CURRENCY DEPRECIATION AND THE TRADE BALANCE: AN ELASTICITY APPROACH AND TEST OF THE MARSHALL-LERNER CONDITION FOR BILATERAL TRADE BETWEEN THE US AND THE G-7

by

Taggert J. Brooks

A Dissertation Submitted in
Partial Fulfillment of the
Requirements for the Degree of

Doctor of Philosophy

Economics

at

The University of Wisconsin-Milwaukee

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The United States has experienced a large and growing trade deficit for the last 30, which has often been the topic of political if not economic concern. On occasion policy makers have debated using the exchange rate to motivate an improvement in the trade balance. This result hinges on the satisfaction of the Marshall-Lerner conditon, which states that the import and export demand price elasticities must sum to greater then unity. Previous research

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Chapter I

Introduction

In 1973 total trade for the United States, imports plus exports, was 11% of GDP, by 1996 it had grown to 20%. Clearly seen in Figure 1 this trend is expected to continue into the future, due in part to trade negotiations and trade liberalizations being "fast tracked" in Washington. Therefore, what was once a closed economy has now become quite dependent upon foreign trade. Along with this dependence comes an increased need to understand the dynamic relationship that exists between the volume of foreign trade and the exchange rate. Additionally, it is equally important to understand the consequences of public policy targeted at this relationship.

1.1 Trade Imbalance

A concern related to our increasing openness, is our trade balance, which has often been a topic of political if not economic concern. The size of the merchandise trade deficit has increased dramatically, particularly among key trading partners, such as Japan and Canada. I can see these trends mirrored in the trade balance of the US vis-à-vis other members of the group of seven, see Figure 2. Among the other 6 countries of the G-7 (France, Germany, Italy, Canada, Japan, and the UK), 5 of them are among the United States' top ten trading partners based on total trade volume, with only Italy missing. In fact, the rest of the G-7 makes up almost half of all trade for the US; which implies total trade with the G-7, as a percentage of GDP stood at 10% in 1996. Additionally, 5 of the 6 countries are among the top ten partners with which the US has a trade deficit, where the UK is missing from this list. In an effort to correct this situation the dollar has often been allowed, and even induced to depreciate with mixed success. The fundamental research question in this work concerns whether or not a coordinated bilateral depreciation can improve the trade balance. This paper focuses on estimating a condition that is generally thought necessary for a depreciation to be successful. It is widely known as the Marshall-Lerner Condition, herein referred to as the M-L condition. Its origins lie in the elasticities approach to the balance of payments. This approach answers the question of whether or not a domestic currency depreciation (devaluation) will improve the domestic trade balance by looking at the import and export demand price elasticities. If the absolute value of the import and export demand relative price elasticities sum to greater then unity, it is generally thought that the trade balance will improve following a depreciation. This is known as the Marshall-Lerner. If this condition is satisfied, then real devaluation of a currency can lead to an improvement in the current account. The Marshall-Lerner condition is originally due to Bickerdike (1920), but has been named after Marshall, the father of the elasticity concept, and Lerner (1944) for his later exposition of it. For a simple discussion of this approach see Alexander (1959).

The current work will focus on the estimation of this condition by estimating import and export demand equations on a bilateral basis. Most previous studies estimate these equations on an aggregate basis, which is subject to potential bias and measurement error. It is maintained throughout this work that the appropriate level of aggregation, one which addresses econometric and policy concerns, involves the use of quarterly bilateral data. Therefore, I will estimate the import and export demand elasticities for bilateral trade between the US and each of the other 6 members of the group of seven industrialized countries (G-7).

The choice of the G-7 is made for several reasons. First, the most pragmatic reasons are that data for GDP, imports, exports, and exchange rates are widely available, and reliable for these countries and have the smallest measurement error. Secondly, the trade balance vis-à-vis the remaining 6 countries closely follows the aggregate trade balance. Thirdly, as previously mentioned, they represent a large portion of US trade.

1.2 Policy implications

The research focuses on the bilateral trade balance, not because of its economic importance, but rather due to the political nature of the bilateral trade balance. Often a trade deficit is taken as evidence of unfair trading practices on the part of the other country. It is often believed that the deficit is due to the foreign partner's import restrictions. In particular, the US has at different times pleaded with Japan to help reduce the US trade deficit. The estimates of bilateral elasticities will help to identify the quantity and volume effects of a tariff, or the impact of a coordinated dollar depreciation.

Chapter II

Literature Review

Given that the goal of this work is to provide possible policy prescription for reducing the US trade deficit, I am interested more specifically in whether or not the M-L condition is satisfied; and therefore, whether or not the exchange rate could be a policy tool to achieve this end. As such, it is important to discuss the previous literature written to address this issue. There are primarily two methods for testing the M-L condition. The first method, hence further referred to as the elasticities method, involves directly estimating the import and export demand price elasticities. Section 2.1 discusses the large surveys of this literature and section 2.2 discusses some of the recent papers in more detail. The indirect method entails estimating the dynamic reaction of the trade balance to a real domestic depreciation. If the trade balance eventually improves following a depreciation, it is considered implicit evidence that the M-L condition is meet. The body of literature that uses the indirect method is generally referred to as the J-curve literature. The J-curve literature gets its name from the plot of the time path of the trade balance in response to a real depreciation. Since the short run elasticities are generally thought to be low, the trade balance initially worsens before eventually improving, thus tracing the shape of a J. Section 2.3 discusses the general findings in the J-curve literature.

2.1 Elasticities Surveys

The estimation of income and price elasticities for imports and exports is one of the oldest empirical efforts in economics. According to Goldstein and Khan (1985), there were 42 books and articles by 1957 and Stern et al. (1976) cite some

130 articles from the period 1960-1975, which estimate the trade elasticities. Sprinkle and Sawyer (1996) pick up in 1976 and survey approximately 50 articles, which estimate the trade elasticities. While I intend to broadly review some of the literature, I am in no way attempting a thorough review. In this section, I will discuss the large surveys previously mentioned and evaluate their general findings. Sawyer and Sprinkle (1996) provide the most recent survey article, and they focus on U.S. import and export demand. Previous to their research, there were large surveys by, Goldstein and Khan (1985), Stern et al. (1976), Magee (1975), and Leamer and Stern (1970).

Beginning with the work of Stern et al. (1976), an annotated bibliography that briefly discusses the work that has gone before them. These works study many different countries, both developed and less developed, while also estimating price elasticities for many different levels of aggregation. Some studies estimate import and/or export elasticities over a range of different commodity classes, while still others estimate the aggregate price elasticities. Stern et al. (1976) covers approximately 14 articles, which estimate the aggregate US import and export price elasticities. The import demand price elasticities range from –0.41 to –3.00, while the export demand price elasticities range from -0.56 to –2.53. The sum of the absolute value of these ranges runs from 0.97 to 5.53, suggesting that the M-L condition is satisfied.

Goldstein and Khan (1985), and Magee (1975) primarily focus on the methodological concerns of previous work. They survey the econometric issues involved in estimating the elasticities and in how previous works have addressed them. However, Goldstein and Khan (1985) do provide summary estimates of import and export price elasticities. The import demand price elasticities range from –1.03 to –1.73, and export demand price elasticities range from –0.32 to –2.32. This gives a range of the M-L condition from 1.35 to 4.05. Again, as in Stern et al. (1976), there seems to be much support for a depreciation improving the US trade balance. Additionally, Goldstein and Kahn (1985) also report the estimates of import and export demand income elasticities. They find that these elasticities, sometimes called activity elasticities, vary systematically between imports and exports. For the United States, import demand income elasticities range from 1.53 to 4.03, while export demand income elasticities range from 0.99 to 2.15. Clearly the income elasticity of imports is larger then the export elasticity. In fact, every article that Goldstein and Kahn (1985) reference find this to be true.

Sawyer and Sprinkle (1996), unlike previous researchers, concentrate solely on US trade elasticities. They report an aggregate import price elasticity around –0.58 and an aggregate export price elasticity around -0.97; this too suggests that the M-L condition is satisfied, with an estimate of 1.55. Finally, Sawyer and Sprinkle (1996), like the others, point out that the estimates of the import demand income elasticity is on the order of 2.14; while the estimates of the export demand income elasticity is around 1.11.

The large surveys present the policy maker with a myriad of results to digest. While they all find that the US satisfies the M-L condition on an aggregate basis, their estimates range from as low as 1 to as high as 5.53. Additionally, almost all of them concern aggregate trade, and therefore, provide the policy maker interested in affecting the bilateral trade balance with no direction. The surveys do, however, offer potentially interesting insight into the source of the large trade deficits. The differences in income elasticities may, in fact, be the source of the current large deficits. It will be important to see if these results hold for the bilateral trade equations.

2.2 Import and Export Demand Estimation

In this section, I will endeavor to review a few recent articles that pursue the estimation of the US trade elasticities, upon which this research is focused. The elasticity estimates differ for many reasons and can be explained largely by differences in data and estimation techniques employed. I will attempt to divide recent research along these issues. More specifically, they can be demarcated along the following lines: the sample period, the frequency of the data, the level of aggregation, the specification of the estimating equation, and finally the estimation technique. The first major point of difference between the existing literature concerns the level of aggregation. Traditionally, most of the literature employs aggregate data, that is imports from the rest of the world and exports to the rest of the world. Recent examples of this are to be found in Carone (1996), and Bahmani-Oskooee (1998a).

2.3 Trade Balance Equation and the J-Curve

There are some peculiar inconsistencies between testing the M-L condition directly versus testing it indirectly. This section will discuss some of the major findings in the J-curve literature and compare them with those found in the elasticities literature. The J-curve literature generally estimates a trade balance equation of the form found in equation 2.1.

$$TB_{ROW} = f(Y_{us}, Y_{ROW}, REX_{ROW}) \tag{2.1}$$

Where the left hand side represents the real trade balance with the rest of the world, and the right hand side includes US real income, the real income for the rest of the world and finally, the real exchange rate vis-à-vis the rest of the world. If the trade balance is defined such that an increase represents an improvement in the trade balance and the real exchange is defined as foreign currency units per domestic currency unit. Then a real depreciation should initially worsen the trade balance if there is a positive relationship between the trade balance and the exchange rate, and eventually the trade balance will improve when the coefficient on the real exchange rate becomes negative and significant. The M-L condition is assumed to be met if this long-run coefficient is negative and significant.

There are many studies which attempt to estimate the J-curves. Some notable studies involving less developed countries (LDCs) include Bahmani-Oskooee (1985, 1991, 1992), and Arize (1994). Of immediate interest for this research are the studies which estimate a J-Curve for the United States. These include studies by Moffett (1989), Rose and Yellen (1989), Rose (1991), Marwah and Klein (1996), Shirvani and Wilbratte (1997), and Marquez (1991). These studies are evenly split between those that find an improvement in the trade balance after a real depreciation, and those that fail to find an improvement. There are several reasons for the different conclusions.

I will first address the studies that found no significant support for the M-L condition. Moffett (1989) decomposes the J-curve into its three distinct stages. The first stage is the currency contract period, in which trade contracts are executed based upon pre-depreciation relative prices. The second period is known as the pass through period in which the prices adjust to the new exchange rate. The final period, known as the quantity response period, involves the adjustment of import and export quantities to the new prices. Moffett estimates the response in each period and then uses the estimates to simulate the response of the trade balance to a depreciation. He finds an initial worsening of the trade balance followed by a short lived improvement. The trade balance more closely resembles a sine wave then the letter J.

