). Their combined GDP accounts for one-third of the world economy. These two countries have a long political and economic history, going back to their post WWII alliance (U.S. Department of State 2009). Since then, Japan has become increasingly important for the U.S. economy. Figure 1.1 shows import and export values exchanged between the United States and Japan, excluding shipping, tariff, and insurance costs.

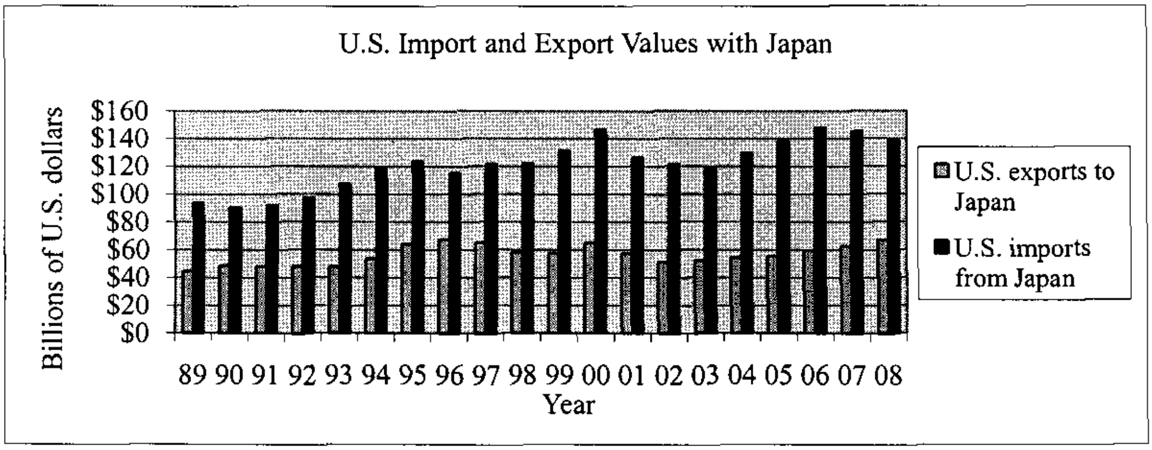

Figure 1.1 U.S. Import and Export Values with Japan, 1989-2008.
Source: U. S. International Trade Commission: Interactive Tariff and Trade Dataweb 1989-2008.

Currently, the United States is Japan's fourth largest export market, and Japan is the fourth largest importer of U.S. goods (U.S. Census Bureau 2009). More than $200 billion dollars worth of goods were exchanged in 2008. Japan has maintained a trade surplus with the United States for the past two decades, which has played a part in the increase of the U.S. trade deficit.

Japan also is a large source of investment in the U.S. economy. As of 2008, Japan is the second-largest source of foreign direct investment (FDI) and one of the largest foreign holders of U.S. treasury securities (U.S. Department of State 2008). Japanese FDI in the United States continues to grow faster than the overall U.S. economy. U.S. FDI in Japan was minimal before 2001. Since the creation of the U.S.-Japan Investment Initiative, U.S. FDI has increased 94% in five years (U.S. Department of State 2009). U.S. FDI in Japan totaled $101 billion in 2008, with investment focused primarily in financial services, internet services, and software (U.S. Department of State 2009). Figure 1.2 shows the growth of U.S. FDI in Japan and Japanese FDI in the United States for 1987-2007.

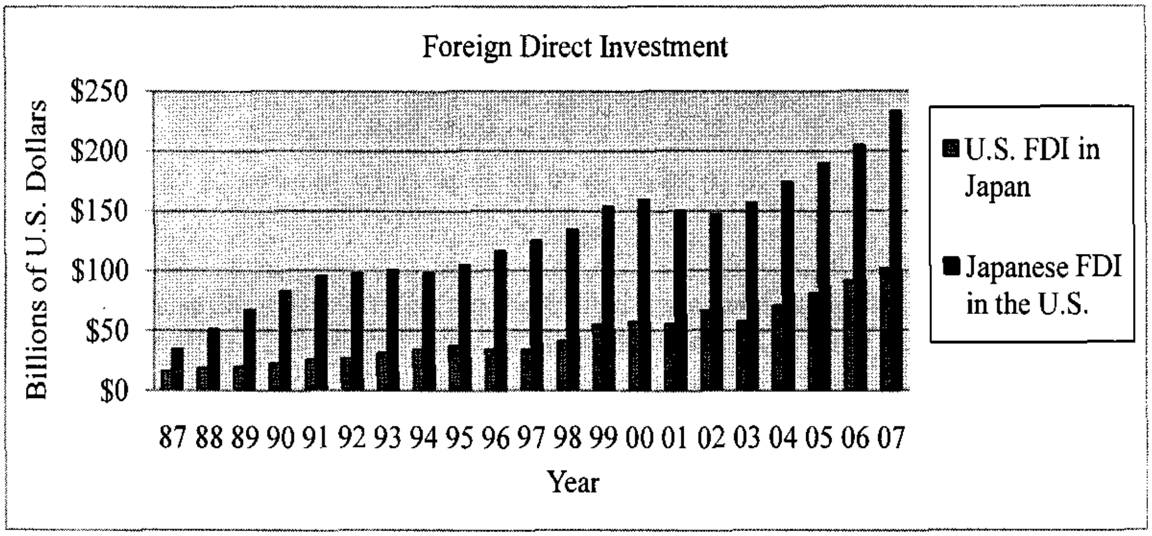

Figure 1.2 Foreign Direct Investments for the United States and Japan, 1987-2007. Source: U.S. Bureau of Economic Analysis-International Transaction Accounts: Japan: U.S. direct investment abroad and Foreign direct investment in the United States.

The GDP for Japan is over $4 trillion, one-third of the U.S. GDP; however, gross national income per capita is relatively high for both countries (World Bank 2008). Japan and the United States are considered high income countries by the World Bank, ranking in the top 25 countries in terms of per capita income. GDP growth in both countries has differed greatly in the past 20 years. While the U.S. GDP has grown from $4.7 trillion in 1987 to $14 trillion in 2007, the Japanese economy has struggled since 1994, when it peaked at $4.87 trillion. As of 2007, Japan's GDP was $4.52 trillion, which is still below its 1994 apex. The United States has maintained relatively steady growth, with the exception of two mild recessions. From 1984 to 2008, U.S. GDP has tripled in size. Figure 1.3 shows the growth of both the United States and Japan's GDP from 1987 through 2007.

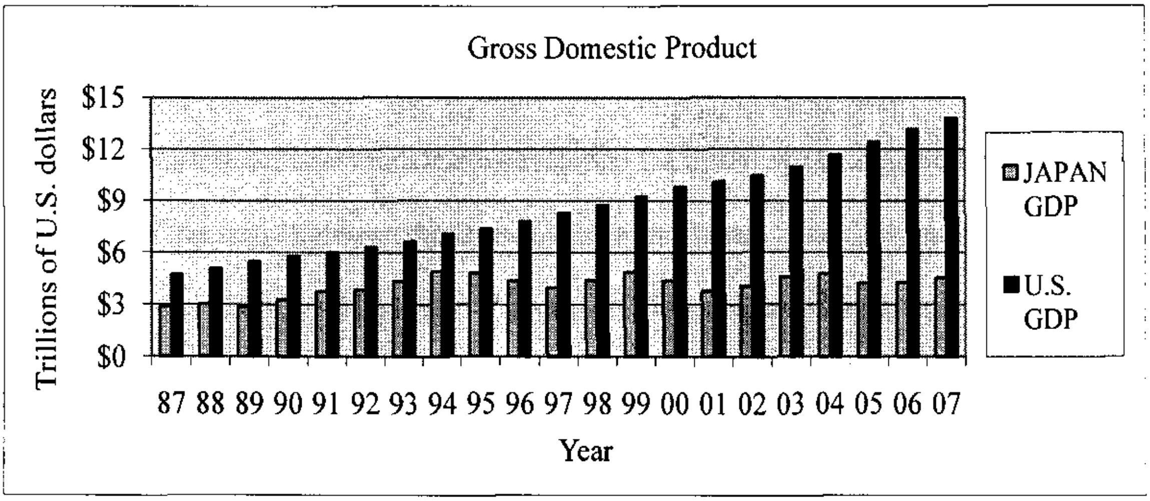

Figure 1.3 Gross Domestic Product for the United States and Japan, 1987-2007.
Source: International Monetary Fund-Data and Statistics: Interactive Database.

Objectives

This study's focus is to show the impact of income, interest rates, exchange rates, and government expenditures on bilateral trade of selected commodity groups between the United States and Japan. The commodity groups are established on the basis of the Standardized International Trade Classification (SITC) system[1], classifying the industries by SITC one-digit codes. The specific objectives of this analysis are to:

1) Identify the structure and composition of bilateral trade between the

[1]SITC by group: 0-Food and live animals; 1-Beverages and tobacco; 2-crude materials, inedible, except fuels; 3-Mineral fuels, lubricants, and related materials; 4-Animal and vegetable oils, fats and waxes; 5-Chemicals and related products, N.E.S.; 6-Manufactored goods classified chiefly by material; 7-Machinery and transport equipment; 8-Miscellaneous manufactured articles; 9-Commodities and transactions not classified elsewhere the SITC. Source: U.N. Statistics Division: Detailed Structure and Explanatory Notes.

U.S. and Japan

2) Analyze how trade from each commodity group is affected by changes in exchange rates, income, interest rates and government expenditures
3) Evaluate the different effects that exchange rates, income, interest rates and government expenditures have on imports for the United States and Japan.

Method

Two import demand models are developed for this study to analyze factors affecting bilateral trade between the United States and Japan. The first model analyzes the effect of macroeconomic variables on U.S. imports from Japan. The main variables included in the model are U.S. national income (GDP), U.S. government expenditures, the ratio of interest rates between the United States and Japan, exchange rate, and the value of U.S. imports from Japan by commodity group.

The second model analyzes the effects of macroeconomic variables on Japanese imports from the United States. Relevant variables in the model include Japan's national income (GDP), Japanese government expenditures, ratio of interest rates between the United States and Japan, exchange rate, and the value of Japanese imports from the United States by commodity group.

This study uses quarterly time series data from the first quarter of 1989 through the second quarter of 2008 to analyze bilateral trade between the United States and Japan by commodity group, using SITC one-digit codes for industry categories. The industry trade data were obtained from the *United States International Trade Commission: Trade Database*. GDP growth rates, interest rates, and government expenditure estimates were obtained from *International Monetary Fund: Data and Statistics* for the United States and Japan. The interest rates used is each country's discount policy, these were obtained from each country's central bank. Monthly exchange rates were obtained from the *United States Department of Agriculture: Economic Research Service.*

Organization

A background on U.S.-Japanese trade relations will be discussed in chapter two, along with studies regarding bilateral trade will be examined. Chapter three includes economic background and an evaluation of the composition of U.S.-Japan bilateral trade and resource endowments. In chapter four, the theoretical framework is examined to develop an empirical model. Chapter five provides the necessary statistical tests. Chapter six interprets the empirical results and discusses the inference drawn from them. Chapter seven provides a summary of the results, and discusses possible areas for further study.

CHAPTER 2. LITERATURE REVIEW

In this section, literature pertaining to international trade is discussed. A brief background on Japanese and U.S. trade relations is followed by an overview of studies focusing on exchange rates, income, interest rates, government expenditures, and trade.

Background

The United States and Japan have a long standing trade relation extending back to post WWII. Since then, trade relations have changed dramatically. Post WWII, Japan and the United States were in very different conditions. Japan was devastated physically and economically, while the United States had positioned itself as a major military and economic power. After regaining sovereignty in 1952, Japan focused on economic development by upgrading its industries and expanding its export markets (Katada 2001). Japan frequently ran trade deficits with the United States, until 1965. At that time, U.S. administration sought to increase Japanese exports to the United States (Katada 2001). During the late 1960s, Japan experienced enormous economic growth, driven by its industrial development and increased exports. Trade relations between Japan and the United States changed, as Japan began experiencing a trade surplus (Katada 2001), which continues to be the case through 2008.

Before 1980, various U.S. industries sought protection from Japanese exports of textiles, steel, televisions and automobiles (Flath 1998). The government of Japan agreed to voluntary reductions in its exports. By the mid-1980s, the Japanese government had substantially reduced exports to the United States (Flath 1998). In 1985, increased imports of Japanese goods prompted the U.S. Senate to pass a non-binding resolution aimed at punishing Japan. The Senate proposed a 25% surtax on any nation with large U.S. bilateral trade surpluses. Japan was one of the four countries that met the criterion. During the G-5 meeting in 1985, participating nations agreed upon monetary coordination to depreciate the U.S. dollar (Flath 1998). Since 1985, the U.S. government has obtained numerous Japanese concessions, to the benefit of U.S. exporters (Flath 1998).

In 1989, the U.S and Japan began the Structural Impediments Initiative, which focused on increasing entry to Japanese markets for U.S. exporters and investors (Cooper 2007). Further negotiations were reached under the Economic Partnership framework. With the creation of dispute settlement within the World Trade Organization (WTO), bilateral trade issues have been resolved by WTO panel members (Cooper 2007). While trade concerns between the United States and Japan still exist, WTO involvement has improved resolution of these concerns (Cooper 2007). Table 2.1 shows the U.S. and Japanese trade balance for the last two decades.