Rose and Yellen (1989) and Rose (1991), not only find that the trade balance does not improve after a depreciation, but also find no statistical relationship exists between the two variables. Rose and Yellen (1989), use data disaggregated on a bilateral basis, that is trade between the US and UK, between the US and Japan, and similarly for the rest of the G-7. Rose (1991) uses aggregate data and, similarly, finds no relationship between the exchange rate and the trade balance. While both of these papers employ cointegration techniques in estimation, they are potentially troubled by several problems. First, they use the technique attributed to Engle and Granger (1987), which involves a two step process. This method does not account for the simultaneity of income and the trade balance and can compound measurement error in the first stage.

Next I will turn to the papers that find a real currency depreciation has a positive impact on the trade balance, these include, Marwah and Klein (1996), Shirvani and Wilbratte (1997), and Marquez (1991). While these studies use different econometric techniques or different levels of aggregation, they all conclude that, in the case of the United States, a real dollar depreciation will improve the trade balance. Marwah and Klein (1996) find that the trade balance should improve after as little as 3 quarters, while Shirvani and Wilbratte (1997) find that the trade balance will improve on average in 24 months. Finally, Marquez (1991) finds that the average adjustment period is around 6 quarters before the depreciation improves the trade balance. Given the different estimates of the trade balance adjustment period it is worth noting that Marwah and Klein (1996), Shirvani and Wilbratte (1997), and Marquez (1991) agree the trade balance is improved in the long-run; and, therefore, the M-L condition is satisfied after, at most, a period of two years. However, as is noted in Appendix A, the country need not satisfy the M-L condition for the trade balance to improve following a depreciation if the country initially has a trade deficit. So the results of the J-curve studies should not be taken as implicit evidence of the satisfaction of the M-L condition.

Chapter III

Model

3.1 Bickerdike-Robinson-Metzler Condition (B-R-M condition)

The elasticities approach to the balance of payments can trace its origins to the work of Bickerdike (1906, 1920). Despite stern warnings from Alfred Marshall against the use of partial equilibrium analysis in international trade, Bickerdike used just such analysis to derive the general condition under which a devaluation improves the trade balance. The derivation is given in detail in Appendix A and follows Stern (1973), but I will present the basic argument here. The trade balance in foreign currency terms is:

$$B_f \equiv p_{fx} X - p_{fm} M \qquad (3.1)$$

The change in the trade balance after a depreciation can be denoted as:

$$\Delta B_f \equiv (p_{fx}\Delta X + X\Delta p_{fx}) - (p_{fm}\Delta M + M\Delta p_{fm}) \qquad (3.2)$$

If I indicate the initial value of exports and imports as follows:

$$V_{fx} \equiv p_{fx} X \qquad \text{Foreign value of exports} \qquad (3.3)$$

$$V_{fm} \equiv p_{fm} M \qquad \text{Foreign value of imports} \qquad (3.4)$$

Then rearranging terms and substituting (3.3) and (3.4) into (3.2) yields:

$$\Delta B_f \equiv V_{fx}\left(\frac{\Delta X}{X} + \frac{\Delta p_{fx}}{p_{fx}}\right) + V_{fm}\left(-\frac{\Delta M}{M} - \frac{\Delta p_{fm}}{p_{fm}}\right) \qquad (3.5)$$

The elasticities of demand and supply of exports and imports are defined in equations (3.6)-(3.9) below. Note that traditionally negative demand elasticities are expressed so as to enter positively into the expression.

$$e_x \equiv \frac{\Delta X}{X} \bigg/ \frac{\Delta p_{hx}}{p_{hx}}$$ Home export supply elasticity (3.6)

$$\eta_x \equiv -\frac{\Delta X}{X} \bigg/ \frac{\Delta p_{fx}}{p_{fx}}$$ Foreign export demand elasticity (3.7)

$$e_m \equiv \frac{\Delta M}{M} \bigg/ \frac{\Delta p_{fm}}{p_{fm}}$$ Foreign import supply elasticity (3.8)

$$\eta_m \equiv -\frac{\Delta M}{M} \bigg/ \frac{\Delta p_{hm}}{p_{hm}}$$ Home import demand elasticity (3.9)

Since foreign currency and home currency prices are related by the exchange rate, r, I have:

$$p_{fm} \equiv p_{hm} r \tag{3.10}$$

After further manipulation and assuming that the proportion of the depreciation is small, then I can write the change in the foreign currency value of the trade balance in terms of the demand and supply elasticities from equations (3.6)-(3.9).

$$\Delta B_f = V_{fx} \frac{\eta_x - 1}{1 + \left(\eta_x / e_x\right)} + V_{fm} \frac{\eta_m \left[1 + \left(1/e_m\right)\right]}{\left(\eta_m / e_m\right) + 1} \tag{3.11}$$

This is generally referred to as the Bickerdike-Robinson-Metzler condition, herein (BRM). According to Chipman (1987), Bickerdike developed equation (3.11) by modeling nominal import and export prices as a function of import and export quantities, assuming no cross-price effects. Later Robinson (1944) and Metzler (1947) would serve to clarify and detail Bickerdike's original idea. Equation (3.11) implies that the change in the foreign currency value of the trade balance depends upon the import and export supply and demand elasticities and the initial volume of trade. Equation (3.11), while of theoretical interest is not tractable in the sense that there are many elasticity combination that would improve the trade balance for a given domestic depreciation. With some additional assumptions I present a more appealing version of (3.11).

3.2 M-L condition

If prices are fixed in seller's currencies, then the supply elasticities are infinite, which is expressed in equation (3.12).

$$e_x = e_m = \infty \tag{3.12}$$

Then (3.11) reduces to:

$$\Delta B_f = V_{fx}(\eta_x - 1) + V_{fm}(\eta_m) \tag{3.13}$$

Furthermore, if I assume that trade was initially balanced so that the foreign currency value of exports equals the foreign currency value of imports which is given in equation (3.14).

$$V_{fx} / V_{fm} = 1 \tag{3.14}$$

Then the foreign currency value of the trade balance will improve

$$\Delta B_f > 0 \qquad (3.15)$$

if the sum of the import and export demand price elasticities is greater than unity

$$\eta_x + \eta_m > 1 \qquad (3.15)$$

This is known generally as the Marshall-Lerner condition. The M-L condition states that a real devaluation will improve the trade balance if the import and export demand elasticities sum to greater then unity. A graphical demonstration of this for the domestic currency value of the trade balance can be seen in Figure 3. The total revenue from exports minus imports before trade must be larger after the depreciation. This is true if the following holds

$$P_x q_1^x - P_m q_1^m < P_x q_2^x - P_m^{'} q_2^m \tag{3.16}$$

Figure 4 compares the change required for an improvement of the trade balance when measured in domestic and foreign currency terms.

It may be of additional value to investigate the consequences when the assumption of initially balanced trade, made in equation (3.14), is relaxed. First I will consider the case where the trade balance is in surplus. So:

$$V_{fx} / V_{fm} > 1 \tag{3.17}$$

the foreign currency value of the trade balance will improve

$$\Delta B_f > 0 \tag{3.18}$$

if the sum of the export demand elasticity and the "weighted" import demand elasticity are greater than unity, where the weight is the foreign currency value of imports divided by the foreign currency value of exports.

$$\eta_x + \frac{V_{fm}}{V_{fx}} \eta_m > 1 \tag{3.19}$$

It can be seen that when the trade balance is in surplus the M-L condition is no longer a sufficient condition. If I turn to the final case where there is a trade deficit initially, I have:

$$V_{fx} / V_{fm} < 1 \tag{3.20}$$

then:

$$\Delta B_f > 0 \tag{3.21}$$

if

$$\eta_x + \frac{V_{fm}}{V_{fx}}\eta_m > 1 \tag{3.22}$$

Now the M-L condition becomes a sufficient and not a necessary condition, as the "weighted" import demand elasticity can be much smaller then previously and still insure an improvement in the trade balance. The M-L condition is more stringent then necessary to insure a depreciation improves the trade balance, when the country initially has a trade deficit.

3.3 Trade Model

In order to test this condition I need to estimate the import and export demand price elasticities. This requires specifying and estimating the demand equations. I am presented with the choice of two models that may be viewed, according to Goldstein and Khan (1985), as competing or complementary models depending upon the focus of research. These are the perfect substitutes model and the imperfect substitutes model.

The perfect substitutes model assumes that domestic goods and imports from foreign countries are perfect substitutes for each other. Therefore, the model predicts that a country will entirely export or import a particular good, with no domestic production if the good is imported. Accordingly, you should not see the simultaneous importation and domestic production of any particular good, which is contrary to what I see in the raw data.

The imperfect substitutes model, however, assumes that imports are imperfect substitutes for domestically produced goods, and as such, you could well see the good imported and domestically produced. The empirical evidence seems to support the imperfect substitutes model at any level of aggregation. In fact, this model is so often used to estimate trade equations that it is often referred to as a "Popular Model of Trade"; see for example Rose (1991) and Rose and Yellen (1989).

The imperfect substitutes model posits import and export demand equations as functions of the landed price, money income, and domestic price. Quite often the absence of money illusion is imposed on the demand equations. This allows us to further impose the restriction of homogeneity of degree zero in prices so that demand for real imports is a function of real income and relative prices. On the supply side, import and export supply are solely a function of domestic prices and landed prices.

Estimation of the imperfect substitutes model requires that one simultaneously estimate a supply and demand equation. This is seldom done in practice due to the difficulty in specifying the supply side. In fact, as Goldstein and Kahn (1985) note, it is generally addressed by assumption only. This current work will continue in that great tradition. It should be noted that the assumption made in the M-L condition, that supply elasticities are infinite, also serves the econometric function of *a priori* identification of the demand equation. This assumption coupled with the assumption that demand is relatively stable serves to guarantee identification.

The potential pitfalls of model estimation by assumption are many and not at all new. Orcutt (1950), in his seminal article, made this point which served to cast serious doubts regarding the arguments put forth by the elasticity pessimists of the 40's.

The demand equations for aggregate trade are given in equations (3.23) and (3.24).

$$M_{ROW} = f(Y_{us}, REX_{ROWi}) \tag{3.23}$$

$$X_{ROW} = f(Y_{ROW}, REX_{ROWi}) \tag{3.24}$$

the left hand side represents real US imports or real exports to or from the rest of the world. Y_{us} is real GDP for the US and Y_{ROW} is the real GDP of the rest of the world. Finally REX_{ROW} is the real exchange rate between the US and the rest of the world. It is clear from these equations that you need proxy world income and the real exchange rate which are ad-hoc at best and at worst misleading constructs. In chapter IV I discuss at more length the problems with estimating equations such as (3.23) and (3.24). Therefore I will pursue the estimation of the import and export demand equations on a bilateral basis.

The demand equations of the imperfect substitutes model for trade disaggregated on a bilateral basis are given in equations (3.25) and (3.26).

$$M_i = f(Y_{us}, REX_i) \tag{3.25}$$

$$X_i = f(Y_i, REX_i) \tag{3.26}$$

where Y_{us} is GDP for the United States, Y_i is GDP for the foreign country i and REX_i is the real bilateral exchange rate measured as country i’s currency units per dollar. M_i is real US imports from country i and X_i is real US exports to country i. The log linear representation of the import demand equation is as follows:

$$LM_{i,t} = \alpha + \beta \ LY_{us,t} + \gamma \ LREX_{i,t} + \varepsilon_{i,t} \tag{3.27}$$

I would expect a real depreciation of the dollar(i.e. a decline in $LREX_i$ to cause a decrease in imports), therefore, I expect $\gamma > 0$. I also expect the income elasticity, β, to be positive, implying an increase in US income increases US imports. The export demand equation can be modeled in a similar fashion as follows:

$$LX_{i,t} = \alpha' + \beta' LY_{i,t} + \gamma' LREX_{i,t} + \varepsilon_{i,t} \qquad (3.28)$$

Here I would expect that a real depreciation of the dollar, $LREX_i$ decreasing, would cause an increase in exports; therefore, the price elasticity, $\gamma' < 0$. The income elasticity, β', should be positive implying an increase in foreign income increases foreign demand for US exports.

The M-L condition concerns the import and export price elasticities. If I also assume that the supply elasticities are infinite, I have the simple M-L condition. Specifically, the import price elasticity plus the export price elasticity must sum to greater then 1. In this model, it would be equivalent to $\gamma + \left|\gamma'\right| > 1$. If this condition is met, a depreciation will lead to an improvement in the trade balance in the long-run.

Before I proceed further, it is appropriate to mention a few additional past problems of estimation, some which this work answers and some not. As mentioned previously, the simultaneity of demand and supply are traditionally dealt with by assumption, although this work uses econometric techniques which try to account to some degree for the simultaneity. It should be noted that Orcutt (1950) has shown this leads to a downward bias in the price elasticity estimates. Traditionally, there has also been a concern over the lag length of the relative price term in equation 3.27 or 3.28. It is generally understood that short-run price elasticities tend to be smaller then long-run price elasticities, due to the fact that trade relationships are sticky and less price responsive in the short-run. The econometric technique that I employ in this work is particularly well suited for estimating the long-run elasticities, and doesn't involve choosing the lag length of the relative price term. Another issue that has often been addressed in previous research involves the specification of the relative price term. On occasion, it is estimated in a split format, where I have an import demand equation as given in equation (3.29).

$$LM_t = \alpha + \beta\ LY_{us,t} + \gamma\ PW_t + \varphi\ PD_t + \varepsilon_t \tag{3.29}$$

Export demand would have a symmetrical split price representation. The problem with such a representation is that the price terms tend to be highly collinear, leading to large standard errors; and therefore, most previous studies have not estimated this equation. Unfortunately, the equation with the relative price representation imposes homogeneity of degree zero in prices on the demand equation. That is to say that people are assumed not to suffer money illusion. According to Sawyer and Sprinkle (1996), this appears to be appropriate for export demand equations but not neccesarily import demand equations.

Chapter IV

Aggregation Issues

One of the fundamental arguments of this work is that the level of aggregation employed in most previous research is subject to bias and useless for policy makers. The aggregation bias critique is not new to import and export demand elasticity estimation; see for example Magee (1975), Orcutt (1950), Leamer and Stern (1970), and Goldstein and Khan (1985). Magee (1975) illustrates the potential bias by demonstrating that the average product price change times the average elasticity will generally not give the correct quantity change instigated by a policy-induced price change. The reason is that if product price changes are negatively related to their elasticities, then the actual quantity change will be less than the product of the total elasticity times the aggregate price change. Effectively, items with large prices are given too much weight in the aggregate elasticity. For a detailed example of this, see appendix 3. Here I will demonstrate the potential bias in a simple example from Magee (1975).

A paper by Pesaran and Barker (1990) they suggests that the applied researcher should ask four questions when deciding on the appropriate level of aggregation for their work. They are as follows: (1) What is the purpose of the exercise? (2) What are the specification errors involved? (3) What data are available? (4) What is the attitude of the investigator towards the postulates of simplicity and parsimony? I will address each of these questions in turn.

What is the purpose of the exercise? As Pesaran and Barker (1990), herein PB, suggest, this question is crucial in the design of the research. They suggest that a desire to prescribe policy ought to pursue a high level of detail only attainable through disaggregation. If, however, the researcher is only interested in describing a phenomenon, where only the sign of a coefficient matters and not its size then they need not disaggregate. In fact in the latter case PB suggest aggregating to provide general conclusions. Since this work is concerned with policy prescription however, I will disaggregate along country lines.

Question 2 asks, What are the errors of specification? Pesaran and Barker (1990) make the fundamental point that it is better to estimate a correctly specified model than an incorrectly specified model. This obvious suggestion could involve estimating disaggregated demand equations even if the research question is only concerned with forecasting the aggregate demand for imports and exports.

Question 3 asks pragmatically about the availability of data. Generally, data are not available on a highly disaggregated basis and, therefore, the researcher is often constrained. Here I are constrained by several factors. While trade is available on a highly disaggregated basis, it is generally disaggregated by commodity or country only; but, not both. Since I are interested in the total bilateral trade balance and not the total trade balance for a particular commodity I should disaggregate on a country basis.

Next I will address question 4 which concerns the degree of simplicity of the model. PB argue that a simple model should be preferred to a more complex model ceterus paribus, often this criticism is more superficial than substantive. Peseran and Baker (1990) argue that, all else equal, a more simplistic and parsimonious model should be preferred to a model which is less so.

Finally, PB point out that when a researcher has a disaggregated model correctly specified, free from measurement and the appropriate data, they can do no worse and, in fact, may do better than an aggregate model. I believe that the bilateral trade model employed in this work satisfies these criteria. That is to say, it is no more suscpetible to measurement error, or mispecification than its aggregate counterpart.

The aggregation bias holds not only for aggregation over commodities, but also for aggregation over time. The next section discusses the types of aggregation and their relevance to the current work.

4.1 Cross Sectional

The problem with choosing the level of aggregation is that there are very few distinct points. Aggregation can be thought of as a continuum. At the disaggregated end I have data for individual products (i.e. specific brands), their prices, and the quantities of each imported and/or exported. On the aggregate side of the continuum, I have data for total imports and exports to and from the rest of the world. Clearly, there are many compromises along the way, but there are at least two distinct points of disaggregation. The first involves disaggregating trade on the basis of commodities classes and the second involves disaggregating trade on the basis of country origin or destination. As an example one could disaggregate commodities based on their Standard Industry Classification Codes and then estimate the elasticities for particular commodity classes. I will discuss this further in section 4.1.1 and in section 4.1.2 I will discuss the case where the disaggregation is based on the commodity's country of origin or destination.

4.1.1 Commodity

As I previously mentioned I can disaggregate merchandise trade by commodity. This is not done for several reasons. First, it isn't the best answer to Peseran and Barker's question 1. That is to say it fails to address the policy question of whether a coordinated depreciation will improve a countries bilateral trade balance. Second, I would need data on all commodities exported to the G-7 countries from the US and imported by the US from the G-7 countries. This data if and when available is subject to enormous measurement error due to the desire to cheat on tariffs.

4.1.2 Country

Alternatively I suggest disaggregating on a bilateral basis, which according to Goldstein and Khan (1985) can be viewed as a form of cross-sectional commodity aggregation since certain countries tend to export and import certain classes of goods. This level of aggregation will best answer the four questions of Pesaran and Barker (1990). It speaks directly to the purpose of the exercise, to test whether a bilateral depreciation can improve the trade balance. It also minimizes the potential specification errors, since there is no need to proxy world income as is the case in the aggregate export demand equation. Additionally the data are available and relatively easy to attain and are subject to less measurement error than the individual commodity data.

4.2 Temporal

Deciding on the level of temporal aggregation, is nothing more than deciding on the frequency of the data to use. As is noted in the econometric section below, little is to be gained, in the way of increased power, through larger sample size by increasing the frequency of the data. In fact Pierse and Snell (1995) and Shiller and

Perron (1985) show that time span is important and not the number of observations. In addition I can not get accurate GDP data on a monthly basis. It is then prudent to use quarterly data, as do most other works.

Chapter V

Econometric Techniques

5.1 Unit Roots

The identification of non-stationarity as a problem in econometric analysis is a fairly recent event. The problem, described initially in the seminal piece of Granger and Newbold (1974), highlights the extreme shortcomings of Ordinary Least Squares when the regression involves non-stationary variables. They independently generated two random walks shown in equation (5.1) and (5.2)

$$y_t = y_{t-1} + \varepsilon_t \qquad (5.1)$$

$$z_t = z_{t-1} + \varepsilon_t \qquad (5.2)$$

They then regressed one on the other using OLS, given in equation (5.3), and incorrectly found a statistically significant relationship 75% of the time.

$$y_t = \alpha + \beta z_t + \varepsilon_t \qquad (5.3)$$

The assumptions of the classical model require y_t and z_t to be stationary and have errors whose mean is zero and variance is finite. Granger and Newbold (1974) show that an ordinary least squares regression can be spurious in the face of non-stationary variables, the r-squared may be high, and t-statistics significant, even though there is no relationship. The output looks good because OLS does not give consistent estimates and the asymptotics of the t-test are non-normal. Later, Phillips (1986) gave this problem a more theoretical treatment. However, it was Nelson and Plosser (1982) that demonstrated the existence of unit roots and non-stationarity in most macroeconomic time series.

At this point it would help to elaborate on the theoretical existence of a unit root. Let us propose the following general model:

$$A(L)y_t = B(L)\varepsilon_t \tag{5.4}$$

where $A(L)$ and $B(L)$ are polynomials in the lag operator. If all the roots of $A(L) = 0$ lie outside the unit circle, then y_t is a stationary ARMA process; but, if at least one root lies on the unit circle, then the process is non-stationary, and contains a unit root. The series is also referred to as being integrated of order one, I(1).

The problem with many empirical works on trade elasticities is that they very seldom address the issue of non-stationarity. It is visually obvious from a graph of the data that most all variables under consideration are non-stationary. Figures 5 through 29 clearly demonstrate non-stationarity, since the data do not revert to a mean in a timely fashion. Less clear visually is whether the series can be characterized by a stochastic trend (unit root) or a determinist trend. In order to make this determination, I must apply a more rigorous empirical test. Very few of the numerous articles that estimate the price elasticities actually test the data in order to distinguish between these types of non-stationarity.

In this work, I will apply a two different unit root tests. The first test used extensively in other works is the Augmented Dickey-Fuller test, herein ADF. The null hypothesis of the ADF test is that a unit root can characterize the series, and the series is in fact non-stationary. Unfortunately, this test suffers from very low power, particularly in small samples; so, I will also implement a test attributed to Kwiatkowski et. al. (1992), herein KPSS. This second unit root test adopts as the null hypothesis the characterization of the series as a mean stationary process, or a trend stationary process. It, therefore, transposes the null and alternative hypotheses of the ADF test.

The ADF test has been explored at length in the literature. For a thorough explanation of the procedure see Bahmani-Oskooee (1991) and Chueng and Chinn (1994). Here I will simply discuss the estimation methods. The ADF tests involves estimating via OLS, equation (6.15).

$$\Delta y_t = \alpha_0 + \delta t + \gamma y_{t-1} + \sum_{i=1}^{p} \Delta y_{t-i} + u_t \qquad (5.5)$$

The test concerns the coefficient of the lagged dependent variable, γ. The null hypothesis is, $H_0 : \gamma = 0$. Due to the potential non-stationarity of the error, the traditional t distribution is non-normal and involves nuisance parameter dependencies. The results of the ADF test can be found in Table 1, where the choice of augmenting lag was made using the Akaike Information Criterion, herein AIC, and the Schwartz Bayesian Criterion, herein SBC. It appears in parenthesis following the test statistic. In all cases for all variables, I fail to reject the null hypothesis that the series contains a unit root. The first two columns include only an intercept in the estimating equation, while the last two columns include an intercept and a trend. The results suggest overwhelmingly that the data are in fact non-stationary; but, it would be prudent to further consider this question, since the ADF test is known to suffer from low power. Toward this end, I will apply the KPSS test.