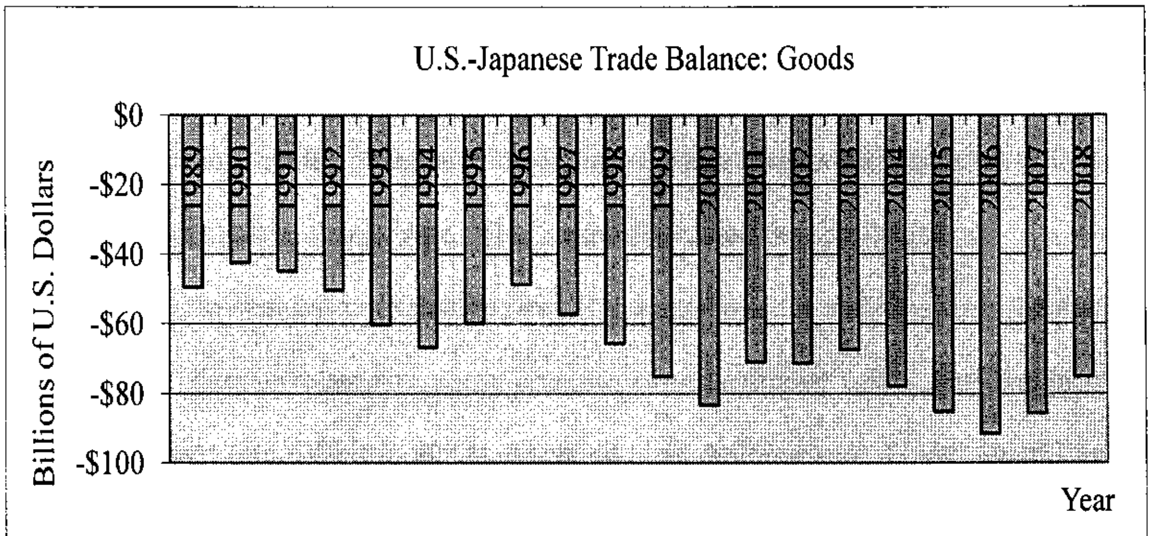

Figure 2.1 U.S.-Japanese Trade Balance: Goods, 1989-2008.
Source: U.S. Census Bureau: International Transactions Account Data.

Review of Trade Studies

Frenkel et al. (2005) analyzed the effects of the Bank of Japan's currency intervention on yen/dollar exchange rates. From 1993 to 2000, the Bank of Japan intervened in the foreign exchange market on 171 days (Frenkel et al. 2005). Of those days, the bank bought U.S. dollars on 165 days and sold U.S. dollars on 6 days. Frenkel et al. examined the Bank of Japan's intervention activity by evaluating the exchange rate, lagged volatility, and Nikkei in relation to the yen/dollar exchange rate. The analysis showed, on average, that the Bank of Japan interventions were positively correlated with yen/dollar exchange rate changes. Moreover, their analysis showed secret Bank of Japan interventions tended to be correlated with increases in exchange rate volatility (Frenkel et al. 2005).

Bahmani-Oskooee and Goswami (2003) analyzed the effects of currency depreciation on trade balance by using the elasticity of trade volume to relative prices. Examining nine of Japan's largest trading partners, Bahmani-Oskooee and Goswami focused on bilateral trade data to estimate the elasticities of trade volume to relative prices. Elasticities are determined using import/export values and exchange rates. A two-equation model was used to examine changes in the value of Japan's export/import relative to each country's income and exchange rate. This method revealed the sensitivity of imports/exports to changes in exchange rate. Bahmani-Oskooee and Goswami estimate the export (import) demand elasticity, using previous export (import) values, national income, and real exchange rate. Their model is expanded to an Autoregressive Distributed Lag method by Pesaran et al. (2001). The model includes lagged values of national income, real exchange rate, and exports to examine short-run and long-run relationships. Bahmani-

Oskooee and Goswami's analysis demonstrates that Japanese export demand is relatively inelastic, and gives evidence that Japanese exporters offset yen depreciation with reduced profit margins. However, Japanese imports are relatively elastic, fluctuating with exchange rate changes.

Tomlin (2008) analyzes the impact exchange rates on Japanese FDI within the U.S. service industry. Tomlin describes the unique characteristic of the service industry, including the intangibility and non-storability of most services. Using 207 service industries, Tomlin models the response of Japanese FDI to changes in sunk costs, relative labor cost, exchange rate, and expected profits. His measurement shows that Japanese FDI in U.S. service industries is positively correlated to increased FDI flows and the yen/dollar exchange rate. Tomlin's results illustrates that the relatively higher U.S. labor costs were a deterrent for Japanese FDI in the service industry.

Bahmani-Oskooee and Hegerty (2008) examined the effects of exchange rate fluctuations between the yen and dollar on U.S. and Japanese trade. Looking at 117 industries, they analyzed changes in the annual trade balance from 1973 through 2006. Using cross-sectional data, Bahmani-Oskooee and Hegerty followed a model previously developed by Ardalani and Oskooee (2007). The Ardalani and Oskooee trade balance model examines short-run and long-run effects of currency depreciation at the commodity level. In addition, the model shows the relationship of domestic income, foreign income, and real exchange rates to trade balances. Bahmani-Oskooee and Hegerty extend this long-run model to incorporate short-run exchange rate changes together with long-run changes. In order to see these relationships, they developed an error-correction model that includes both annual changes and lagged adjustments. Lagged values are adjusted using Akaike

Information Criterion with a maximum of three time periods. The majority of the short-run coefficients are positive, signifying immediate increases in Japan's exports with a depreciation of the yen. Bahmani-Oskooee and Hegerty explained that of the 117 industries studied, exports within 45 of those industries showed large responses to uncertainty; specifically, capital-intensive durable goods. Imports from 35 industries confirmed significant increases from volatility; specifically, intermediate goods. Bahmani-Oskooee and Hegerty conclude that long-run appreciation of the yen would be detrimental to Japanese export industries.

Income

Alfaro et al. (2004) examined the effects of FDI on economic growth within countries with developed financial markets. The study used 20 countries within the Organization for Economic Co-operation and Development (OECD) and 51 non-OECD countries to analyze their credit markets. Alfaro et al. utilized several variables within their growth model, including population growth, education level, FDI, and GDP. This study results are similar to Carkovic and Levine (2003); that is, gains from FDI are more significant within developed financial markets. Alfaro et al. concludes that FDI is significant in promoting economic growth, with developed financial markets further increasing the effects.

Frankel and Romer (1999) examined the effects of trade on income, by using a cross-country regression of income per capita on area, population, proximity to other countries, and domestic port access. They utilized data from the Penn World Table, with a sample of 150 countries in 1985. Their estimation is compared to an ordinary least squares

(OLS) estimation[2] examining the same variables; however, their model distinguishes itself by assuming that trade is an endogenous variable. Frankel and Romer's basic OLS regression results show a significant relationship between trade and income. Their analysis of each model explains that the link between trade and income may be understated by OLS. Their model estimates that a one-percent increase in trade share increases income per capita by two percent. Frankel and Romer examined possible bias in their analysis, specifically regional trade differences and the inclusion of oil exporting countries, both of which may produce skewed results. They proceeded with an additional estimation of both models, included regional dummy variables and the removal of major oil exporting countries to correct for the previously mentioned bias. The analysis of each model with the additional variables had no significant impact on Frankel and Romer's results. In their model, the estimated effects of trade, on growth, maintains a higher effect than OLS estimates. Frankel and Romer's explanation for the understated OLS estimates is from measurement error, due to interactions that are not limited to trade.

Baek and Koo (2007) examined the effects of income, exchange rates, and the money supply on the U.S. agricultural trade balance. Agricultural data were collected from the Foreign Agricultural Trade of the United States (FATUS). Income was measured by the real GDP index from the IMF. The U.S. and its major trade partners' monetary base was collected from the IFS. They examined quarterly data from the fourth quarter of 1975 to the fourth quarter of 2004. Baek and Koo utilized an auto-regressive distributed lag (ARDL) model to measure both long and short term effects. Their results show that the U.S. exchange rate plays a significant role in agricultural trade. This correlates with the

[2] Ordinary least squares estimation is a statistical method used to obtain a representative line, by minimizing the difference of each observation and the representative line.

deterioration of the agricultural trade balance in late 1990s when the dollar appreciated. Baek and Koo conclude that U.S. income and money supply play a significant role with exchange rates on the U.S. agricultural trade balance in both the short and long-run.

Interest Rates

Michaelides and Kalyvitis (2001) investigated the effects of U.S. monetary policy shocks on exchange rates (U.S. dollar vs. Yen, Mark, Lira, Franc, Sterling). Utilizing the monetary indicator developed by Bernanke and Mihov (1998), Michaelides and Kalyvitis use a vector auto-regression with relative output and prices. They analyze monthly data between 1975 and 1996 from the International Financial Statistics within the IMF. The results show that monetary shocks significantly alter all five exchange rates for at least three months; with the sterling having a significantly longer effect. Michaelides and Kalyvitis concluded that contractionary U.S. monetary policy results in persistent appreciation of the U.S. dollar.

Government Policy

Muller (2008) examined the effects of fiscal policy on foreign trade, utilizing a vector auto-regression with six variables: real government expenditures, private spending, GDP deflator, nominal exchange rates, terms of trade, and three variations for the sixth variable (net exports, real private investment, and real private consumption). The calculations are based on data from the U.S. Bureau of Economic Analysis for 1973 to the third quarter of 2005. Muller calculates point estimates and constructs 95% confidence intervals, based on the Hall bootstrap procedure. A 1% increase in government expenditures illustrates that the terms of trade significantly appreciate, peaking after four quarters. Similarly, the ratio of net exports to GDP, show an extended increase of 0.1%. Muller concludes that an increase in government expenditures significantly depreciates the nominal exchange rate; although, government expenditures appreciate the terms of trade and increase net exports.

Trade

Head and Ries (2001) evaluated the effects of FDI on trade. Using Japanese manufacturing firms' data, they analyze the effects between trade and FDI. Including 25 years of data from 932 Japanese manufacturing firms, Head and Ries evaluated the relationship between FDI and exports. Their analysis focused on firm level production costs, which utilized distribution and manufacturing investment. They examine the relationship of manufacturing firms' exports with wages, capital intensity, and productivity. FDI was found to have a substitution effect on firms exporting intermediate inputs, while other industry had net complementary effect on exports. However, Head and Ries cautioned that this relation may be limited to firms with superior products, not a causal relationship between FDI and exports.

Blonigen's (2001) analysis of bilateral-trade focused on examining the complimentary or substitution effects of trade within disaggregated product-level data. The study centers on Japanese production and exports of automobile parts to the United States Blongien derives a U.S. demand function utilizing Japanese production, U.S. production, and input prices. His analysis utilized product level data from 11 final goods. Blongien found that all final goods in his analysis had a substituting relationship with exports. The only exception was automobiles which had a complementary relationship. Blongien explains that while aggregated trade data show net-complimentary effects, substitution is easily identified with product-level data.

Breuer and Clements (2003) examined disaggregated trade data to identify composition of bilateral trade between the United States and Japan. Using SITC at the one-digit level, they detail the changes in trade composition for four periods: 1978-1980, 1981-1985, 1986-1991, and 1992-1996. Their analysis shows that the United States maintained a net trade surplus in SITC-0, 1, 2, 3, 4, and 5, while SITC-6, 7, and 8 have maintained a net trade deficit. Breuer and Clements found that there has been a significant decrease in the U.S. exports of SITC-0 (agricultural commodities), SITC-2 (crude materials, inedible, except fuels), and SITC-3 (mineral fuels, lubricants and related materials). However, trade between the U.S. and Japan has increased rapidly in SITC-7 (machinery and transport equipment) and SITC-8 (miscellaneous manufactured articles).

Breuer and Clements continued their examination by studying two-digit SITC to pick up disaggregated values. They estimated the effects of the real exchange rate (with 24 lags), industrial production (12 lags), and imports/exports (12 lags) on exports/imports. Their analysis of commodities sensitivity to exchange rates shows that U.S. exports are more sensitive relative to U.S. imports. Breuer and Clements conclude that their estimates found that 10 percent real depreciation of the U.S. dollar against the yen would cause U.S. exports to Japan to increase by 4 percent and imports to decrease by 3 percent. This would result in a significant improvement of the trade gap in real terms.

CHAPTER 3. U.S.-JAPAN ECONOMIC COMPARISON

In this section, historical economic conditions in the United States and Japan, including monetary policy, government expenditures, and exchange rates are discussed. The characteristics of bilateral trade also are analyzed, including resource endowments and trade composition.

U.S. Economy

The United States has the largest economy in the world with a GDP of $14.11 trillion in 2007, and per capita GDP of $46,800 (CIA: World Factbook 2009). Currently, the United States is primarily a service economy, which accounts for 79% of GDP. The remaining sectors of the economy are agriculture (1%) and manufacturing (20%). Relative to Western Europe and Japan, U.S. business has greater flexibility in laying off workers, obtaining capital, and product development (CIA: World Factbook 2009). U.S. business expansion to Western European and Japanese markets face greater constraints, thus creating barriers to entry for U.S. firms. Alternatively, foreign businesses entering the United States enjoy fewer barriers, relative to their home markets. During the 90s, the United States experienced prosperous growth, with low inflation and unemployment. In 2000, economic growth slowed, however, expansion continued until mid-2008, when the U.S. financial crisis began. In 2007, U.S. government debt was 60.8% of GDP, ranking it the 22nd highest country in the world in terms of debt.

The Federal Reserve (U.S. central bank) averaged a federal funds rate of 4.6% from 1989 to 2007. The federal funds rate peaked around 10% in 1989. Expansionary monetary policy was implemented to counter the decrease in its GDP growth, for the recession experienced in the early 90s. The real GDP growth slowed during this period from 3.5% in 1989 to -.2% in 1991. The federal funds rate was maintained at a relatively steady rate during the 1990s, around 5%, and real GDP grew between 2.5% and 4.5%. During the early 2000s, U.S. GDP growth diminished to .8%, which persuaded the Federal Reserve to quickly ease the federal funds rates. A mild recession occurred in the early 2000s, and the federal funds rate remained below 2% from December 2001 until December 2004. Real GDP growth rate averaged above 2% from 2003 to 2007, with a high of 3.6% in 2004 (FRED 2009). Contractionary monetary policy was implemented and continued until July 2007 when the United States was again facing recessionary pressures from a collapsing housing bubble.