The KPSS test is a more recent innovation in the literature and, as such, has been applied less frequently; however for good discussions of the procedure see Cheung and Chinn (1994) and Bahmani-Oskooee (1998b). It is worth mentioning a few things about the test before I proceed. The KPSS test amounts to a Lagrange

Multiplier test with the Null hypothesis of trend stationarity or level stationarity. It decomposes the process to a random walk and stationary error, for the test of level stationarity, and a deterministic trend is included in the case where the null hypothesis is trend stationary. Equations (5.6) and (5.7) show this decomposition, where t is a constant or a linear trend depending upon the test.

$$Z_t = a\, t + r_t + \varepsilon_t \tag{5.6}$$

$$r_t = r_{t-1} + u_t \tag{5.7}$$

The KPSS test then amounts to a test of the variance of the random walk component, equation (5.7), with the null hypothesis equivalent to a residual with zero variance. The test statistic is constructed as follows:

$$T^{-2} \sum S_t^2 / s^2(l) \tag{5.8}$$

where

$$S_t = \sum_{i=1}^{t} e_i \tag{5.9}$$

and e_i are the residual from equation (5.6)

$$s^2(l) = T^{-1} \sum_{t=1}^{T} e_t^2 + 2T^{-1} \sum_{s=1}^{l} w(s,l) \sum_{t=s+1}^{T} e_t e_{t-s} \tag{5.10}$$

the Bartlett window was chosen so

$$w(s,l) = 1 - s / l + 1 \tag{5.11}$$

The test requires choosing the lag truncation of spectral window. I use the Bartlett window as suggested in KPSS (1992), but I take a rather agnostic approach to the choice of the lag truncation parameter due to the size and power distortions in finite samples and under different specifications of the error.

The null hypothesis of the KPSS test is mean stationary if a trend is excluded from equation (5.6), and trend stationary if it is included. The null hypothesis test for $\sigma_u^2 = 0$. The alternative hypothesis suggests the series is better described as a unit root process (non-stationary). In Table 2, I report the test statistic for the null of mean stationarity for lags 1-8; and in Table 3, I report the results of the KPSS test with trend stationarity as the null hypothesis. The evidence here is not as overwhelming as the ADF, but still convincing. For a lag truncation parameter of 0 and a 10% significance level, I can reject the null for all series in both the trend and mean stationarity case.

The results of the ADF and KPSS tests can be used together as suggested by Cheung and Chinn (1994, forthcoming), to develop a 2 by 2 matrix. The first cell, the upper left hand corner, consists of failing to reject the null hypothesis for both the ADF and KPSS tests. Chueng and Chinn argue that this demonstrates the lack of power the tests have in small samples. They argue the series are not informative enough to classify the variable as I(1) or I(0), so the prudent measure is to proceed under the assumption that the series are I(1). The second cell represents failing to reject the null of the ADF test and rejecting the null of the KPSS test. This corresponds to a robust acceptance of the existence of a unit root. Since all of the series fit into this category I proceed under the assumption that they contain a unit root. The third cell, where I reject the ADF null and fail to reject the KPSS null, is a robust acceptance of stationarity. The fourth and final cell represents the rejection of both nulls. This is possibly a nonsensical result or an indication of a fractional or explosive root.

	Fail to Reject KPSS Null	Reject KPSS Null
Fail to Reject ADF Null	Low Power of tests I(?)	I(1)
Reject ADF Null	I(0)	Nonsensical results I(?)

5.2 Cointegration

Now that I have determined the order of integration, I can proceed with our cointegration tests. Since I are interested in the long-run relationship between the variables and in particular the estimates of the long-run elasticities, testing for the existence of cointegration among the variables is an appropriate method to employ. Cointegration roughly captures the long-run stationary relationship between two or more non-stationary variables. For this task, I have chosen Johansen-Juselius' Full Information Maximum Likelihood (FIML) estimation technique (1990).

5.2.1 OLS

In order to appreciate the improvement in coefficient estimates from using the proper econometric technique, it will be of some use to apply the previously used methods to these data. I will trace the progress of the econometric literature through the estimation of the import and export demand equations, (3.27) and (3.28) respectively. Initially I estimate these equations using OLS for each country. The results can be found in Table 4. The last column in the table gives the Durbin-Watson test statistic for serial correlation. It is clear that in all cases the residuals display a high degree of serial correlation, with the Durbin-Watson below the lower critical bound of 1.623. It is also important to note that the estimates of the M-L condition, found in Table 5, suggest that, in fact, depreciation will not improve the bilateral US trade balance. One should be careful with the output from an OLS regression with non-stationary variables. This is demonstrated in section 5.1, in which I noted the invalidity of t-statistics in this case. Furthermore, this estimation is potentially a spurious one, if the residuals are also non-stationary. If, however, the residuals from this regression are stationary, then the variables are referred to as cointegrated. Generally speaking, cointegration refers to a linear relationship between I(d) variables whose residuals are I(d-b), where b=> 1.

Most studies after Stern et al. (1975) recognized the problem of serial correlation and attempted to correct for it. I too use the Cochrane-Orcutt method to correct the elasticity estimates for first order serial correlation, and they are found in Table 6. The estimates of the price elasticities are generally smaller then the estimates with no correction. In fact, Table 7 gives the estimates of the M-L Condition when correcting for serial correlation, and every country has a lower estimate. Again, the conclusion would be that the US does not satisfy the M-L condition on a bilateral basis with the rest of the G-7.

While I have applied OLS to the demand equations knowing that the variables are non-stationary, I may not have been far from the proper technique. Engle-Granger (1987) show that if there are two variables that are I(1), but a linear combinations of the two are I(0), then they are cointegrated. That is to say, they have a stable long-run relationship. They further suggest that the relationship be estimated using OLS which provides "hyper" consistent parameter, although the t statistics are still invalid. They then test the residuals for stationarity using the ADF test with adjusted t-statistics. It should be noted that Table 7 provides estimates of RHO, the first order autoregressive coefficient, which in all cases is less then one.

$$u_t = \rho u_{t-1} + \varepsilon_t \tag{5.12}$$

This implies stationary residuals and, therefore, a cointegrating relationship. The problems with this procedure, which was used by Rose(1991) and Rose and Yellen(1989), are many. First is the problem of including endogenously determined regressors. Another problem occurs because it provides estimates on only one cointegrating relationship when, in fact, there may be as many as 2 in my case. Finally, the Engle-Granger method estimates the short-run and long-run responses in separate stages. The next section uses a technique proposed by Phillips and Hansen (1990) to overcome the problem of endogeneity.

5.2.2 Fully Modified OLS

The first cointegration method I use is based on Phillips and Hansen (1990), referred to as Fully-Modified Ordinary Least Squares (FM-OLS). This method proposes a semi-parametric correction for serial correlation of the residuals and the endogeneity of the regressors. It, like the KPSS test, involves a choice of spectral window and lag length. In this work I use, the Bartlett window and a lag length of 8.

I now turn to the application of FM-OLS to equations (3.27) and (3.28), the results of which are given in Table 8. It is clear that the semi-parametric correction results in larger price elasticity estimates. This supports the monte carlo simulations in Phillips and Hanson (1990) where they show that the FM-OLS has a much smaller bias then OLS in small samples. In fact, for every country the estimate of the M-L condition by FM-OLS is larger then the estimate for OLS or OLS with a correction for serial correlated errors (see Tables 9,7, and 5). Further inspection reveals that the source of the increase stems from an upward revision in the estimates of all export demand price elasticities, whereas, the import demand price elasticity for Canada, Germany, and Italy are revised downward. While the sum of the export and import demand price elasticities are larger then the previous estimates, they still sum to less then unity. The FM-OLS estimates the US does not satisfy the M-L condition on a bilateral basis. In fact, Italy and the U.K. are the closest to satisfying the M-L condition with estimates of 0.978 and 0.908 respectively.

Another interesting result from the application of FM-OLS involves the apparent lack of change in the income elasticities. In fact, none changes by more then 10%. The asymmetry in elasticities noted earlier, where income elasticity of US exports is much lower then the US import income elasticity, is thus retained. It appears that, while previous authors underestimate the price elasticities, they correctly estimated the income elasticity.

5.2.3 Error-Correction Modeling

Johansen-Juselius' Full Information Maximum Likelihood (FIML) estimation technique (1990) is a multivariate cointegration technique, where the cointegrating relationship is estimated within a dynamic vector autoregressive. This method should be preferred to the Engle and Granger (1987) and the Phillips and Hansen (1990) methods. Unlike the previous two methods Johansen's for more then one cointegrating vector and also estimates the entire model simultaneously, while allowing for the endogenous determination of the regressors.

One shortcoming of Johansen's method is that the results are sensitive to the lag length chosen for the vector autoregression (VAR) (see for example Toda, 1994; and Bahmani-Oskooee, 1995). I use Akaike's information criterion (AIC) and the

Schwarz Bayesian Information Criterion (SBC) from the unrestricted VAR in levels to select the lag length. This method is suggested by Sims (1980) and involves estimating equation (5.13).

$$X_t = A_0 + A_1 X_{t-1} + \dots + A_q X_{t-q} + \varepsilon_t \tag{5.13}$$

The AIC is then constructed as

$$\tfrac{1}{2}(T-q)\log DET\left[S(q)\right] + (k^2 q + k) \tag{5.14}$$

and the SBC is constructed as

$$\tfrac{1}{2}(T-q)\log DET\left[S(q)\right] + (k^2 q + k)\log(T-q) \tag{5.15}$$

where $DET\left[S(q)\right]$ is the determinate of the variance-covariance matrix of the unrestricted VAR(q) in levels. Generally, the lag length associated with the smallest AIC or smallest SBC is chosen; however, it should be noted that the statistics presented in Table 10 are based upon the maximum likelihood version of equations (5.14) and %.15). Therefore, the proper lag is the one with the largest AIC or SBC. When comparing these criteria across lag lengths it is important to correct for sample size differences. All statistics in Table 10 are, therefore, based upon the same sample from 1975Q1 to 1996Q2, which corresponds to a maximum lag length of 8.

Traditionally in other studies such as Carone (1996), the lag length is chosen arbitrarily. If the data are quarterly, then they choose 4 lags, if the data are monthly, 12 lags. The results of my work suggest that this may be a good approximation for the export demand equations, but it leads to an overparameterization of the import demand equations. This is true when compared to the AIC; however, when using the SBC to select lag length, the models are always more parsimonious then when using 4 lags. Kiviet and Phillips (1992) show that there is only one optimal lag length for a particular data generating process (DGP). They further show that insufficient lag length leads to an underparameterization of the model and an over rejection of the null of no cointegration. Conversely, a lag length that is too long results in the over parameterization of the model; and thus, the cointegration tests display a loss in power.

Once the proper order of the VAR has been selected, the next step is to test for cointegration. The Vector Error Correction Model (VECM) of order q can be summarized as follows:

$$\Delta X_t = A_0 + \Pi_0 X_{t-1} + \sum_{i=1}^{q} \Pi_i \Delta X_{t-i} + \varepsilon_t \tag{5.16}$$

where X_t consists of a vector of all I(1) variables, shown in (5.17) and (5.18), where the variables come from equation (3.27) and (3.28)

$$X_t = \begin{bmatrix} LM_t \\ LYUS_t \\ LREX_t \end{bmatrix} \tag{5.17}$$

$$X_t = \begin{bmatrix} LX_t \\ LYUS_t \\ LREX_t \end{bmatrix} \tag{5.18}$$

The test for cointegration in the Johansen-Juseluis method tests for the reduced rank of the coefficient matrix of the lagged variables in levels, Π_0 in equation (5.16). The rank of the matrix represents the number of cointegrating vectors that exist. That is to say, it represents the number of unique stationary linear combinations of the non-stationary variables. I use Johansen's lambda-trace and lambda-max tests for reduced rank. These amount to significance tests of the eigenvalues of Π_0. If the rank of Π_0 is greater then zero and less then full, then the variables are cointegrated with the number of cointegrating vectors equal to the rank. If the rank is equal to zero, then there are no cointegrating relations between the variables, and the VECM is a stationary VAR in differences. However, if Π_0 is of full rank, then the variables are stationary. That is to say the variables of the VAR have non stochastic trends, a direct contradiction to the unit root tests. Equation (5.19) gives the trace statistic and equation (5.20) gives the max statistic

$$\lambda_{trace}(r) = -T\sum_{i=r+1}^{n}\ln(1-\lambda_i) \tag{5.19}$$

$$\lambda_{\max}(r, r+1) = -T\ln(1-\lambda_{r+1)}) \tag{5.20}$$

The results of max and trace tests can be found in Tables 11,and 12 for the case where the lag was chosen by the AIC. Tables 15 and 16 provide the results of the max and trace tests for the case where the lag was chosen with the SBC. The results using the AIC lag selection criterion suggest there is at least one cointegrating relationship for import and export demand for all countries except Canada. The US import demand from Canada fails to support the existence of a cointegrating relationship according to the trace or max tests at the 10% significance level. Using the SBC lag selection criterion, there is evidence of at least one cointegrating relation for all countries. For most countries there are often two cointegrating vectors for import and export demand. This result is expected and follows from Kiviet and Phillips (1992). Since the SBC always selects a more parsimonious model then the AIC, the results are a possible over rejection of the null of no cointegration.

Once I have determined the number of cointegrating vectors, I can turn to the estimates of those cointegrating vector(s). The estimates of the long-run relationship can be extracted from the coefficient matrix, $\Pi_0 = \alpha\beta'$, where β represents the cointegrating vector(s). The researcher is faced with the decision of which variable to normalize in the β vector. Given that the current research is interested in the relationships in equations (3,27) and (3.28), it is appropriate to normalize on the log of imports in the case of import demand, and the log of exports in the case of export demand. Having done that, the estimates are presented in Table 13, which uses the AIC lag selection method; and Table 17, which uses the SBC lag selection method.

First turning to the AIC estimates of Table 13. In the case of one cointegrating vector, the choice of price elasticities is unambiguous, however, for French and Italian imports as well as Italian and Japanese export demand, I am faced with two price elasticity estimates. King et al. (1991) suggest using the estimates of the cointegrating vector which most closely matches the relevant economic theory. For our purpose, the appropriate cointegrating vector is the one that displays the appropriate sign and size. A real depreciation should discourage imports. Therefore, the import demand price elasticity should be positive, since a depreciation is defined as a decrease in the real exchange rate.

After selecting the appropriate cointegrating vector, it is evident the elasticities tend to be larger then the OLS and FM-OLS estimates. This can be seen in the estimates of the M-L condition presented in Table 14. France, Italy, Japan, and the U.K. elasticities sum to greater then unity, while Germany's sum to slightly less. It should be noted that, while Canada is included in these tables, it is simply for completeness. Since there is no cointegration for the import equation, it is inappropriate to comment on the elasticity estimates derived from it. Unlike the OLS estimates, there is now cause for optimism. It appears that a depreciation will in fact improve the bilateral trade balance between the US and France, Italy, Japan, and the U.K.

Now I will turn to the estimates of the cointergating vectors when the SBC is used to select the lag length. In this case I find that there is at least one cointegrating vector for all countries. In fact only the US import demand from Canada and Germany and US export demand from Canada and Italy contain only 1 cointegrating vector. The estimates of all cointegrating vectors are presented in Table 17. Again, following King et al. (1991) I report the M-L condition estimates using the theoretically appropriate elasticities and they can be found in Table 18. Here I have Germany, Japan, and the U.K. demonstrating large enough elasticities to satisfy the M-L condition, while France and Italy fall just short at 0.90 and 0.70 respectively. There is reason to believe that the demand equations for Canada are misspecified, because the export demand elasticity estimates very large at -58.25. Additionally the import demand price elasticity carries the wrong sign at -0.65.

This work seems to suggest that there is good reason to believe that the U.S. satisfies the M-L condition on a bilateral basis with all of the remaining G-7 countries except Canada. Leaving aside Canada for the moment and looking to the remaining countries. Japan and the U.K. satisfy the M-L condition using both the AIC and the SBC, while Germany satisfies it using the SBC and Italy and France satisfy it using the AIC. Even though these results are less robust for the latter three countries it is clear that depreciation would improve the bilateral trade balance given I are currently carrying a large deficit with that country. As is shown in appendix A, the M-L condition is overly stringent in this case.

Returning to the case of Canada, it appears as though the model is misspecified in some way. One possible explanation involves the recent trade agreement between the U.S., Canada, and Mexico. The agreement known as the North American Free Trade Agreement, herein NAFTA, was implemented in 1994. This introduces a potential structural change in the import and export demand relationships that are not entirely captured by the real exchange rate. Still another explanation highlights important factors that are not included in the model such as the resistance to terminating trade relationships, and therefore a decreased price sensitivity.

5.3 Stability Tests

Once the income and price elasticities are estimated I might naturally inquire about their stablity. If in fact the cointegrating vectors and therefore the price elasticities are unstable over time policy prescription based on the estimated elasticities would be unwarranted, or at least risky. There are many possible methods for testing the stability of the cointegrating vector(s). I will apply at least two tests for the stability of the error-correction model, the cumulative sum of recursive residuals (CUSUM) and cumulative sum of the square of the recursive residuals (CUSUMSQ), due to Brown et al. (1975). These tests are visual and require plotting the test statistic, which is a function of time, and the appropriate confidence interval. If the test statistic meanders outside the confidence interval it suggests a possible structural break or non-constancy of the parameters. More formally, the test involves several stages. I first estimate the vector error correction equation given in equation (5.16), using the lag selected by the AIC. Then I fix the cointegrating vector(s) and decompose the vector error correction equation by each variable as follows.

$$\Delta X_t = \begin{bmatrix} \Delta LM_t \\ \Delta LYUS_t \\ \Delta LREX_t \end{bmatrix} \tag{5.21}$$

This represents the import demand system of equations and similarly for the export demand system I can decompose the vector into the variables of interest.

$$\Delta X_t = \begin{bmatrix} \Delta LX_t \\ \Delta LYUS_t \\ \Delta LREX_t \end{bmatrix} \tag{5.22}$$

I can then concentrate on the first equation in each model, the import demand equation or the export demand equation, and estimate it consistently with OLS. From here forward I will focus on the import demand equation, but the same arguments apply to the export demand equation. I use the data up to and including t-1 to estimate the coefficients of the single equation Autoregressive Distributed Lag Model, given in equation (5.23).

$$\Delta LM_{t-1} = \beta_0 + \beta_1 EC_{t-2} +$$

$$\sum_{i=1}^{p} \left(\gamma_i \Delta LM_{t-1-i} + \phi_i \Delta LYUS_{t-1-i} + \theta_i \Delta LREX_{t-1-i} \right) + \varepsilon_{t-1} \tag{5.23}$$

I then calculate the one step ahead prediction error defined in equation (5.24)

$$v_t = \Delta LM_t - \Delta \hat{L}M_t \tag{5.24}$$

Where $\Delta\hat{LM}_t$ is the one step ahead prediction using the coefficients estimated in equation (5.23), and the data up to point t. I can similarly calculate the export demand one step ahead prediction error. Then define the scaled recursive residuals as

$$w_t = \frac{v_t}{s.e.(v_t)} \qquad (5.25)$$

The CUSUM test statistic is then

$$W_t = \sum_{j=k+1}^{t} w_j \qquad \text{t=k+1, …, n} \qquad (5.26)$$

The CUSUMSQ test statistic is

$$S_t = \frac{\sum_{j=k+1}^{t} w_j^2}{\sum_{j=k+1}^{n} w_j^2} \qquad \text{t=k+1, …, n} \qquad (5.27)$$

If the estimated parameters are constant then the one step ahead prediction errors should be white noise such that their sum is always zero. The CUSUM and CUSUMSQ statistics are plotted against the 5% critical lines, for import and export demand for each country. They appear in Figures 30-53.

The CUSUM test results suggest that for all countries the bilateral import and export demand relationships have been stable. Hanson (1991) suggests that this test be view as an intercept constancy test. Therefore it appears as though the intercept has remained constant for import and export demand equations for all countries. Hanson (19991) also suggests that the CUSUMSQ test is equivalent to a test of the stability of the variance of equation (5.23). The variance appears to be stable for all countries except U.S. import demand from France, Italy and the U.K., while the

Japanese export demand appears to be unstable. It should again be noted that the CUSUM and CUSUMSQ results are reported for Canadian export demand simply for completeness since there was no evidence of cointegration using the AIC lag selection.

Chapter VI

Summary and conclusion

The emphasis of this work is to provide more reliable estimates of income and price elasticities of import and export demand to policy makers so that they may make more informed public policy decisions. Specifically I estimate these elasticities on a bilateral basis between the US and each of the following countries: Canada, France, Germany, Italy, Japan, and the UK. These elasticities can be used to test the M-L condition, if it is satisfied the estimates can then the US can improve its bilateral trade balance by depreciating its currency vis-à-vis the partner country. The elasticities are then used to calculate the size of the depreciation needed to improve the trade balance. Previous work has generally done this on an aggregate basis, however in an attempt to improve the estimates I argue that it is critical to choose the appropriate level of aggregation for the estimation of these elasticities. The factors important in determining this level include the policy makers potential policy tools, data availability, and econometric concerns. Therefore it is clear that the bilateral approach in this paper is superior given the objectives.

I also further improve the estimates of the trade elasticities by employing recent econometric innovations. Johansen's method is applied to the estimation of the import and export demand equations, along with several other cointegration techniques. The results indicate that the US satisfies the M-L condition on a bilateral basis with all of the countries except Canada. Therefore a devaluation of the dollar vis-à-vis the other 5 currencies should improve the US bilateral trade balance with those countries.

There are several other important conclusions in this work. It confirms, on a bilateral basis, the disparity in income elasticities noted in the aggregate case by Sawyer and Sprinkle (1996), and others. That is the US import demand income elasticity is larger then the export demand income elasticity. In fact this is probably a plausable explanation for the failure of the trade balance to improve after the dollar started to fall in 1985.

While this study has advanced the literature on several fronts there are some shortcomings that will be addressed in future work. Elasticities could be estimated for major commodity classes, which would provide a better description of the impact of a depreciation on each sector of the economy. Additionally it would remove another layer of aggregation, and further reduce any potential bias associated with it. The other major shortcoming of this work is that it does not address the means by which a policy maker induces and sustains a real depreciation, nor does it address all the potential consequences of such an action. A further examination of these issues may relegate this work to the level of a simple intellectual exercise, unable to be applied in practice. It could therefore be the most perverse of all arguments made Ceterus paribus.

TABLES

Table 1: The ADF Unit Root Test Statistics.