Since 1989, the United States has experienced relatively low unemployment and inflation. The unemployment rate averaged 5.4% from 1989 to 2007. Unemployment peaked at 7.8% in June 1992, which preceded a steady decrease to 3.8% in April 2000. During the early 1980s, inflation was a major concern of the Federal Reserve, peaking at 13.9% (BLS 2009). Anti-inflationary policy was implemented, and inflation decreased to 2.4% in 1983. By 1987, inflation had rebounded again, remaining above 4% from 1988 to 1991. Inflation remained below 4% from 1992 until 2007, when it peaked again at 4.2%. Overall, inflation averaged 4.19% annually from 1989 to 2007 (BLS 2009).

The United States is the third largest exporter in the world with an estimated export value of $1.14 trillion in 2007 (CIA: World Factbook 2009). U.S. exports are mainly comprised of capital goods, with 49% of exports related to transistors, aircraft, motor vehicles parts, computers, and telecommunications equipment. The largest importers of

U.S. goods are Canada (21.4%), Mexico (11.7%), China (5.6%), and Japan (5.4%) (CIA: World Factbook 2009).

The United States is the largest importer in the world, with an estimated $2.19 trillion worth of goods in 2008. U.S. imports are mainly spread across three commodity groups: industrial supplies (32.9%), capital goods (30.4%), and consumer goods (31.8%). Agricultural products make up less than 5% of U.S. imported goods. The four largest exporters to the United States are China (16.9%), Canada (15.7%), Mexico (10.6%), and Japan (7.4%) (CIA: World Factbook 2009).

The U.S. trade balance deficit has increased significantly since 1989. In 2007, the U.S. trade deficit was $701 billion, an increase of $608 billion since 1989 (U.S. Census Bureau: Trade Statistics 2009). Figure 3.1 shows the U.S. trade balance using the balance of payments basis.

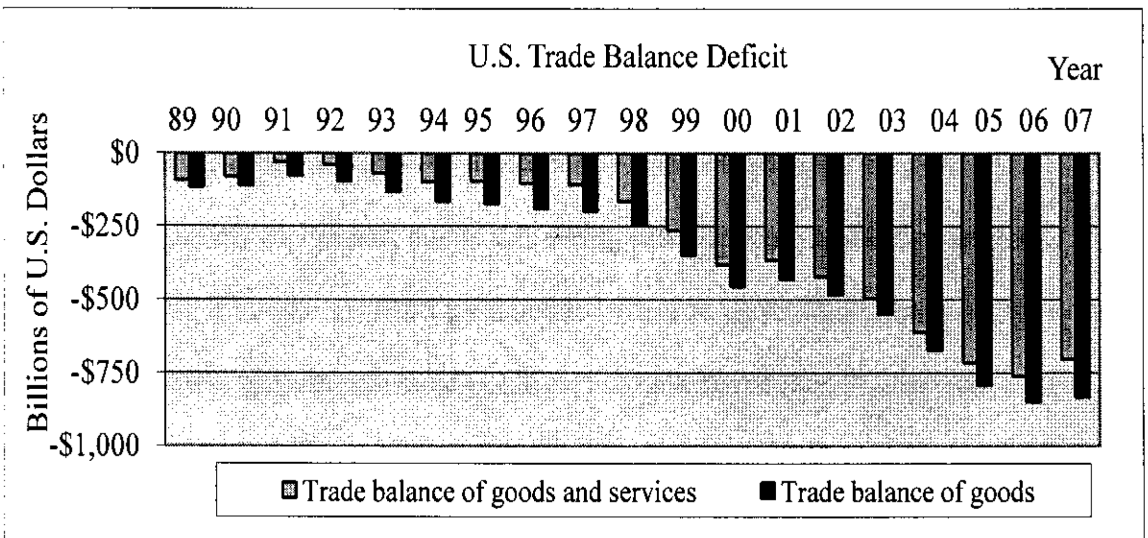

Figure 3.1 U.S. Trade Balance Deficit, 1989-2007.
Source: U.S. Census Bureau: Foreign Trade Division.

Japanese Economy

The Japanese economy is the third largest in the world, estimated at $4.365 trillion in 2007, with per capita income of $34,300 (CIA: World Factbook 2009). Japan has primarily a service economy, totaling 72% of Japan's GDP. The remaining sectors of the economy are agriculture (1%) and manufacturing (26%). Japan is the second most technologically powerful economy, with a unique interlocking connection between manufacturers, suppliers, and distributors called the Keiretsu (CIA: World Factbook 2009). The Keiretsu and the guarantee of life employment for urban workers are under pressure from global competition and demographic changes (CIA: World Factbook 2009). Japanese exports are primarily industrial goods; although, Japan is largely dependent on imported raw materials and agricultural products. The Japan's agricultural sector is small and highly subsidized and protected, while its agricultural production provides only 40% of domestically consumed calories (CIA: World Factbook 2009).

Since 1960, Japan's economy grew at an impressive rate for three consecutive decades, averaging 10% in the 1960s, 5% in the 1970s, and 4% in the 1980s. However in the 1990s, Japan's economic growth substantially diminished, averaging only 1.7%. Japan's slow growth was in part due to a bursting asset bubble. Economic growth recovered in 2000, but the growth rate failed to mirror to its previous size. Between 2000 and 2007, Japanese growth remained positive, but never exceeded 3% annually. As of 2008, Japan's public debt was estimated to be 170.4% of its GDP; ranking it the 2nd highest country in terms of public debt in the world.

The Bank of Japan (Japanese central bank) has had two different monetary structures from 1989 to 2007. The Bank used a discount rate on commercial bills and interest rates for loans secured by government bonds from 1973 to 1995. In 1989, the Bank of Japan's discount rate was 3.25%, but a sharp increase in growth in 1990 persuaded the bank to increase the discount rate to 6% (Bank of Japan 2009). Japan experienced an economic slow-down for most of the 1990s, which led to an expansionary discount policy. By 1995, the discount rate had been reduced to .5%; however, this policy did not remedy the slowing growth. The Bank of Japan's monetary policy was constrained by the already near-zero interest rates from 1995 to 2001. Japan's economy continued to experience periods of limited or negative growth. In 2001, the Bank of Japan changed its monetary policy to a consolidated basic discount and loan rate. Limited economic growth continued to pressure the Bank of Japan to maintain a discount rate below 1% through 2007 (Bank of Japan 2009).

Japan has experienced relatively low unemployment and inflation since 1989. Unemployment averaged 3.7% from 1989 to 2007, peaking in 2002 at 5.3%. Unemployment did not exceed 3% until 1995, however, unemployment has stayed above this since 1995 (IMF 2009). Japan's inflation from 1989 to 1991 maintained a rate between 2.6% and 3.8%. During the rest of the 1990s, inflation remained relatively minor, never exceeding 2%. Deflation has been a main concern for Japan. Beginning in 1999, Japan experienced five consecutive years of deflation resulting in a 3.4% decrease in their price level (IMF 2009). Since then, Japan has continued to experience minor deflation and inflation.

Japan is the fifth largest exporter in the world, exporting an estimated $776.8 billion in 2008, which is comprised largely of transport and electrical equipment. The three largest importers from Japan are the United States (20.4%), China (15.3%), and South Korea (7.6%) (CIA: World Factbook 2009).

Japan is the sixth largest importer, with an estimated $696.2 billion imported in 2008. The three largest imported commodities are machinery, fuels and foodstuffs. The three largest exporters to Japan are China (20.5%), the United States (11.6%), and Saudi Arabia (5.7%) (CIA: World Factbook 2009).

In 2007, Japan had a trade balance surplus of $83.48 billion, with a balance of trade in goods of $104.6 billion. Japan currently has a deficit balance of trade in services of $21.2 billion in 2007, less than half of its trade deficit in 2001 ($42.7 billion) (JETRO 2009).

U.S. and Japanese Bilateral Trade

In this section, trade data and exchange rates are analyzed. This is discussed in terms of 2007 U.S. dollars. Trade data were obtained from the United States International Trade Commission: Dataweb (USITC), unless otherwise noted.

U.S. Exports to Japan

U.S. exports to Japan have changed over the past two decades, not only in composition, but also in magnitude. Japan continues to be an important export market for the United States. In 2008, Japan was the third largest agricultural export market for the United States (Office of U.S. T-R 2009). U.S. exports to Japan have continually increased in the past decade, accounting for 5.3% of U.S. exported goods in 2007 (U.S. BEA 2009). Figure 3.2 shows the values of U.S. exports to Japan by SITC number, in U.S. dollars.

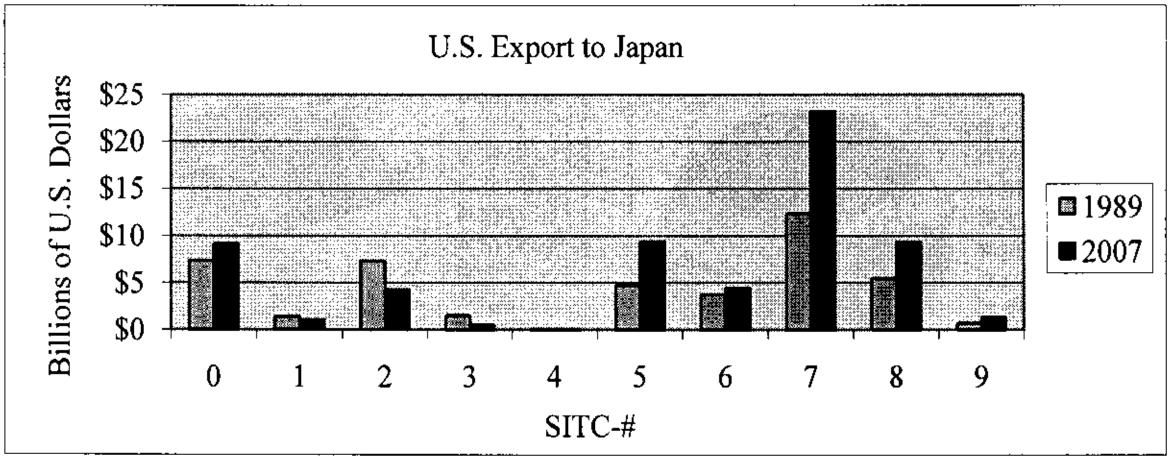

Figure 3.2 U.S. Exports to Japan, by One Digit SITC-#.
Source: U.S. International Trade Commission: Interactive Tariff and Trade Dataweb.

U.S. exports to Japan were $62 billion in 2007, an increase of 5.1% over the previous year. In annual terms, U.S. exports to Japan have averaged an increase of $1.96 billion or 13% growth annually.

Machine and transport equipment (SITC-7) comprised the largest part of U.S. exports to Japan. In 1989, these items made up 27% of total U.S. exports to Japan; it has increased to 36% since then. Only two groups of the one-digit SITC had decreases in value from 1989 to 2007, SITC-2 (crude materials, inedibles, except fuels) and SITC-3 (mineral fuels, lubricants and related material). Of the remaining one-digit SITC groups, three groups (SITC-1, SITC-4, and SITC-5) have had growth of 125% to 200%. The rest have at least doubled in value (SITC-0 SITC-5, SITC-7, SITC-8, and SITC-9). SITC-5 (Chemicals and related products, N.E.S.) has had the largest growth, increasing from $2.75 billion to $9.17 billion; more than triple the 1989 value. Figure 3.3 shows the composition of U.S. exports to Japan in 1989 and 2007.

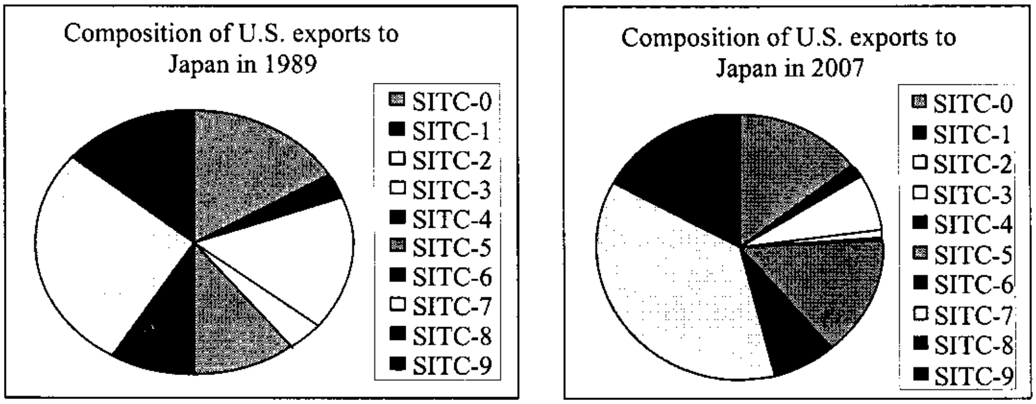

Figure 3.3 Composition of U.S. Exports to Japan in 1989 and 2007, by One Digit SITC-#.
Source: U.S. International Trade Commission: Interactive Tariff and Trade Dataweb.

U.S. Imports from Japan

The United States is an important part of the Japanese export market. From 1989 to 2007, Japanese exports to the United States increased by $90 billion to $146 billion. In 2007, U.S. imports of Japanese goods accounted for 20% of total Japanese exports. Although the growth of U.S. imports from Japan has varied greatly in the past two decades (see figure 1.1), Japanese exports to the United States increased an average 14% annually. Figure 3.4 shows the changes in U.S. imports from Japan in U.S. dollars.

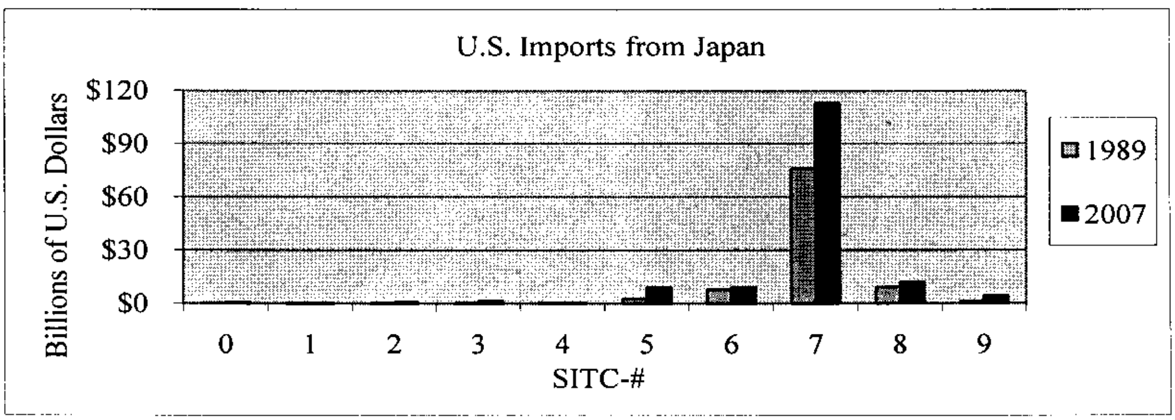

Figure 3.4 U.S. Imports from Japan, by One Digit SITC-#.
Source: U.S. International Trade Commission: Interactive Tariff and Trade Dataweb.

Japanese exports to the United States continue to be dominated by machinery and transport equipment (SITC-7). However, machinery and transport equipment have declined as a percent of U.S. imports from Japan, from 78% to 76%. The overall value of machine and transport equipment imports has increased from $44 billion to $110 billion from 1989 to 2007. Within the machine and transport equipment category (SITC-7), the two largest sub-categories are vehicles and electrical machinery. Exports of these are $56 billion and $11 billion, respectively. Japanese exports to the United States have become more diverse since 1989, but changes in exports remain minor.

Japanese exports, excluding machine and transport equipment, total only $36 billion. The export value of SITC-5, SITC-6, and SITC-8 each totaled more than $8 billion, while SITC-0, SITC-1, SITC-2, and SITC-4 totaled less than $1 billion worth of goods. The largest increase of Japanese exports was mineral fuels, lubricants and related materials (SITC-3), which increased 15-fold to $1.4 billion. Figure 3.5 shows the composition of U.S. imports in 1989 and 2007 from Japan.

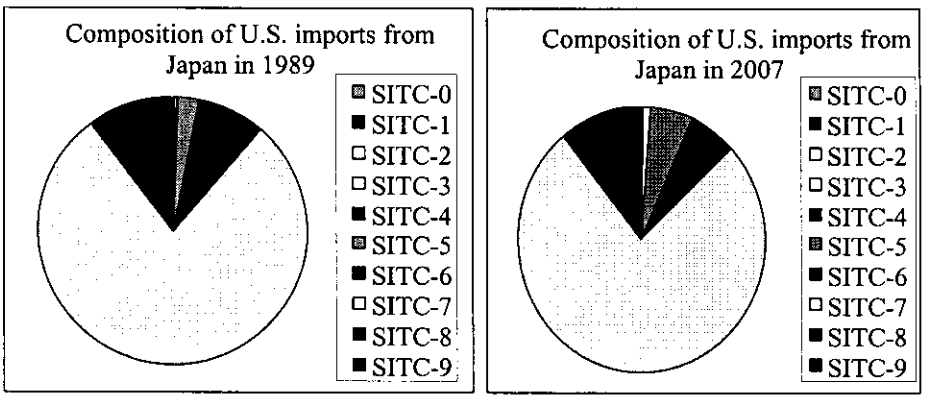

Figure 3.5 Composition of U.S. Imports from Japan in 1989 and 2007, by One Digit SITC-#. Source: U.S. International Trade Commission Interactive Tariff and Trade Dataweb.

Exchange Rates

The Yen and the U.S. dollar exchange rate affect prices of goods traded between the United States and Japan. Changes in the exchange rate impacts the ability of both the United States and Japan to export and import goods. Appreciation of a country's currency decreases the price of foreign goods, but increases the price of domestic goods for foreigners. The Yen on average has appreciated in value relative to the U.S. Dollar. In January, 1970, one U.S. dollar was worth 358 yen; by December 2007, one U.S. dollar was worth 112 Yen.

During the period being analyzed, the Yen/$ exchange rate has varied greatly. The peak value for the U.S. dollar was 158 Yen/$ in April 1990 with a low of 83 Yen/$ in April 1995. During the last five years, the Yen/$ exchange rate has stayed between 100 and 130 Yen per U.S. dollar. Figure 3.6 shows the nominal exchange rate during 1989 to 2007.

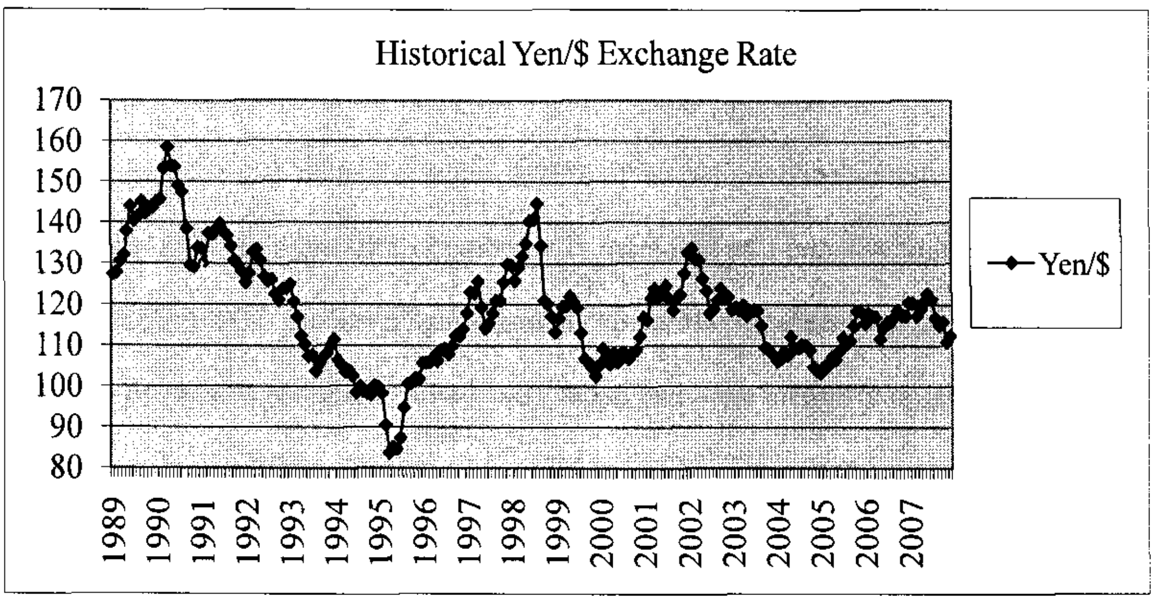

Figure 3.6 Historical Yen/$ Exchange Rate, 1989-2007.
Source: St. Louis Federal Reserve Bank: Federal Reserve Economic Data (FRED).

Government Expenditures

Both the United States and Japan have relatively high public debt. As previously mentioned, Japan and the United States have public debts of 170% and 60% of their annual GDP, respectively. Figure 3.7 shows the historical government expenditures from 1989 to 2007 as a percentage of GDP.

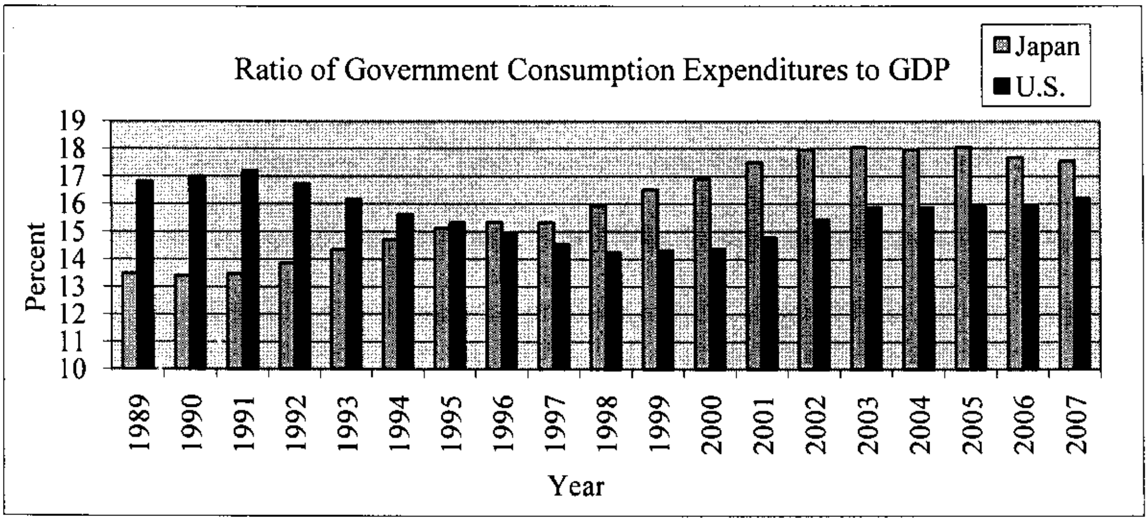

Figure 3.7 Ratio of Government Consumption Expenditures to GDP, 1989-2007.
Source: United Nations Statistics Division: Estimates of GDP and selected components.

Social security for both countries exceeds 20% of annual government expenditures. Japanese government expenditures continually increased as a percentage of GDP throughout the 1990s. However, government expenditures increased until 1995, the beginning of Japan's economic slowdown. Japan had huge increases in government consumption expenditures, increasing by 13% in 1995. Since then consumption expenditures have remained stable; with changes in expenditures following increases or decreases in economic output. U.S. consumption expenditures decreased as a percentage of GDP throughout the 1990s, when the United States experienced relatively steady growth. However, actual government expenditures have continually risen since 1989, averaging a 5% annual increase.

Characteristics of U.S.-Japanese Bilateral Trade

International trade can be divided into two categories: intra-industry and inter-industry trade. Intra-industry trade occurs when trade between partners is in the same industry, whereas inter-industry trade occurs when partners exchange goods from different industries. Countries with different resource endowments will produce goods based on their relatively abundant resource. Trade between countries will depend on their comparative advantage (Heckscher and Ohlin 1991), leading to inter-industry trade. Countries with similar endowments may produce and exchange similar goods. Helpman and Krugman (1985) conclude that countries with more comparable resource endowments will have a higher ratio of intra-industry trade to total trade, due to economies of scale and imperfect competition.

Using the Grubel-Lloyd index, characteristics of U.S.-Japanese bilateral trade can be analyzed to show the type of trade. The Grubel-Lloyd index is calculated using the following equation:

$$(3.1) \quad T_i = 1 - |X_i - M_i| / (X_i + M_i)$$

X_i and M_i are export and import values, respectively, from industry i. T_i is the associated index value for that industry. Values of T_i that are close to 1 are considered intra-industry trade and values close to zero are considered inter-industry trade. The data are aggregated to show relationship among four industries: agriculture, chemicals and materials, machinery and transport equipment, and manufactured articles (descriptions of aggregated one-digit SITC commodities are given in table 3.1). Table 3.1 shows the Grubel-Lloyd index for each of the aggregated industries for U.S. and Japanese trade in 1989 and 2007.

Table 3.1 Grubel-Llyod Index of Commodity Groups

SITC-#	and Description	1989	2007
SITC-0,1,4	Agriculture	0.080	0.113
SITC-2,3,5,6	Materials	0.765	0.965
SITC-7	Machinery	0.279	0.341
SITC-8	Manufacturing	0.756	0.882
SITC-9	Other	0.775	0.473

Source: Data obtained from U.S. International Trade Commission: Interactive Tariff and Trade Dataweb, calculations done by author.

Agriculture remains as an inter-industry trade, because Japan imports most of its agricultural commodities (SITC-0, 1, and 4), and machinery and transport equipment (SITC-7) also is inter-industry traded, because Japan automobile makers have dominated U.S. markets. Materials and chemicals (SITC-2, 3, 5, and 6), and manufactured goods (SITC-8) trade is classified as an intra-industry traded. Both the United States and Japan are technologically advanced economies, so each country is expected to produce specialized manufactured goods. SITC-9 (which consists of imported/exported goods of less than $250 in value, unclassified goods, coins, and precious metals) has shifted from intra to inter-industry trade.

U.S. and Japanese Factors of Production

The Heckscher-Ohlin (H-O) theorem describes trade between two partners based on their endowments: labor, and capital. H-O theorem explains that capital abundant countries will export capital-intensive goods, and the opposite for labor abundant countries (Fukiharu

2004). Capital, labor, and technology endowments between the United States and Japan are examined below.

The capital endowment is measured by the ratio of each country's average annual discount as a percent plus one. Labor endowment is measured by the ratio of average hourly manufacturing wage, and technology abundance is measured by the ratio of patents granted in each country. Figure 3.8 shows the ratio of interest rates, wage rates and patents.