	Intercept only		Intercept and Trend	
Variable	AIC	SBC	AIC	SBC
US				
LY	-1.54(1)	-1.54(1)	-2.96(1)	-2.96(1)
Canada				
LY	-1.84(1)	-1.84(1)	-2.32(1)	-2.32(1)
LREX	-1.34(4)	-1.73(3)	-2.77(3)	-2.77(3)
LM	-0.03(5)	-0.41(4)	-2.28(4)	-2.28(4)
LX	0.37(8)	-0.21(4)	-1.42(8)	-2.06(4)
Japan				
LY	-3.06(1)	-3.06(1)	-0.19(1)	-0.19(1)
LREX	-1.55(1)	-1.55(1)	-2.33(1)	-2.33(1)
LM	-1.71(1)	-1.71(1)	-1.41(1)	-1.41(1)
LX	0.05(2)	-0.19(1)	-3.14(1)	-3.14(1)
Germany				
LY	-0.17(1)	-0.17(1)	-1.44(1)	-1.44(1)
LREX	-1.76(1)	-1.76(1)	-1.94(1)	-1.94(1)
LM	-1.25(4)	-0.69(1)	-3.24(8)	-1.80(1)
LX	-0.62(4)	-0.62(4)	-1.93(4)	-1.93(4)
UK				
LY	-0.44(8)	-0.64(3)	-2.39(8)	-1.53(1)
LREX	-2.10(1)	-2.10(1)	-2.22(1)	-2.22(1)
LM	-0.91(1)	-0.91(1)	-1.97(1)	-1.97(1)
LX	-0.47(4)	-0.31(2)	-2.65(5)	-1.93(2)
France				
LY	-1.63(2)	-1.62(1)	-3.08(2)	-3.08(2)
LREX	-1.95(1)	-1.95(1)	-2.08(1)	-2.08(1)
LM	-0.91(1)	-0.91(1)	-1.97(1)	-1.97(1)
LX	-1.61(8)	-1.26(4)	-3.04(8)	-3.04(8)
Italy				
LY	-2.59(3)	-2.61(1)	-2.64(1)	-2.64(1)
LREX	-1.65(1)	-1.65(1)	-2.30(1)	-2.30(1)
LM	-1.00(2)	-1.00(2)	-2.40(2)	-2.40(2)
LX	-1.66(8)	-1.66(8)	-2.90(8)	-2.90(8)
95% Critical Value	-2.90	-2.90	-3.46	-3.46

Note : The critical values come from MacKinnon (1991 Table1) and the augmenting lag was selected by the AIC or SBC and appears in parenthesis behind the statistic

Table 2: The KPSS Test for Mean Stationarity for All Variables.
(The 5% critical value is 0.463, 10% is .347)

	Lag Truncation Parameter								
Variable	0	1	2	3	4	5	6	7	8
US									
LY	3.095	2.332	1.876	1.573	1.357	1.195	1.070	0.969	0.886
Canada									
LY	3.053	2.303	1.855	1.557	1.345	1.186	1.063	0.965	0.885
LREX	1.733	1.309	1.058	0.892	0.776	0.690	0.625	0.570	0.522
LM	2.730	2.074	1.675	1.410	1.219	1.077	0.968	0.876	0.799
LX	2.724	2.075	1.677	1.413	1.222	1.079	0.969	0.877	0.800
Japan									
LY	3.144	2.367	1.902	1.593	1.372	1.207	1.079	0.977	0.893
LREX	1.919	1.451	1.175	0.993	0.864	0.770	0.698	0.635	0.580
LM	2.929	2.205	1.771	1.483	1.277	1.124	1.006	0.910	0.832
LX	2.845	2.150	1.733	1.456	1.259	1.110	0.995	0.899	0.818
Germany									
LY	2.963	2.233	1.796	1.506	1.299	1.145	1.025	0.927	0.846
LREX	0.484	0.367	0.298	0.253	0.221	0.198	0.181	0.165	0.150
LM	2.532	1.916	1.542	1.295	1.118	0.987	0.886	0.801	0.730
LX	2.283	1.750	1.430	1.213	1.052	0.932	0.838	0.760	0.694
UK									
LY	3.055	2.300	1.848	1.547	1.334	1.174	1.050	0.949	0.866
LREX	0.708	0.539	0.440	0.376	0.331	0.298	0.274	0.251	0.230
LM	2.801	2.135	1.728	1.453	1.256	1.107	0.992	0.898	0.820
LX	2.561	1.955	1.591	1.344	1.165	1.031	0.927	0.842	0.770
France									
LY	3.037	2.291	1.846	1.540	1.339	1.181	1.059	0.960	0.880
LREX	0.424	0.322	0.262	0.223	0.196	0.177	0.162	0.147	0.135
LM	2.948	2.231	1.796	1.506	1.298	1.143	1.023	0.926	0.845
LX	2.434	1.848	1.500	1.265	1.094	0.966	0.868	0.786	0.717
Italy									
LY	3.062	2.311	1.862	1.563	1.350	1.190	1.066	0.967	0.885
LREX	1.371	1.037	0.841	0.711	0.620	0.553	0.502	0.456	0.416
LM	2.669	2.019	1.628	1.368	1.183	1.045	0.938	0.849	0.774
LX	1.190	0.964	0.817	0.714	0.629	0.569	0.523	0.481	0.443

Note : The critical values come from Kwiatkowski et al. (1992), Table 1 p166.

Table 3: The KPSS Test for Trend Stationarity for All Variables

(The 5% critical value is 0.146, 10% is .119)

	Lag Truncation Parameter								
Variable	0	1	2	3	4	5	6	7	8
US									
LY	0.119	0.091	0.075	0.065	0.058	0.053	0.049	0.045	0.042
Canada									
LY	0.385	0.292	0.273	0.202	0.177	0.159	0.145	0.133	0.122
LREX	0.237	0.179	0.145	0.123	0.108	0.097	0.088	0.081	0.074
LM	0.318	0.256	0.215	0.188	0.167	0.153	0.142	0.132	0.123
LX	0.522	0.421	0.351	0.304	0.267	0.240	0.219	0.201	0.185
Japan									
LY	0.315	0.240	0.195	0.166	0.146	0.131	0.120	0.109	0.100
LREX	0.281	0.214	0.175	0.149	0.132	0.120	0.110	0.101	0.093
LM	0.260	0.202	0.167	0.144	0.128	0.116	0.107	0.098	0.090
LX	0.295	0.230	0.192	0.167	0.149	0.136	0.126	0.117	0.109
Germany									
LY	0.510	0.386	0.313	0.265	0.231	0.206	0.187	0.170	0.156
LREX	0.420	0.318	0.258	0.219	0.191	0.171	0.156	0.142	0.130
LM	0.183	0.142	0.117	0.101	0.089	0.081	0.075	0.070	0.065
LX	0.321	0.256	0.217	0.188	0.166	0.149	0.136	0.125	0.115
UK									
LY	0.256	0.195	0.158	0.135	0.118	0.106	0.097	0.088	0.081
LREX	0.134	0.103	0.084	0.072	0.064	0.058	0.054	0.049	0.045
LM	0.134	0.114	0.100	0.091	0.084	0.078	0.074	0.070	0.066
LX	0.155	0.125	0.107	0.094	0.083	0.076	0.070	0.065	0.060
France									
LY	0.186	0.141	0.115	0.098	0.087	0.078	0.071	0.065	0.060
LREX	0.319	0.242	0.197	0.168	0.147	0.133	0.121	0.111	0.101
LM	0.141	0.115	0.097	0.085	0.077	0.070	0.065	0.061	0.056
LX	0.187	0.148	0.126	0.109	0.097	0.087	0.080	0.074	0.068
Italy									
LY	0.377	0.288	0.237	0.205	0.182	0.165	0.152	0.139	0.128
LREX	0.224	0.170	0.139	0.118	0.104	0.094	0.086	0.079	0.072
LM	0.176	0.138	0.114	0.099	0.088	0.080	0.074	0.069	0.064
LX	0.183	0.154	0.134	0.120	0.108	0.099	0.093	0.087	0.081

Note : The critical values come from Kwiatkowski et al. (1992), Table 1 p166.

Table 4: OLS Estimates of Import and Export Demand Elasticities
1973:I – 1996:II

Import Demand	LYUS	LREX	Constant	DW-stat*
Canada	1.8783 (15.3465)	0.10814 (0.57184)	-3.1613 (-6.1131)	0.458
France	2.6176 (41.0031)	0.11331 (1.7099)	-8.6883 (-25.9991)	1.094
Germany	2.0565 (19.5046)	-0.064086 (-0.67048)	-5.1552 (-10.6437)	0.321
Italy	2.3704 (19.3727)	0.12823 (1.1689)	-8.3450 (-6.8062)	0.419
Japan	3.2940 (23.5316)	0.21338 (2.1128)	-10.6774 (-9.9507)	0.379
U.K.	2.0989 (25.8027)	0.20691 (2.4279)	-5.5818 (-16.0727)	1.062
Export Demand	**LY****	**LREX**	**Constant**	**DW-stat***
Canada	1.8661 (13.6306)	-0.43871 (-1.7824)	-3.1400 (-5.5209)	0.406
France	1.9814 (21.1724)	-0.52897 (-6.5198)	-4.7833 (-9.9627)	0.777
Germany	1.2804 (20.8498)	-0.44988 (-7.2231)	-1.9731 (-6.7888)	1.185
Italy	0.23442 (2.1233)	-0.76651 (-7.8083)	7.3584 (6.6750)	1.533
Japan	1.1403 (15.2222)	-0.42023 (-5.1050)	1.4747 (2.1237)	0.342
U.K.	2.1160 (19.2019)	-0.62381 (-6.3287)	-6.0180 (-12.720)	0.885

Note: t-stats in parenthesis.
* The lower 5% bound for the Durbin-Watson statistic, with 95 observations and 2 regressors is 1.623

Table 5: OLS Estimates of the M-L Condition

Country	M-L Condition
Canada	0.54685
France	0.64228
Germany	0.38579
Italy	0.89474
Japan	0.63361
U.K.	0.83072

Table 6: OLS Estimates of Import and Export Demand Equations Correcting for First Order Serial Correlation
1973:I – 1996:II

Import Demand	LYUS	LREX	Constant	RHO*
Canada	2.15 (7.85)	0.08 (0.24)	-4.38 (-3.71)	0.75 (11.29)
France	2.63 (25.67)	0.09 (0.93)	-8.73 (-16.58)	0.44 (4.63)
Germany	2.25 (7.32)	-0.27 (-1.72)	-5.92 (-4.24)	0.82 (14.76)
Italy	2.52 (9.12)	0.11 (0.65)	-8.91 (-4.08)	0.76 (11.42)
Japan	2.64 (6.84)	-0.20 (-1.36)	-5.68 (-2.69)	0.87 (15.15)
U.K.	2.11 (16.73)	0.11 (0.90)	-5.70 (-10.45)	0.45 (4.90)
Export Demand	**LY****	**LREX**	**Constant**	**RHO***
Canada	2.10 (5.46)	-0.20 (-0.42)	-4.23 (-2.56)	0.80 (12.60)
France	2.10 (12.25)	-0.46 (-3.65)	-5.44 (-6.40)	0.57 (7.00)
Germany	1.29 (13.50)	-1.43 (-4.67)	-2.02 (-4.50)	0.41 (4.22)
Italy	0.27 (1.88)	-0.74 (-5.94)	6.95 (4.94)	0.23 (2.25)
Japan	1.36 (7.46)	-0.28 (-2.25)	-0.18 (-0.15)	0.82 (13.92)
U.K.	2.27 (9.67)	-0.31 (-1.76)	-6.58 (-6.42)	0.63 (7.23)

Note: t-stats in parenthesis.
* RHO was estimated using the Cochrane-Orcutt iterative procedure

Table 7: OLS Estimates of the M-L Condition Correcting for First Order Serial Correlation

Country	M-L Condition
Canada	0.28
France	0.55
Germany	0.16
Italy	0.85
Japan	0.08
U.K.	0.42

Table 8: FMOLS Estimates of Import and Export Demand Elasticities

Import Demand	**LYUS**	**LREX**	**Constant**
Canada	1.9387	0.01949	-3.4248
France	2.5994	0.13186	-8.6478
Germany	2.0335	0.055226	-5.1353
Italy	2.3252	0.10642	-7.9968
Japan	3.5028	0.37979	-12.4635
U.K.	2.1470	0.24557	-5.7752
Export Demand	**LY****	**LREX**	**Constant**
Canada	1.9073	-0.54323	-3.3041
France	2.0043	-0.58665	-4.7736
Germany	1.2545	-0.47502	-1.8570
Italy	0.1391	-0.87128	8.5594
Japan	1.1030	-0.48851	2.0008
U.K.	2.1323	-0.66284	-6.0922

Note: The sample period is 1973:I – 1996:II, Bartlett weights were used with a truncation lag=8, Non-trended case.