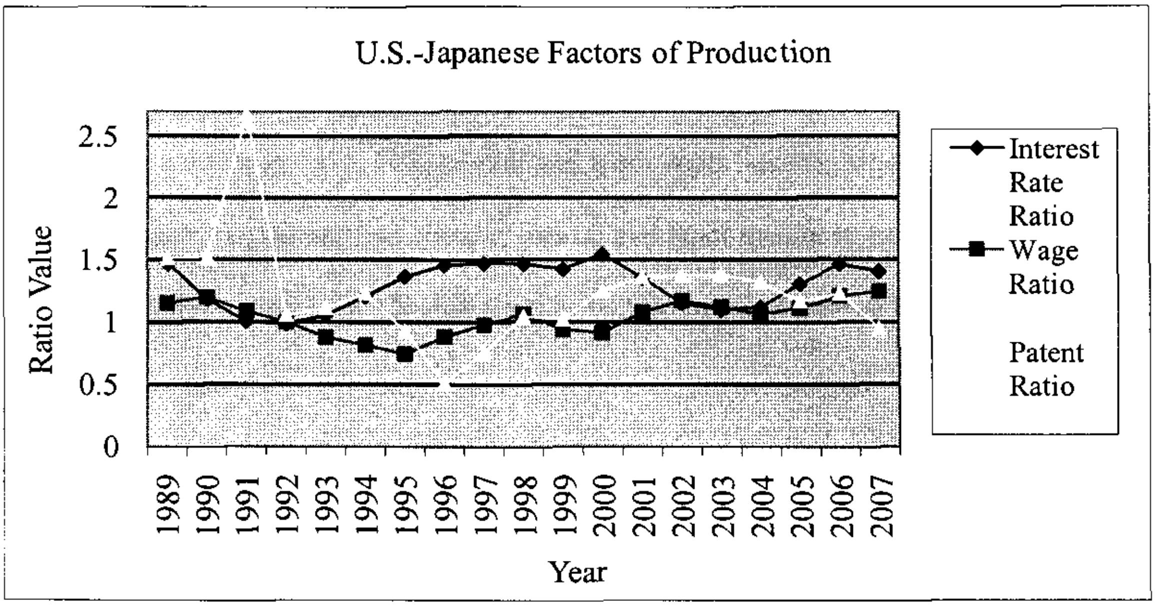

Table 3.8 U.S. and Japanese Factors of Production: Interest Rates, Wage Rates and Patents. Source: World Intellectual Property Organization-World Patent Report: A Statistical Review (patent information), BLS: Hourly compensation costs in manufacturing (wage information), The Federal Reserve (FRED) and Bank of Japan (interest rate information).

The number of U.S patents is divided by the number of Japanese patents to calculate a technology ratio. A higher technology ratio shows technological abundance, whereas lower wage (interest) rate shows labor (capital) abundance. Using these ratios to measure resource endowments, Japan has a slightly higher level of capital available. The wage ratios have fluctuated over this period. During 1989-1992 and 2001-2007, Japan has had lower labor wages than the United States. Technology also fluctuated, with the United States granting more permits between 1989 to 1994 and 1999 to 2006. Differences in capital costs have remained significant. Interest rates have remained higher in the United States, while Japan has maintained low interest rates to encourage economic growth. Manufacturing wages for the United States have consistently risen, while manufacturing wages in Japan have decreased significantly since 1995, and have yet to return to their 1995 levels.

Japan's fluctuations in interest rates, wage rates, and patents coincide with the diminished economic growth of the 1990s. This analysis shows that since Japan's economic slowdown in 1995, U.S. capital and labor costs have significantly increased relative to Japan. Japan has had cheaper capital and labor available since 2001, but the United States has maintained a higher level of technology and a more labor intensive manufacturing sector.

CHAPTER 4. THEORTICAL FRAMEWORK AND MODEL

In this chapter, international trade theory is discussed. This theory is used to develop an empirical model for studying the determinants of bilateral trade.

Theoretical Framework

To begin an analysis of bilateral trade, the determinants of real GDP are analyzed (representing both domestic production and national income) in order to discuss the relationship between international trade and national income. Using the general definition of GDP from Pugel (2005), GDP (Y) can be written as:

$$(4.1) \quad Y = C + I + G + (X - M)$$

where consumption (C) represents currently produced goods and services purchased by households, investments (I) are currently produced goods bought for future use by businesses, government purchases (G) are currently produced goods and services purchased by the government. Exports (X) are purchases of domestic goods and services by foreigners, and imports (M) represents domestic purchases of foreign goods and services.

This study's focuses on the determinants affecting each component as discussed by Pugel (2005) and Mankiw (2004) in their analysis of aggregate income. Consumption is positively related to disposable income[3], which Pugel (2005) defines as "the difference between total income (Y) and taxes (T)." Investment is negatively related to interest rates[4] (R), which is the cost of borrowing capital. Lower real interest rates decrease the cost of financing, thus increasing the amount of investment expenditures.

[3] For simplicity, other potential determinants are removed, such as the effects of wealth.
[4] Other potential determinants of investment also are removed, such as foreign direct investment.

Government expenditures are based on political decisions, and are thus treated as exogenous. Following from Barro (1981), government expenditures can be separated into two categories. Barro describes them "as a direct conveyer of utility to households," and as "an input to private production processes." The first process causes household consumption to exceed private expenditures, or an income effect. The second process results in additional productive input and thus raises commodity supply (Barro 1981).

Imports are positively related to disposable income; that is, as income rises, spending on goods and services from abroad increases. Similarly, exports also are related to disposable income in foreign countries. Both imports and exports are dependant on price competitiveness. As prices of foreign produced goods and services rise, the quantity of imports will fall and the quantity of exports will rise, for example.

Exchange rates affect the price of foreign goods and services relative to the price of domestic goods. The nominal exchange rate is defined as the value of country A's currency in terms of country B's currency. Equation (4.2) shows this relationship.

$$(4.2) \quad N = C^A / C^B$$

where C^A and C^B represent the currencies of countries A and B; N is, by definition, the nominal exchange rate. The exchange rate can be used to show the price of foreign goods in terms of domestic currency. However, price levels in each country are continually changing.

Inflation is defined as increases in the overall price level of currently produced goods and services. Price level changes in foreign and domestic markets distort the price of foreign goods and services relative to domestic prices. This distortion occurs because the price levels in each country are changing at different rates. In order to obtain the real price, nominal exchange rates are adjusted for inflation. Equation (4.3) is used to calculate the real exchange rate (e):

$$(4.3) \quad e = (C^A / P^A) / (C^B / P^B)$$

where P^A and P^B are changes in the price level for country A and B.

Incorporating these variables into the real GDP definition yields:

$$(4.4) \quad Y = C(Y\text{-}T) + I(R) + G + X(e, Y^*) - M(e, Y)$$

where Y* represents foreign income, T represents taxes, and R represents the real interest rate. Equation (4.4) can be rewritten as:

$$(4.5) \quad X(e, Y^*) - M(e, Y) = Y - C(Y\text{-}T) - I(R) - G$$

Equation (4.5) shows that imports and exports are dependent on the real exchange rate, real income, real interest rate and government expenditures. This relationship is used to develop an empirical model.

Empirical Model

This study's primary goal is to examine the determinants affecting bilateral trade between the United States and Japan; however, prices of individual imports and exports are not available. Following the study completed by Bahmani-Oskooee and Goswami (2004), this study focuses on U.S. and Japanese imports, instead of the bilateral trade balance, primarily because (1) imports and export prices are not available for selected commodities and (2) each country exports different goods (Bahmani-Oskooee and Goswami 2004). A secondary goal of this study is to identify how different import commodities respond to changes of each determinant.

By aggregating the import/export data into sectors, one can examine bilateral trade pattern of distinct commodities between the United States and Japan. Koo and Zhuang (2007) analyze trade between China and the United States by separating trade into three sectors: AGR, MID, and HIGH. They used 2-digit SITC to filter each commodity into the appropriate sectors. AGR corresponds to agricultural goods, MID represents middle-technology and manufactured goods, and HIGH represents high-technology manufactured goods.

This study will utilize a different disaggregation, with four sectors: agriculture, materials and chemicals, machinery and transport equipment, and manufactured goods. Agriculture is comprised of the same goods as Koo and Zhuang's study (SITC-0, 1, and 4). However, the other sectors differ in several ways. SITC-9 is comprised of coins, precious metals, special transactions, and low-valued imports, which Koo and Zhuang include in their MID sector. This study will remove SITC-9, because the majority of the value of SITC-9 trade between the United States and Japan is unspecified goods.

The materials and chemicals sector includes the rest of the commodities, except SITC-8, that Koo and Zhuang include in their middle-technology and manufactured goods sector (SITC-2, 3, 5, and 6). SITC-8 is comprised of manufactured goods and is removed from the middle-technology and manufactured goods group, and will comprise the manufacturing sector. Finally, machinery and transport equipment (SITC-7) is removed from Koo and Zhunag's HIGH sector, and included as an independent sector. In terms of value, machinery and transport equipment is the largest commodity exchanged between the United States and Japan. Thus, machinery and transport equipment will comprise its own commodity sector. By splitting the value of imports into distinct commodity groups, this study evaluates the effects of the macroeconomic variables on bilateral trade of each commodity group.

In evaluating the role of real interest rates, McCallum (1999) uses monetary policy rule[5] as an indicator of the price of capital. By using a ratio of monetary policy rules from both countries, the model captures the effect of changes to the cost of capital. This study assumes that capital costs in foreign markets affects investment in domestic markets. This assumption is appropriate due to increases in foreign investment in domestic markets for the United States and Japan, and the financing of government expenditures by selling treasury securities abroad. The interest rates set by monetary policy differ in each country, so capital mobility is assumed to be imperfect.

Following from Bahmani-Oskooee and Goswami (2004), real exchange rate and real GDP are used in the model. Real government expenditures also are included; however, transfer payments are removed in order to obtain government consumption expenditures, similar to Kueh et al. (2008) and Muller (2008). This study assumes taxes are proportionally related to income, and is thus removed from the analysis. This allows real income to be used, rather than disposable income as a determinant of imports.

To include the effects of interest rates, equation (4.5) can be rewritten for each commodity group as:

(4.6) $M_i = f(e, Y, G, r^j / r^{U.S})$

where r^J and $r^{U.S}$ represents the monetary policy of the Bank of Japan and the Federal Reserve, respectively. M_i represents the real import value of commodity group i

[5] McCallum (1999) uses a "monetary policy rule that specifies each period's setting of an interest rate instrument." In order to have a uniform comparison, discount policies from each country is used. Discount policy is the interest rate on loans from a central bank to its member banks.

Specification of Long- and Short-run Bilateral Trade Model

From this empirical model, an econometric model is developed to estimate the relationship of the real exchange rate, real income, real government consumption expenditures, and nominal interest rates on imports (real GDP is used as proxy for real income). Equation (4.6) is rewritten in a double-logarithmic functional form as:

(4.7) $\ln M_{U.S.,i,t} = \beta_0 + \beta_1 \ln Y_{U.S.,t} + \beta_2 \ln e_t + \beta_3 \ln G_{U.S.,t} + \beta_4 \ln (r^j / r^{U.S.})_t + \varepsilon_t$

(4.8) $\ln M_{J,i,t} = \gamma_0 + \gamma_1 \ln Y_{J,t} + \gamma_2 \ln e_t + \gamma_3 \ln G_{J,t} + \gamma_4 \ln (r^j / r^{U.S.})_t + z_t$

Equations (4.7) and (4.8) show the long-run relationship of U.S. imports from Japan and Japanese imports from the United States. For the analysis, the short-run dynamic needs to be included as well. Using an error-correction model and the approach developed by Pesaran et al. (2001), the analysis employs an auto-regressive distributed lag (ARDL) approach. This yields the following equations:

(4.9) $$\Delta \ln M_{U.S.,i,t} = \beta_1 \ln M_{U.S.,i,t-1} + \beta_2 \ln Y_{U.S.,t-1} + \beta_3 \ln e_{t-1} + \beta_4 \ln G_{U.S.,t-1}$$

$$+ \beta_5 \ln (r^j / r^{U.S.})_{t-1} + \sum \alpha'_{1k} \Delta \ln M_{U.S.,i,t-k} + \sum \alpha'_{2k} \Delta \ln Y_{U.S.,t-k} +$$

$$\sum \alpha'_{3k} \Delta \ln e_{t-k} + \sum \alpha'_{4k} \Delta \ln G_{U.S.,t-k} + \sum \alpha'_{5k} \Delta \ln (r^j / r^{U.S.})_{t-k} + \zeta_t$$

(4.10) $$\Delta \ln M_{J,i,t} = \gamma_1 \ln M_{J,i,t-1} + \gamma_2 \ln Y_{J,t-1} + \gamma_3 \ln e_{t-1} + \gamma_4 \ln G_{Jt-1} +$$

$$\gamma_5 \ln (r^j / r^{U.S.})_{t-1} + \sum \lambda'_{1k} \Delta \ln M_{J,i,t-k} + \sum \lambda'_{2k} \Delta \ln Y_{J,t-k} +$$

$$\sum \lambda'_{3k} \Delta \ln e_{t-k} + \sum \lambda'_{4k} \Delta \ln G_{J,t-k} + \sum \lambda'_{5k} \Delta \ln (r^j / r^{U.S.})_{t-k} + \varphi_t$$

where Δ denotes the difference operator, and coefficient of the model are estimated in log form. Estimation of equations (4.10) and (4.11) yield both the short-run and the long-run effects of real GDP, real exchange rates, real government expenditures, and nominal interest rates on real bilateral import values for the United States and Japan. This equation is called the error-correction version of the ARDL, because the terms with difference operator represents the short-run dynamics between imports and macroeconomic variables, and the one period lag term representing the long-run relationship.

From the model, several hypotheses can be drawn based on economy theory. The real exchange rate is calculated in terms of Yen/$, thus an increase in the real exchange rate (appreciation of the U.S. dollar) should increase U.S. imports from Japan. Similarly, a decrease in the real exchange rate (depreciation of the U.S. dollar) should increase Japanese imports of U.S. goods. An increase in a country's real GDP is expected to stimulate domestic consumption and consequently increase imports. The effects of government consumption expenditure are generally similar to those for GDP. However, the government expenditure could stimulate production activities in a sector and result in an increase in inputs. Nominal interest rates should only affect commodity groups comprised of capital intensive goods, most likely apparent in manufacturing goods (SITC-8) and machinery and transport equipment (SITC-7).

CHAPTER 5. ECONOMETRIC PROCEDURE

The following section examines the structure of pertinent variables and calculates relevant pre-testing.

To begin the analysis, the characteristics of each variable are identified independently. OLS estimation is used to determine if each variable contains a constant, seasonal, and/or time trend terms. OLS regressions create a linear approximation by minimizing the differences between each observation and estimated line. The constant term in the equation is a representation of an intercept of the linear approximation, while seasonal variables capture the distinct differences between quarters. A time trend is included to capture the magnitude of each variable's increase or decrease over time. The data used are discussed in chapter 4. Each variable is abbreviated for simplicity as follows:

(UGDP) – U.S. gross domestic product index

(UGI) – Real U.S. government consumption expenditure

(RER) - Real exchange rate (¥/ $)

(DR) - Ratio of Bank of Japan's discount rate to U.S. Federal Funds Rate ($r^J/r^{U.S.}$)

(JGDP) - Japanese gross domestic product index

(JGI) – Real Japanese government consumption expenditures

(IC1) –The real value of U.S. agricultural imports from Japan

(IC2) –The real value of U.S. materials and chemicals imports from Japan

(IC3) –The real value of U.S. machinery and transport equipment imports from Japan

(IC4) –The real value of U.S. manufactured goods imports from Japan

(EC1) –The real value of U.S. agricultural exports to Japan

(EC2) –The real value of U.S. materials and chemicals exports Japan

(EC3) –The real value of U.S. machinery and transport equipment exports to Japan

(EC4) –The real value of U.S. manufactured goods exports to Japan

Ordinary Least Squares Estimation

The characteristics of each variable are obtained from the OLS estimation. This information is used to determine the stationarity of each variable. The equations for each variable are specified as a function of seasonal dummy variables (S_i), a constant or intercept term (N), and a time trend variables (T) as:

$$(5.1) \quad Y_t = N + \beta_0 T + \beta_1 S1_t + \beta_2 S2_t + \beta_3 S3_t + u_t$$

where Y represents each variable in the study ($S1_t$, $S2_t$, and $S3_t$ represent dummy variables for quarter 1, 2 and 3, respectively, u_t is a random error term and β_i are the parameters of the model to be estimated, dummy variable representing quarter 4 is excluded to avoid the perfect multi-collinear problem. Table 5.1 provides the results of the OLS estimation for each variable from the first quarter of 1989 to the second quarter of 2008.

Table 5.1 OLS Regression for Characteristics of Variables

NAME	Regressors	Coefficient	T-stat	NAME	Regressors	Coefficient	T-stat
UGDP	S1	4.1094	785.78***	UGI	S1	3.7875	280.37***
	S2	4.1101	777.19***		S2	3.7884	277.32***
	S3	4.1110	774.64***		S3	3.7828	275.95***
	N	4.1100	766.11***		N	3.7819	272.91***
	T	0.0075	84.36***		T	0.0122	53.46***
R			0.98985	R			0.97512
JGDP	S1	4.4288	691.95***	JGI	S1	4.1699	255.58***
	S2	4.4274	684.04***		S2	4.1702	252.77***

Table 5.1 (continued)

	S3	4.4277	681.72***		S3	4.1727	252.04***
	N	4.4292	674.58***		N	4.1755	249.48***
	T	0.0026	23.98***		T	0.0071	25.56***
R			0.88745	R			0.89961
RER	S1	4.4322	129.75***	DR	S1	0.5541	11.45***
	S2	4.4325	128.32***		S2	0.5585	11.41***
	S3	4.4292	127.78***		S3	0.5366	10.92***
	N	4.4144	125.98***		N	0.5538	11.15***
	T	0.0042	7.21***		T	-0.0080	-9.81***
R			0.41717	R			0.56918
IC1	S1	18.0905	717.89***	EC1	S1	21.7234	539.92***
	S2	18.1094	710.66***		S2	21.6970	533.27***
	S3	18.1099	708.21***		S3	21.6751	530.88***
	N	18.2447	705.78***		N	21.6472	524.48***
	T	0.0076	17.72***		T	-0.0004	-.566
R			0.83060	R			0.04810
IC2	S1	21.5740	924.87***	EC2	S1	22.1077	533.15***
	S2	21.5929	915.40***		S2	22.1158	527.42***
	S3	21.5790	911.63***		S3	22.0809	524.76***
	N	21.5599	901.00***		N	22.1232	520.09***
	T	.0094	24.06***		T	-0.0009	-1.223
R			0.88830	R			0.03250
IC3	S1	23.6368	906.08***	EC3	S1	22.0884	386.04***
	S2	23.6169	895.26***		S2	22.1120	382.16***
	S3	23.6275	892.54***		S3	22.1209	380.98***
	N	23.6829	884.98***		N	22.1453	377.29***
	T	0.0054	12.22***		T	0.0062	6.387***
R			0.68180	R			0.36440
IC4	S1	21.5136	654.33***	EC4	S1	21.1364	529.14***
	S2	21.5518	648.21***		S2	21.1191	522.83***
	S3	21.6405	648.62***		S3	21.1029	520.61***
	N	21.7075	643.61***		N	21.1341	515.76***
	T	0.0036	6.48***		T	0.0066	9.78***
R			0.52030	R			0.56960

Each test contains 78 observations.
* represents significance at 10%,
** represents significance at 5%,
*** represents significance at 1%.

The results from each OLS regression shows that, at the 99% level, each variable has seasonal variation. Additionally, the OLS provides significant evidence at the 99% level that each variable has a time trend, with the exception of EC1 and EC2. This result provides characteristics needed to conduct the Augmented Dickey-Fuller test for unit-roots.

Variables containing a unit-root are called non-stationary. The definition of a stationary process is "one whose joint and conditional distributions are invariant with respect to displacement in time" (Pindyck and Rubinfeld 1998). If variables that contain unit-roots are regressed, the estimates would be "spurious" (Granger and Newbold 1974).

Each variable is tested with the appropriate characteristics (obtained from table 5.1) using the Augmented Dickey-Fuller test. Since all the variables have seasonal effects, the number of lags is selected to have a value of four. Equations 5.1 and 5.2 are specified to obtain the test statistic for the Augmented Dickey-Fuller test:

(5.1) $\Delta y_t = \alpha + \xi T + (p - 1)y_{t-1} + \sum^{g}_{j=1} \varphi_j \Delta y_{t-j}$

(5.2) $\Delta y_t = \alpha + \sum^{g}_{j=1} \varphi_j \Delta y_{t-j}$

where g represents the number of lags. Equation 5.1 is the unrestricted model and 5.2 is the restricted model under H_0: $p = 1$ and $\xi = 0$. Using the F-statistics, the Augmented Dickey-Fuller test examines whether the restrictions in equation 5.2 (i.e. $p = 1$ and $\xi = 0$) hold. If these restrictions hold, the analysis fails to reject the null hypothesis (H_0: $p = 1$ and $\xi = 0$) indicating that y_t contains a unit-root (Pindyck and Rubinfeld 1998). In order to reject the null hypothesis, the T-statistic must be less than the critical value.

Table 5.2 presents the results of the Augmented Dickey-Fuller test for each variable. For all variables, the calculated F-stat is greater than critical values at the 1%, 5% and 10% significance levels, indicating that the variables are non-stationary.

Table 5.2 Augmented Dickey-Fuller Test

Variable	Test Stat	Test Level	Critical Value	Variable	Test Stat	Test Level	Critical Value
UGDP	-2.227	1% level	-4.085	UGI	0.466	1% level	-4.081
		5% level	-3.470			5% level	-3.469
		10% level	-3.162			10% level	-3.161
JGDP	-2.099	1% level	-4.081	JGI	-2.495	1% level	-4.085
		5% level	-3.469			5% level	-3.470
		10% level	-3.161			10% level	-3.162
RER	-1.983	1% level	-4.081	DR	-1.343	1% level	-4.086
		5% level	-3.469			5% level	-3.471
		10% level	-3.161			10% level	-3.162
IC1	-2.302	1% level	-4.086	IC2	-2.585	1% level	-4.081
		5% level	-3.471			5% level	-3.469
		10% level	-3.162			10% level	-3.161
IC3	-1.982	1% level	-4.086	IC4	-2.365	1% level	-4.088
		5% level	-3.471			5% level	-3.472
		10% level	-3.162			10% level	-3.163
EC1	-2.048	1% level	-3.522	EC2	-1.018	1% level	-3.517
		5% level	-2.901			5% level	-2.899
		10% level	-2.588			10% level	-2.587
EC3	-2.881	1% level	-4.081	EC4	-2.609	1% level	-4.081
		5% level	-3.469			5% level	-3.469
		10% level	-3.161			10% level	-3.161

Each test contains 78 observations.
* represents significance at 10%,
** represents significance at 5%,
*** represents significance at 1%.

In order to obtain further information regarding stationarity, additional tests are conducted with the difference[6] of each variable. Each of the differenced variables is regressed with a constant and time trend to examine characteristics of the variables. The differenced variables are denoted with a D. Table 5.3 presents the estimated coefficients for the intercept and time trend terms, and the corresponding t-statistics.

[6] Differenced variables (denoted with a D or Δ) are obtained by subtracting the previous value from the current value. Example: $\Delta Y_t = Y_t - Y_{t-1}$

Table 5.3 OLS Regression for Characteristics of Differenced Variables

NAME	Regressors	Coefficient	T-stat	NAME	Regressors	Coefficient	T-stat
DUGDP	C	0.00673	5.609***	DUGI	C	0.00836	4.886***
	T	0.000003	0.114		T	0.00011	3.054***
R			0.0001	R			0.1106
DJGDP	C	0.00384	1.852*	DJGI	C	0.016485	5.777***
	T	-.00001	-.30112		T	-0.00022	-3.496***
R			0.0012	R			0.1401
DRER	C	0.00124	0.105	DDR	C	-0.0053	-.526
	T	0.00004	0.188		T	0.00012	.576
R			0.0004	R			0.0044
DIC1	C	-0.00048	-.016	DIC2	C	0.00607	0.581
	T	0.00024	0.364		T	0.00007	0.346
R			0.0017	R			0.0016
DIC3	C	0.0077	0.568	DIC4	C	0.01926	0.631
	T	-0.00005	-0.196		T	-0.00038	-0.568
R			0.0005	R			0.0042
DEC1	C	0.00215	0.104	DEC2	C	-0.01391	-0.995
	T	0.000101	0.223		T	0.00044	1.459
R			0.0006	R			0.0276
DEC3	C	0.03277	1.477	DEC4	C	0.01455	0.826
	T	-0.00055	-1.151		T	-0.00017	-.458
R			0.0173	R			0.0027

Each test contains 77 observations.
* represents significance at 10%,
** represents significance at 5%,
*** represents significance at 1%.

The estimates indicate that DJGI and DUGI show evidence of a significant time trend and constant term at the 90% level, thus they are required for the unit-root test on the differenced variables. The estimates of DUGDP and DJGDP contain a constant term at the 90% level, which is required for unit-root testing. Since all variables showed evidence of seasonality, a lag length of four is specified. Table 5.4 shows the results of the Augmented Dickey-Fuller test on the differenced variables.

Table 5.4 Augmented Dickey-Fuller Test for Differenced Variables

Variable	Test Stat	Test Level	Critical Value	Variable	Test Stat	Test Level	Critical Value
DUGDP	-6.634***	1% level	-3.519	DUGI	-8.912***	1% level	-4.083
		5% level	-2.900			5% level	-3.470
		10% level	-2.587			10% level	-3.161
DJGDP	-7.944***	1% level	-3.519	DJGI	-9.569***	1% level	-4.085
		5% level	-2.900			5% level	-3.470
		10% level	-2.587			10% level	-3.162
DRER	-7.233***	1% level	-2.596	DDR	-2.301**	1% level	-2.596
		5% level	-1.945			5% level	-1.945
		10% level	-1.613			10% level	-1.613
DIC1	-4.351***	1% level	-2.597	DIC2	-8.757***	1% level	-2.595
		5% level	-1.945			5% level	-1.945
		10% level	-1.613			10% level	-1.613
DIC3	-3.368***	1% level	-2.597	DIC4	-4.075***	1% level	-2.597
		5% level	-1.945			5% level	-1.945
		10% level	-1.613			10% level	-1.613
DEC1	-3.058***	1% level	-2.597	DEC2	-8.465***	1% level	-2.595
		5% level	-1.945			5% level	-1.945
		10% level	-1.613			10% level	-1.613
DEC3	-11.112***	1% level	-2.595	DEC4	-10.702***	1% level	-2.595
		5% level	-1.945			5% level	-1.945
		10% level	-1.613			10% level	-1.613

Each test contains 77 observations.
* represents significance at 10%,
** represents significance at 5%,
*** represents significance at 1%.

For all of the variables, the calculated T-statistic is larger than the critical values at the 10%, 5%, and 1% significance levels. This indicates that all of the differenced variables are stationary with four lags at the 5% level.

In order to obtain accurate estimates, the differenced variables could be regressed, however, this would result in the loss of information about the long-run relationship (Pindyck and Rubinfeld 1998 pg. 513). An alternative would be to determine if a linear combination of the variables is stationary. Co-integration means that a linear combination of non-stationary variables is stationary (Kennedy 1992). Co-integration tests developed by Engle and Granger (1987), or Johassen (1991) are used to determine whether a relationship among the variables included in the theoretical framework exists.

As an alternative test for co-integration, an ARDL model can be used for each import/export equation. The use of ARDL has several advantages for this study. ARDL provides more robust results compared to Engle and Granger co-integration methods for small sample sizes (Kueh et al. 2008). Pre-testing for unit roots is not necessary, however, by estimating each variables level of stationarity, additional statistical inference can be completed. Finally, both short-run and long-run estimates can be calculated simultaneously. In order for the ARDL results to be valid, a co-integration relationship among the variables should be found.

Lag Selection Procedure

The initial ARDL estimates are conducted for the four import commodity groups for the United States and Japan in equations (4.14) and (4.15), respectively. The Akaike Information Criterion (AIC) and Schwarz-Bayesian Criterion (S-B) are methods of measuring goodness of fit. The AIC criterion is used to select the maximum lag length for the ARDL model, and S-B is used to select the maximal number of lags for individual variables.

The main difference between S-B and AIC is the weight associated with the additional lags of each variable. S-B penalizes additional lags more heavily, thus decreasing the possibility of over-parameterizing. By using S-B to select individual lag lengths (or the order of the estimation), it is less likely that individual variables will be over-parameterized. The AIC is used to select the optimal maximum lag allowed.