Table 9: FMOLS Estimates of the M-L Condition

Country	M-L Condition
Canada	0.56272
France	0.71851
Germany	0.53025
Italy	0.97770
Japan	0.73408
U.K.	0.90841

Table 10: Lag Selection Criteria for Unrestricted Vector Autoregressive
Choice criteria for selecting the order of the VAR model, based on 86 observations from 1975Q1 to 1996Q2. Max Order of VAR = 8. Results from the Unrestricted VAR in levels for import and export demand equations for each country. Optimal lag in bold lettering, based on the maximizing the likelihood function.

CANADA

Order	Import-AIC	Import-SBC	Export-AIC	Export-SBC
8	621.922	533.5655	626.4761	538.1196
7	625.0693	547.7573	630.5761	553.2642
6	627.6361	561.3687	636.3499	570.0826
5	**628.4888**	573.266	**640.6834**	**585.4606**
4	615.6407	571.4624	627.034	582.8558
3	609.2866	576.1529	606.1691	573.0354
2	614.5293	**592.4402**	603.6342	581.545
1	592.3107	581.2661	573.3129	562.2683
0	-129.972	-129.972	-152.807	-152.807

FRANCE

Order	Import-AIC	Import-SBC	Export-AIC	Export-SBC
8	496.6377	408.2812	528.2852	439.9287
7	499.5225	422.2106	530.7459	453.4339
6	503.1907	436.9234	537.5125	471.2451
5	511.226	456.0032	**543.1455**	487.9227
4	513.9615	469.7833	538.5221	494.3439
3	514.2032	481.0695	540.0849	506.9512
2	**519.2752**	**497.1861**	525.4073	503.3182
1	492.0002	480.9557	522.41	**511.3654**
0	-241.464	-241.464	-197.232	-197.232

GERMANY

Order	Import-AIC	Import-SBC	Export-AIC	Export-SBC
8	494.5259	406.1694	454.2042	365.8477
7	492.7448	415.4328	458.0552	380.7432
6	496.3394	430.072	463.4068	397.1394
5	501.283	446.0602	**470.7999**	415.5771
4	505.0195	460.8412	469.841	425.6627
3	510.7395	477.6058	460.9066	427.7729
2	**516.8111**	**494.7219**	461.3445	439.2554
1	503.7994	492.7549	458.6462	**447.6016**
0	-234.506	-234.506	-176.888	-176.888

Table 10: Lag Selection Criteria for Unrestricted Vector Autoregressive
Choice criteria for selecting the order of the VAR model, based on 86 observations from 1975Q1 to 1996Q2. Max Order of VAR = 8. Results from the Unrestricted VAR in levels for import and export demand equations for each country. Optimal lag in bold lettering, based on the maximizing the likelihood function.

ITALY

Order	Import-AIC	Import-SBC	Export-AIC	Export-SBC
8	492.4123	404.0558	500.8294	412.4729
7	493.9157	416.6037	494.9332	417.6212
6	500.2714	434.004	500.5588	434.2914
5	507.0128	451.79	501.0834	445.8606
4	510.2875	466.1092	**504.7476**	460.5694
3	513.1035	479.9698	488.0041	454.8704
2	**515.276**	**493.1869**	493.7552	**471.6661**
1	502.1724	491.1279	479.7641	468.7195
0	-270.549	-270.549	-251.923	-251.923

JAPAN

Order	Import-AIC	Import-SBC	Export-AIC	Export-SBC
8	500.7244	412.3679	527.8661	439.5096
7	499.1422	421.8302	532.6838	455.3719
6	500.7293	434.4619	535.5844	469.3171
5	504.221	448.9982	539.4427	484.2199
4	508.4021	464.2238	540.3081	496.1298
3	511.6914	478.5577	546.5244	513.3907
2	**517.7136**	495.6245	547.5002	525.4111
1	508.983	**497.9385**	**552.0185**	**540.9739**
0	-269.846	-269.846	-219.301	-219.301

UK

Order	Import-AIC	Import-SBC	Export-AIC	Export-SBC
8	474.7288	386.3723	465.1886	376.8321
7	473.0857	395.7737	467.6264	390.3145
6	476.0136	409.7462	471.2411	404.9737
5	479.4365	424.2137	476.183	420.9602
4	**485.1999**	441.0217	474.1773	429.9991
3	484.4318	451.2981	**476.258**	443.1243
2	481.3344	459.2453	472.32	450.2309
1	472.8597	**461.8151**	474.9624	**463.9178**
0	-201.594	-201.594	-201.868	-201.868

Table 11: Johansen's Lambda-Max Cointegration Test using the AIC Lag
Cointegration Test for Import and Export Demand Equations. (r= # of cointegrating vectors)

	λ–Max		
Null	r=0	r<=1	r<=2
Alternative	r=1	r=2	r=3
Canada			
Import (5)	13.74	5.39	4.04
Export(5)	25.05	6.96	6.04
France			
Import (2)	25.69	16.42	6.88
Export (5)	25.66	8.90	5.08
Germany			
Import (2)	28.58	14.81	7.92
Export (5)	21.27	6.25	2.28
Italy			
Import (2)	22.35	17.51	11.35
Export (4)	27.01	12.02	6.90
Japan			
Import (2)	22.16	12.73	5.90
Export (1)	76.86	15.57	4.80
UK			
Import (4)	21.14	11.47	4.76
Export (3)	18.24	13.12	1.75
95% Critical Value	22.00	15.67	9.24
90% Critical Value	19.77	13.75	7.53

Note : The lag order for the each VECM was selected with AIC, and it appears in parenthesis

Table 12: Johansen's Lambda-Trace Cointegration Test using the AIC Lag
Cointegration Test for Import and Export Demand Equations. (r= # of cointegrating vectors)

	λ–Trace		
Null	r=0	r<=1	r<=2
Alternative	r=1	r=2	r=3
Canada			
Import (5)	23.16	9.42	4.04
Export(5)	38.09	13.04	6.04
France			
Import (2)	48.99	23.31	6.88
Export (5)	39.65	13.99	5.08
Germany			
Import (2)	51.31	22.73	7.93
Export (5)	29.80	8.53	2.28
Italy			
Import (2)	51.19	28.87	11.35
Export (4)	45.99	18.92	6.90
Japan			
Import (2)	40.79	18.63	5.90
Export (1)	97.24	20.37	4.80
UK			
Import (4)	37.37	16.23	4.76
Export (3)	33.11	14.88	1.75
95% Critical Value	34.91	19.96	9.24
90% Critical Value	32.00	17.85	7.53

Note : The lag order for the each VAR was selected with AIC, and it appears in parenthesis

Table 13: Estimates of the Import and Export Demand Elasticities using Johansen's Method and the AIC criteria.

Import Demand	**LYUS**	**LREX**	**Constant**
Canada(5)*	2.27	0.31	-5.22
France(2)	2.65	0.21	-9.02
	12.89	32.35	-105.59
Germany(2)	2.32	0.42	-6.68
Italy(2)	2.24	-0.13	-6.03
	4.62	2.77	-37.76
Japan(2)	3.84	0.78	-16.06
UK(4)	3.02	2.34	-8.43
Export Demand	**LY****	**LREX**	**Constant**
Canada(5)	64.56	-58.25	-277.17
France(5)	1.82	-0.96	-3.04
Germany(5)	1.22	-0.48	-1.74
Italy(4)	-0.64	-0.70	11.14
	0.04	-1.20	11.43
Japan(1)	1.02	-0.42	2.45
	1.17	-0.6	2.19
UK(3)	3.21	0.91	-9.96

Note: The lag length of the VECM was chosen by AIC and appears in parenthesis behind the name of the country. The sample period is 1973:I – 1996:II.
* neither the trace or max tests found cointegration at the 10% significance level.

Table 14: M-L Condition Estimates using Johansen's with the AIC Lag.

Country	**M-L Condition**
Canada*	58.56
France	1.17
Germany	0.90
Italy	1.07
Japan	1.38
U.K.	1.43

* neither the trace or max tests found cointegration at the 10% significance level.

Table 15: Johansen's Lambda-Max Cointegration Test using the SBC Lag
Cointegration Test for Import and Export Demand Equations.

(r= # of cointegrating vectors)

	λ–Max		
Null	r=0	r<=1	r<=2
Alternative	r=1	r=2	r=3
Canada			
Import (2)	21.69	7.23	3.49
Export (5)	25.05	6.96	6.04
France			
Import (2)	25.69	16.42	6.88
Export (1)	47.79	27.71	2.75
Germany			
Import (2)	28.58	14.81	7.92
Export (1)	34.95	21.84	2.42
Italy			
Import (2)	22.35	17.51	11.35
Export (2)	32.69	10.97	5.61
Japan			
Import (1)	37.05	15.27	6.36
Export (1)	76.86	15.57	4.80
UK			
Import (1)	44.45	29.24	3.25
Export (1)	34.77	21.86	1.82
95% Critical Value	22.00	15.67	9.24
90% Critical Value	19.77	13.75	7.53

Note: The lag order for the each VECM was selected with SBC, and it appears in parenthesis

Table 16: Johansen's Lambda-Trace Cointegration Test using the SBC Lag
Cointegration Test for Import and Export Demand Equations.

(r= # of cointegrating vectors)

	λ–Trace		
Null	r=0	r<=1	r<=2
Alternative	r=1	r=2	r=3
Canada			
Import (2)	32.42	10.72	3.49
Export (5)	38.09	13.04	6.04
France			
Import (2)	48.99	23.31	6.88
Export (1)	78.26	30.47	2.75
Germany			
Import (2)	51.31	22.73	7.93
Export (1)	59.20	24.25	2.42
Italy			
Import (2)	51.19	28.87	11.35
Export (2)	49.27	16.58	5.61
Japan			
Import (1)	58.67	21.63	6.36
Export (1)	97.24	20.37	4.80
UK			
Import (1)	76.94	32.49	3.25
Export (1)	58.44	23.67	1.82
95% Critical Value	34.91	19.96	9.24
90% Critical Value	32.00	17.85	7.53

Note: The lag order for the each VAR was selected with SBC, and it appears in parenthesis

Table 17: Estimates of the Import and Export Demand Elasticities using Johansen's Method and the SBC criteria.

J-J estimates of Import and Export Demand equations 1973:I – 1996:II
All lag lengths for the VAR were selected using the SBC and appear in parenthesis

Import Demand	**LYUS**	**LREX**	**Constant**
Canada(2)	2.64	-0.65	-6.60
France(2)	2.65	0.21	-9.02
	12.89	32.35	-105.59
Germany(2)	2.32	0.42	-6.68
Italy(2)	2.24	-0.13	-6.03
	4.62	2.77	-37.76
Japan(1)	3.26	0.20	-10.71
	3.67	0.59	-14.17
UK(1)	2.35	0.64	-6.37
	2.01	-0.01	-5.62
Export Demand	**LY****	**LREX**	**Constant**
Canada(5)	64.56	-58.25	-277.17
France(1)	1.68	-0.69	-2.94
	2.16	-0.56	-5.59
Germany(1)	1.28	-0.47	-1.95
	2.92	-1.02	-6.68
Italy(2)	0.20	-0.83	8.00
Japan(1)	1.02	-0.42	2.45
	1.17	-0.6	2.19
UK(1)	3.16	0.75	-9.85
	1.93	-1.02	-5.40

Note: The lag length of the VECM was chosen by SBC and appears in parenthesis behind the name of the country. The sample period is 1973:I – 1996:II.