Serial correlation occurs when errors from different time periods are related. To avoid serial correlation, additional lags can be added. The serial correlation test has a null hypothesis of "no serial correlation." If the null hypothesis is rejected, the model suffers from serial correlation. However, if the p-value is greater than .1, the null hypothesis is not rejected and the model does not suffer from serial correlation. If the model experiences serial correlation, the estimates are inefficient. To avoid this, it is necessary to select the appropriate number of lags to show evidence of not having serial correlation.

Since each observation is quarterly, the maximum allowable lag will be limited to four. Each variable is detrended and seasonally adjusted using the previous OLS estimations[7], denoted by an S in front of each variable. Tables 5.5 and 5.6 provide the initial results for U.S. import and export demand models[8].

[7] EC1 and EC2 are only seasonally adjusted, due to the lack of a significant time trend. All other variables are adjusted using the coefficients of the OLS output. Separate OLS estimations specifying only seasonal variation were used to adjusted EC1 and EC2.

[8] Order column provides the relevant number of lags of each variable, following the format: (SIC-group, SRER, SDR, SUGDP or SJGDP, SUGI or SJGI).

Table 5.5 Regression of SRER, SDR, SUGDP, and SUGI on U.S. Import Commodity Groups

Commodity	Lags	Order	AIC	S-B	Serial Correlation (P-Value)
SIC1	1	1,0,0,0,0	96.21	90.42***	0.048**
SIC1	2	1,2,0,2,0	96.79***	86.3706	0.302
SIC1	3	1,2,0,2,0	96.79	86.3706	0.302
SIC1	4	4,2,4,0,0	96.36	80.23	0.768
SIC2	1	1,0,0,1,1	133.9	125.79***	0.812
SIC2	2	1,0,0,1,1	133.9	125.79	0.812
SIC2	3	1,0,0,3,1	134.69***	124.26	0.376
SIC2	4	1,4,1,3,1	134.12	118	0.195
SIC3	1	1,0,0,0,0	139.28***	133.48***	0.232
SIC3	2	1,0,0,0,0	139.28	133.48	0.232
SIC3	3	1,0,0,0,0	139.28	133.48	0.232
SIC3	4	1,0,0,0,0	136.86	131.1	0.237
SIC4	1	1,0,1,0,0	106.62	99.66	0.381
SIC4	2	1,0,1,0,2	110.02***	100.75***	0.426
SIC4	3	1,0,1,0,2	110.02	100.75	0.426
SIC4	4	1,0,1,0,2	108.78	99.56	0.362

*** Denotes highest AIC and S-B,

** Denotes significant evidence of serial correlation.

Table 5.6 Regression of SRER, SDR, SJGDP, and SJGI on Japanese Import Commodity Groups

Commodity	Lags	Order	AIC	S-B	Serial Correlation (P-Value)
SEC1	1	1,0,0,0,0	94.79***	89***	0.115
SEC1	2	1,0,0,0,0	94.79	89	0.115
SEC1	3	1,0,0,0,0	94.79	89	0.115
SEC1	4	1,0,0,0,0	94.26	88.5	0.122
SEC2	1	1,0,1,1,0	122.76***	114.65***	0.775
SEC2	2	1,0,1,1,0	122.76	114.65	0.775
SEC2	3	1,0,1,1,0	122.76	114.65	0.775
SEC2	4	1,0,1,1,0	120.9	112.84	0.828
SEC3	1	1,0,1,0,1	87.01	78.89	0.066
SEC3	2	2,0,1,0,1	89.36***	80.09***	0.317
SEC3	3	2,0,1,0,1	89.36	80.09	0.317
SEC3	4	2,0,1,0,1	87.84	78.62	0.473
SEC4	1	1,0,1,1,0	103.92	95.81***	0.537
SEC4	2	1,0,2,1,0	104.45***	95.18	0.694
SEC4	3	1,0,2,1,0	104.45	95.18	0.694
SEC4	4	1,0,2,1,0	103.08	93.87	0.821

*** Denotes highest AIC, and S-B

** Denotes significant evidence of serial correlation.

The optimal lag is selected using the highest AIC value for each import demand model that is not suffering from serial correlation. The test shows that SIC1 fails to show evidence of not suffering from serial correlation when the maximum number of lags included is limited to one. The maximal AIC value for each commodity group does not suffer from serial correlation, thus the optimal model is selected for each commodity group from tables 5.5 and 5.6.

Co-integration Testing

The selection of the lag structure for each variable allows this study to test for co-integration. When co-integration exists, the relationship among the co-integrated variables can be used to capture their effect.

Two tests are utilized to test for co-integration among the variables, two different tests are utilized. First, the bounds test by Pesaran et al. (2001) for co-integration is used. The second test is from the ARDL estimation; the short-run estimation provides an Error Correction Term (ECM). The ECM measures whether the included variables are moving toward an equilibrium.

The bounds test by Pesaran et al. (2001), utilizes an OLS regression to determine if co-integration exists. To test for co-integration, a restricted equation is specified with differenced variables to tests the significance of an unrestricted OLS that includes one lag of each variable. Equations 5.1 and 5.2 are the restricted and unrestricted equations for U.S. commodity imports from Japan.

$$5.1)\quad \Delta \ln M_{U.S.,i,t} = \sum \alpha_{1k}\Delta \ln M_{U.S.,i,t-k} + \sum \alpha_{2k}\Delta \ln Y_{U.S.,t-k} + \sum \alpha_{3k}\Delta \ln e_{t-k} + \sum \alpha_{4k}\Delta \ln G_{U.S.,t-k} + \sum \alpha_{5k}\Delta \ln (r^{j}/ r^{U.S.})_{t-k} + \zeta_t$$

5.2) $\Delta \ln M_{U.S.,i,t} = \beta_1 \ln M_{U.S.,i,t-1} + \beta_2 \ln Y_{U.S.,t-1} + \beta_3 \ln e_{t-1} + \beta_4 \ln G_{U.S.,t-1}$

$+ \beta_5 \ln (r^j / r^{U.S.})_{t-1} + \sum \alpha'_{1k} \Delta \ln M_{U.S.,i,t-k} + \sum \alpha'_{2k} \Delta \ln Y_{U.S.,t-k} +$

$\sum \alpha'_{3k} \Delta \ln e_{t-k} + \sum \alpha'_{4k} \Delta \ln G_{U.S.,t-k} + \sum \alpha'_{5k} \Delta \ln (r^j / r^{U.S.})_{t-k} + \zeta_t$

Equations 5.3 and 5.4 are the restricted and unrestricted OLS equations for U.S. imports of Japanese commodities.

5.3) $\Delta \ln M_{J,i,t} = \sum \lambda_{1k} \Delta \ln M_{J,i,t-k} + \sum \lambda_{2k} \Delta \ln Y_{J,t-k} + \sum \lambda_{3k} \Delta \ln e_{t-k}$

$+ \sum \lambda_{4k} \Delta \ln G_{J,t-k} + \sum \lambda_{5k} \Delta \ln (r^j / r^{U.S.})_{t-k} + \varphi_t$

5.4) $\Delta \ln M_{J,i,t} = \gamma_1 \ln M_{J,i,t-1} + \gamma_2 \ln Y_{J,t-1} + \gamma_3 \ln e_{t-1} + \gamma_4 \ln G_{Jt-1} +$

$\gamma_5 \ln (r^j / r^{U.S.})_{t-1} + \sum \lambda'_{1k} \Delta \ln M_{J,i,t-k} + \sum \lambda'_{2k} \Delta \ln Y_{J,t-k} +$

$\sum \lambda'_{3k} \Delta \ln e_{t-k} + \sum \lambda'_{4k} \Delta \ln G_{J,t-k} + \sum \lambda'_{5k} \Delta \ln (r^j / r^{U.S.})_{t-k} + \varphi_t$

Pesaran et al. (2001) bounds test does not require each variable to be differenced stationary. Because of the possible inclusion of stationary and differenced stationary variables, the test statistic is a range (Pesaran et al. 2001). The upper bound represents the critical value if only differenced stationary variables are included, and the lower bound represents the test statistics if only stationary variables are included. A test statistic that falls with-in the range cannot be used to draw inferences without knowing each variables level of stationarity[9]. The test statistic is the F-statistic comparing the restricted model to the unrestricted model. The null hypothesis for the bounds test is $\beta_1=\beta_2=\beta_3=\beta_4=\beta_5=0$ in

[9] Previous unit-root tests allows additional co-integration tests to be conducted and also provides additional inference from Pesaran's bounds test in the event that the critical values would have fallen within the test range.

equation 5.2 (or $\gamma_1 = \gamma_2 = \gamma_3 = \gamma_4 = \gamma_5 = 0$ in equation 5.4). Values that exceed the upper bound show evidence of co-integration.

The F-statistic for all commodity groups is larger than the critical values at the 90% level, indicating that each of the eight commodity groups has its own co-integration among the variables. The results from Pesaran's bounds test indicate that all eight commodities show evidence of co-integration at the 90% level. Table 5.7 shows the results of Pesaran's bounds test for each commodity group. The bounded critical values were obtained from Pesaran et al. (2001).

Table 5.7 Bounds Test for Co-Integration

Variables	Test Stat
SIC1	3.905**
SIC2	3.100*
SIC3	3.362*
SIC4	4.569***
SEC1	3.012*
SEC2	3.490**
SEC3	5.474***
SEC4	3.328*

Critical values: 1.90-3.01 range for 90% level, 2.26-3.48 range for 95% level, and 3.07-4.44 range for 99% level.
* represents significance at 10%,
** represents significance at 5%,
*** represents significance at 1%.

The initial ARDL estimations provide the short-run estimation. The short-run results also provide an estimation of a single error-correction term (ECM). The error-correction term indicates whether the set of variables are moving together toward its own equilibrium and have a long-run relationship. This result is provided as an alternative co-integration test.

If the ECM term is negative, the set of variables are moving together and toward its own equilibrium. Thus, a significant and negative ECM further reinforces the result of a significant co-integration relationship. The error-correction term for every equation is negative and significant. The error-correction term provides evidence, at the 99% level, that each set of variables is moving towards its own equilibrium. This provides additional support for the use of an ARDL model for estimating the relationship for each commodity group. Table 5.8 shows the initial ECM results from the ARDL regressions.

Table 5.8 Analysis of Error-Correction Term

Commodity Group	ECM-coefficient	T-stat
SIC1	-0.536	-4.938***
SIC2	-0.217	-2.737***
SIC3	-0.351	-5.244***
SIC4	-0.519	-5.926***
SEC1	-0.281	-2.965***
SEC2	-0.233	-3.347***
SEC3	-0.346	-3.321***
SEC4	-0.518	-4.895***

* represents significance at 10%,
** represents significance at 5%,
*** represents significance at 1%.

CHAPTER 6. EMPIRICAL RESULTS

The following section discusses the results from the econometric model, and compares the results to previous studies. The analysis examines the long-run results and short-run dynamics of U.S. imported commodities from Japan. The analysis of Japanese imports from the U.S follows, in the same format.

U.S. Imports from Japan

The R-squared value is a measure of the models' goodness of fit, and is listed for each commodity group in the short and long-run. All of long-run models, except agricultural goods, have an R-squared value greater than .78. This indicates that the estimates account for over 78% of the variation in each commodity group. The short-run R-squared values differ by commodity group, and have smaller values implying that the variables do not fully explain the short-run variation.

Table 6.1 provides the estimates for both the long-run and short-run estimates of U.S. imports from Japan for the four different commodity groups: SIC1 (agricultural goods), SIC2 (materials and chemicals), SIC3 (machinery and transport equipment), and SIC4 (manufacturing goods) [10].

[10] As previously defined, SIC1 is seasonally adjusted U.S. imports from Japan for SITC-0, 1, and 4; SIC2 corresponds to SITC-2, 3, 5 and 6, SIC3 corresponds to SITC-7, and SIC4 corresponds to SITC-8.

Table 6.1 Estimated U.S. Import Demand Models for Japanese Commodities

Variable	Commodity Group			
	SIC1	SIC2	SIC3	SIC4
	Long-Run			
SRER	.009 (.055)	-.228 (-.964)	-.889 (-5.888)***	-.285 (-2.064)**
SDR	.205 (1.167)	-.017 (-.071)	.258 (1.715)*	.362 (2.548)**
SUGDP	1.367 (1.165)	-2.138 (-.924)	3.075 (3.023)***	4.633 (4.041)***
SUGI	.273 (.451)	-.600 (-.622)	.030 (.058)	-1.204 (-2.071)**
R	0.4508	0.7841	0.8328	0.7812
	Short-Run			
DSRER	.110 (.671)	-.049 (-.975)	-.312 (-5.585)***	-.148 (-2.009)**
DSRER(-1)	-.354 (-2.038)**			
DSDR	.110 (1.142)	-.003 (-.070)	.090 (1.829)*	-.272 (-1.496)
DSUGDP	1.781 (1.055)	.298 (.283)	1.080 (3.088)***	2.407 (4.197)***
DSUGDP(-1)	2.879 (1.845)*	.853 (.885)		
DSUGDP(-2)		1.998 (1.991)**		
DSUGI	.146 (.444)	1.152 (1.806)*	.010 (.059)	.345 (.390)
DSUGI(-1)				-2.643 (-2.899)***
ecm(-1)	-.536 (-4.938)***	-.217 (-2.73)***	-.351 (-5.244)***	-.519 (-5.926)***
R	0.3423	0.261	.328	.475

t-values are in parenthesis.
* represents significance at 10%,
** represents significance at 5%,
*** represents significance at 1%.

Long-Run Results

The long-run estimates of U.S. imports from Japan indicate that the real exchange rate is significant at the 99% and 95% significance level for SIC3 and SIC4, respectively. The negative coefficient implies that a decrease in the real exchange rate variable increases the value of U.S. imports from Japan.

A decrease in the real exchange rate means that the U.S. dollar is depreciating relative to the Japanese Yen. The depreciation results in an increase in the relative price of U.S. imports from Japan. As the price of U.S. imports from Japan increases as a result of the depreciating U.S. dollar, the quantity of U.S. imports from Japan is expected to decrease. However, if the increase in the price of imported goods changes more than the decrease in the quantity of imported goods (inelastic price elasticity of import demand), the value of Japanese imports will increase with a depreciation of the U.S. dollar. This inelastic relationship is consistent with the results of Bahmani-Oskooee and Hegerty (2008) and Breuer and Clements (2003).

The estimated coefficients of the real exchange rate are not significant for SIC1 and SIC2. SIC1 and SIC2 show no significant response in the long-run to any of the variables. Agricultural imports from Japan (SIC1) are mainly to meet demand for a small segment of the U.S. population, with mollusks and crustaceans for human consumption (SITC-036) being the largest component. Overall, agricultural imports from Japan accounted for only .8% of total U.S. agricultural imports in 2008 (UN COMTRADE 2009). Material and chemical imports from Japan also accounted for a small portion of total U.S. imports. In 2008, the U.S. imported $94 billion of materials and chemicals, while imports from Japan accounted for only 2% of this commodity (UN COMTRADE 2009).

The estimated coefficients of interest rates are significant at the 90% and 95% level for SIC3 and SIC4, respectively. The positive coefficient indicates that an increase in cost of capital in Japan, relative to the United States, increases U.S. imports from Japan. As mentioned in chapter 4, SIC3 and SIC4 is comprised mainly of capital intensive goods (machinery and transport equipment, and manufactured goods), thus interest rates is expected to be significant. The relatively lower cost of capital in the United States gives U.S. industries a comparative advantage; however, U.S. imports from Japan consist of specialized goods. Because of the limited import substitution, the relatively lower U.S. capital costs results in an increase in value of U.S. imports from Japan.

The estimated coefficients of interest rates are not significant for SIC1 and SIC2. Two possible reasons for insignificance of interest rates is the composition and the overall magnitude of U.S. imports of SIC1 and SIC2. The relative small amounts of imports of these two commodity groups are used to meet demands of a small segment of the U.S. market; thus interest rates may not affect demand of these specialized goods. SIC1 and SIC2 are comprised of agriculture and material and chemical goods. Since neither of these commodity groups is comprised of capitals intensive goods, imports of both groups may not be affected by changes in the cost of capital.

The estimated coefficients of real income, represented by real GDP, are significant at the 95% level and have a positive sign for both SIC3 and SIC4. As consumers' income increases, resulting from increases in GDP, consumers purchase more goods, including imports from Japan. The insignificance of real income for SIC1 and SIC2 is expected due to SIC1 and SIC2 being small segmented market in the United States.

The estimated coefficient of government consumption expenditures shows that it is significant for SIC4. The negative coefficient indicates that an increase in government expenditures correlates with a decrease in imports of Japanese manufactured goods.

As previously mentioned, government consumption expenditures can have two effects: income or production. If government expenditures raise consumption more than private production, the result is an income effect. However, if government expenditures are used as inputs for production, the result is an increase in commodity supply (production effect). This result reinforces the argument that government expenditures have a positive production effect for SIC4. As government expenditures increase industries' "productive inputs," domestic commodity supply increases and reduces imports.

Short-Run Dynamic

As mentioned earlier, the error correction term for all four of the models is negative and significant. The ECM term estimates the time required to return to equilibrium after a shock. SIC2 has the slowest response, requiring more than four quarters to return to equilibrium (1 / .217 = 4.61 quarters). SIC1 has the fastest response, requiring less than two quarters (1 / .536 = 1.87 quarters).

The short-run coefficients show whether each variable has a significant effect within the dynamic model. However, drawing inference from these estimates may misrepresent the true effect of each variable. Bahmani-Oskooee and Hegerty (2008) describe this in their study: "the overall short-run effect is uncertain, however, as a positive coefficient could be followed by a negative coefficient at a higher lag (or vice versa), resulting in a net effect of zero."

The estimated coefficients of the real exchange rate is significantly different from zero at the 95% level for SIC1, SIC3, and SIC4, indicating that U.S. imports of these commodities affected by changes to the real exchange rate. The negative coefficients of both DRER and DRER(-1) indicates that depreciation of the U.S. dollar increases the value U.S. imports of Japanese goods for all three groups. The negative coefficient indicates that import demand of these commodities is inelastic, thus changes is the quantity of imports is relatively smaller than changes in price. The short-run effects of changes in the real exchange rate are consistent with the long-run effects for SIC3 and SIC4.

The estimated coefficient of interest rates is only significant for SIC3. The positive coefficient implies that as U.S. capital costs increase, imports from Japan decrease. Similar to the long-run results, as domestic capital costs increase, consumption decreases, thereby decreasing the demand for capital intensive imports. This result coincides with the long-run estimation.

The estimated coefficients of real income for all four commodity groups are significant and have a positive sign. As income rises, domestic consumption increases, thus increasing the demand for imports. The positive short-run estimates of income for SIC3 and SIC4 are consistent with the long-run effects.

The estimated coefficients of government expenditures are significant for both SIC2 and SIC4. The negative coefficient of SIC4 indicates that government expenditures are having a production effect, while the positive coefficient of SIC2 indicates a income effect. The short-run estimates for SIC4 are consistent with the long-run effects.

Japanese Imports from the United States

The long-run R-squared values indicate that the model explains over 82% of the variation for three of the commodity groups. The R-squared value for agricultural goods is lower (.755). The short-run R-squared values show that the model explains less than 50% of each commodities variation.

Table 6.2 provides the estimates for both the long-run and short-run estimates of Japanese imports from the United States for the four different commodity groups: SEC1 (agricultural goods), SEC2 (materials and chemicals), SEC3 (machinery and transport equipment), and SEC4 (manufacturing goods) [11].

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[11]As previously defined, SEC1 is seasonally adjusted Japanese imports from the U.S. for SITC-0, 1, and 4; SEC2 corresponds to SITC-2, 3, 5 and 6, SEC3 corresponds to SITC-7, and SEC4 corresponds to SITC-8.

Table 6.2 Estimated Japanese Import Demand Models for U.S. Commodities

Variable	Commodity Group			
	SEC1	SEC2	SEC3	SEC4
	Long-Run			
SRER	-1.000 (-2.514)**	-1.528 (-3.575)***	-.887 (-1.984)*	-.387 (-2.082)*
SDR	.022 (.080)	-.074 (-.277)	-.901 (-3.552)***	-.751 (-5.550)***
SJGDP	3.355 (1.909)*	3.499 (2.126)**	3.274 (2.161)**	3.425 (4.035)***
SJGI	.241 (.253)	-2.387 (-2.937)***	.709 (.723)	.523 (1.173)
R	0.7553	0.9017	0.8625	0.826
	Short-Run			
DSEC3			-.259 (-2.503)**	
DSRER	-.281 (-3.207)***	-.356 (-5.222)***	-.306 (-3.026)***	-.200 (-2.296)**
DSDR	.006 (.081)	.328 (2.178)**	.435 (1.869)*	.022 (.110)
DSDR(-1)				.325 (1.673)*
DSJGDP	.943 (1.708)*	2.536 (3.562)***	1.131 (1.714)*	3.549 (4.103)***
DSJGI	.067 (.244)	-.556 (-2.671)***	3.058 (4.737)***	.270 (1.119)
ecm(-1)	-.281 (-2.964)***	-.233 (-3.346)***	-.345 (-3.320)***	-.517 (-4.969)***
R	0.2176	0.4020	0.4786	0.428

t-values are in parenthesis.
* represents significance at 10%,
** represents significance at 5%,
*** represents significance at 1%.

Long-Run Results

The estimated coefficients of the real exchange rate are significantly different from zero at the 90% for all the commodity groups. The negative coefficient implies that an increase in the real exchange rate decreases the value of Japanese imports from the United States. An increase, in the real exchange rate, means that the U.S. dollar is appreciating relative to the Japanese Yen. As the prices of U.S. goods increase in terms of the Japanese currency, the quantity of Japanese imports is expected to decrease. The negative coefficient implies that a decrease in the quantity of Japanese imports from the United

States is greater than the change in price, indicating that in the long-run, Japanese import demand for U.S. goods is elastic.

The estimated coefficients of interest rates are significant and negative for SEC3 and SEC4. The negative coefficients indicate that when Japanese capital costs increase relative to U.S. capital costs, Japanese imports from the United States decrease. Since Japanese imports in SEC3 and SEC4 are specific commodities which have limited domesic substitution, higher interest rates in Japan raise its import cost from the United States and decrease its imports from the United States. The coefficient of interest rate is not significantly different from zero for SEC1 and SEC2. Similar to U.S. imports of agriculture, chemical, and materials goods, Japanese imports of the same commodities are not comprised of capital intensive goods, thus changes in the cost of capital may not affect import demand.

The coefficient of national income is positive and significant, indicating that as Japanese income rises, imports from the United States increase. As consumers' income increases, they purchase more goods, resulting in an increase in demand for imports.

The estimated coefficient of government expenditure is negative and significant for SEC2. This indicates that increases in government expenditures correlates with a decrease in imports of U.S. materials and chemicals. This result reinforces the argument that government expenditures have a positive production effect for SEC2.

Short-Run Dynamic

The error correction term for all four of the models is negative and significant. SEC2 has the slowest response, requiring over four quarters to return to equilibrium (1 /

.233 = 4.29 quarters). The slow response of Japanese imported agriculture is expected because of Japan's dependent on foreign agricultural goods. SEC4 has the fastest response requiring only a little more than two quarters (1 / .518 = 1.93 quarters). With the exception of agricultural goods, each commodity group's response time to a shock is comparable to the response of U.S. imports.

The estimated coefficients of real exchange rate are significantly different from zero in the short-run, with all four commodities having a negative coefficient. The negative coefficient of DSRER indicates that appreciation of the Japanese Yen increase the value of Japanese imports of U.S. goods. The estimated effects of the real exchange rate are consistent with the long-run results for all four commodity groups.

The estimated coefficients of interest rates show that they are significant for three commodities: SEC2, SEC3, and SEC4. The positive coefficient indicates that increases in the cost of capital in Japan result in an increase in imports. However in the long-run, the coefficient of interest rate is negative (SEC3 and SEC4) or insignificant (SEC2), thus the short-run positive response would be due to a lagged response.

The estimated coefficients of income are positive and significant for all four commodity groups. The positive short-run effects of income are consistent with the long-run effects for all four commodity groups.

The estimated coefficient of government expenditures shows that SEC2 and SEC3 are significantly affected by government expenditures. The negative coefficient of SEC2 indicates that government expenditures are having a production effect, while the positive coefficient of SEC3 indicates an income effect. The short-run estimates for SEC2 are consistent with the long-run effects.

CHAPTER 7. SUMMARY AND CONCLUSION

The objective of this study was to identify the effects of the real exchange rate, real income, interest rates, and government expenditures on bilateral trade between the United States and Japan. This study utilizes an ARDL approach to estimate the import demand of four distinct commodity groups in the United States and Japan.

The estimation of the eight models provides insight into the determinants of each commodity's trade flow. Six of the eight import commodity groups were significantly affected by the real exchange rate, income, interest rates, and/or government expenditures. U.S. imports of agriculture goods and materials and chemicals from Japan failed to show a significant relationship with any of the variables.

The quantity of agricultural imports from Japan is small in magnitude, and demand is limited to a small segment of the U.S. population. U.S. imports of materials and chemicals and agricultural goods from Japan accounted for less than 3% of total U.S. imports (USITC: trade database 2009).

The remaining six models showed a significant short-run dynamic and long-run effect. The results of the long-run estimations for the remaining six commodity groups are significantly affected by the real exchange rate and income. The value of all six commodity groups is positively correlated with income. This result is consistent with economic theory; increases in income will result in increased imports.

The real exchange rate had different effects for each country. The effects of the real exchange rate on U.S. imports of Japanese goods show that as the U.S. dollar depreciates relative to the Yen, the value of imports increases. Similar to previous studies, this result provides further evidence that U.S. import demand for Japanese goods is inelastic.

The appreciation of the Japanese Yen is expected to increase Japanese imports of U.S. goods. All four of the commodity groups had the same response to exchange rate increases. These results show that as the price of U.S. goods increase in terms of Japanese currency, Japanese imports of U.S. goods decrease.

Interest rates are significant for four of the six commodity groups. Interest rates were predicted to be significant for capital intensive commodity groups: machinery and transport equipment, and manufactured articles. The imports of machinery and transport equipment, and manufactured goods for both countries show a positive relationship with relative interest rates, thus both countries increase imports when domestic interest rates decrease relative to foreign interest rates. This relationship shows that as each country's relative interest rate increases, import demand decreases.

Government expenditures are significant in the long-run for only one commodity group in each country. This finding reinforces Devarajan et al. 1996, that government expenditures can permanently alter resource allocations and gross domestic product (GDP) structure. If expenditures are allocated as productive inputs for the private market, import demand will be reduced. The results show that government expenditures decrease imports from specific commodity groups, however, this differs by country.

Results

All the included macroeconomic variables are significant determinants of bilateral trade between the United States and Japan in the short and long-run. Real exchange rates and income are especially significant in trade between the United States and Japan. The model also shows the significance of interest rates on imports in the long-run, and its relevance to capital-intensive commodities. The effects of government expenditures also are shown to be significant for specific commodities.

This study indicates that monetary policy significantly affects imports from capital intensive industries for both the United States and Japan, while the effects of government expenditures differ by country and commodity group.

Need for Further Study

This study analyzes the effects of the real exchange rate, real income, monetary policy and government expenditures on bilateral trade between the United States and Japan. The results indicate that commodity groups respond differently to interest rates and government expenditures. Few studies have evaluated this relationship.

Additional areas of research that warrant further study, would be to focus on specific import products. Additional information about the composition of government expenditures also would allow further investigation of their effects on each commodity group, and provide information about secondary effects for other industries.

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