Table 18: M-L Condition Estimates using Johansen's Method with the SBC Lag

Country	**M-L Condition**
Canada	57.60
France	0.90
Germany	1.44
Italy	0.70
Japan	1.19
U.K.	1.66

FIGURES

Figure 1: Total Trade as a Percentage of GDP

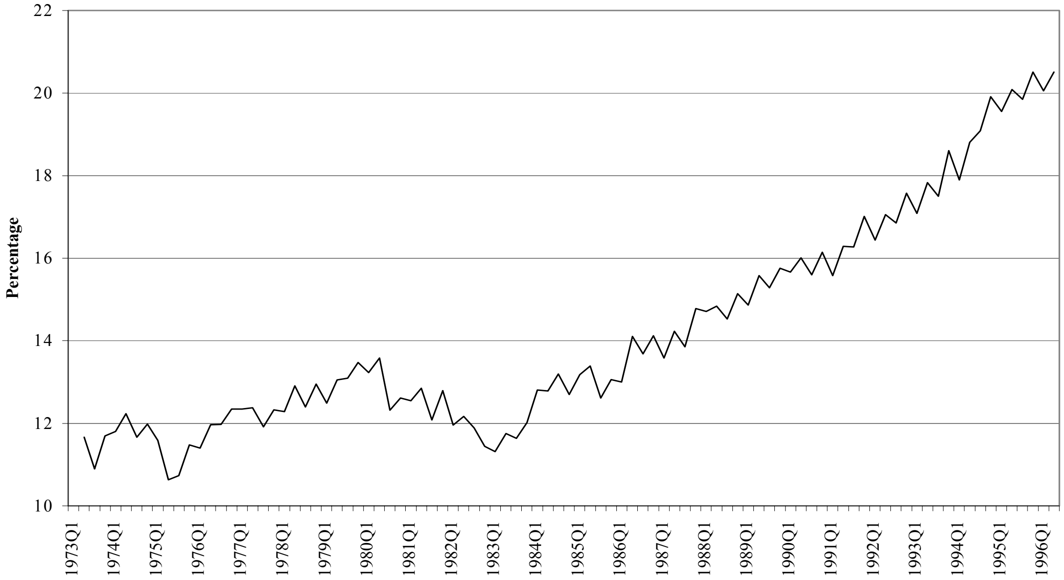


Figure 2: Real Trade Balance U.S. vis-à-vis the G-7

Figure 3: A Graphical Representation of the Marshall-Lerner Condition for Domestic Currency

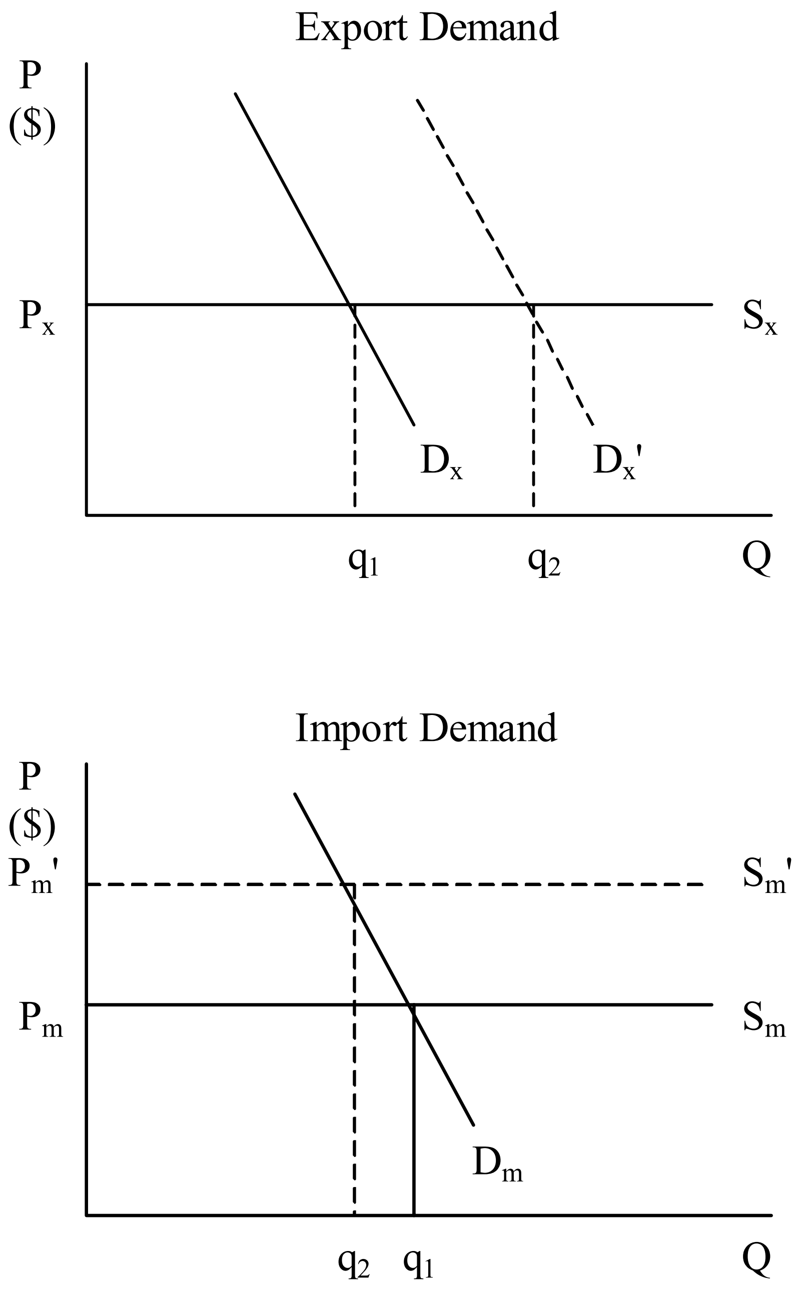
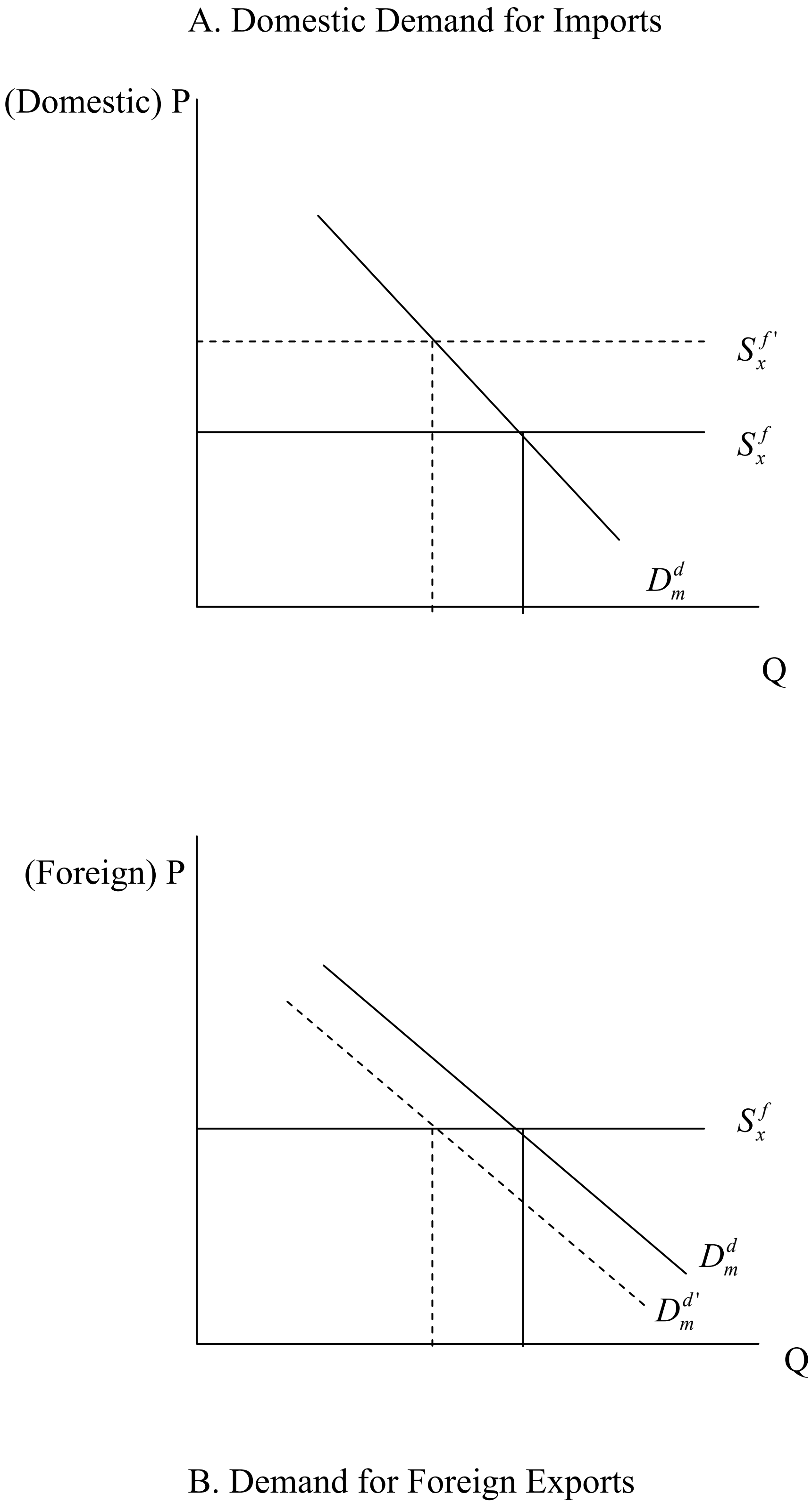


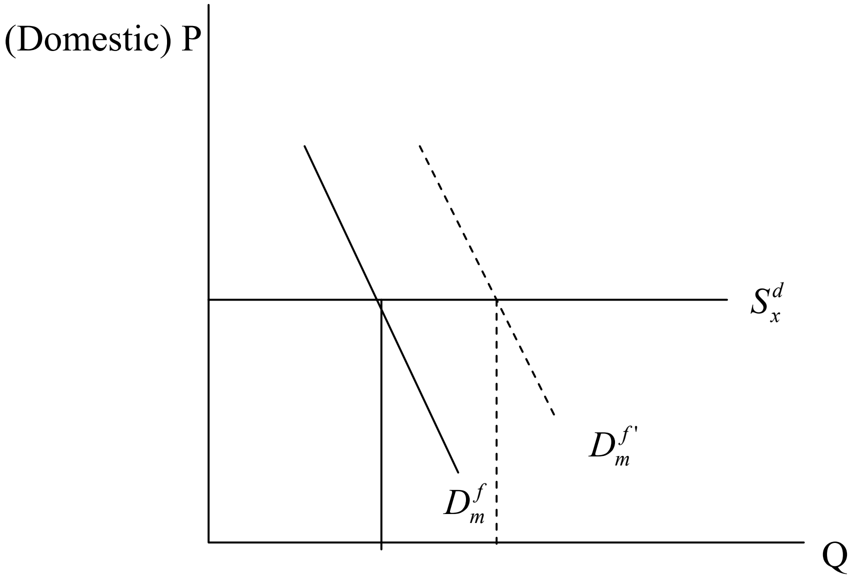
Figure 4: A Graphical Representation of the Marshall-Lerner Condition for Domestic Currency and Foreign Currency

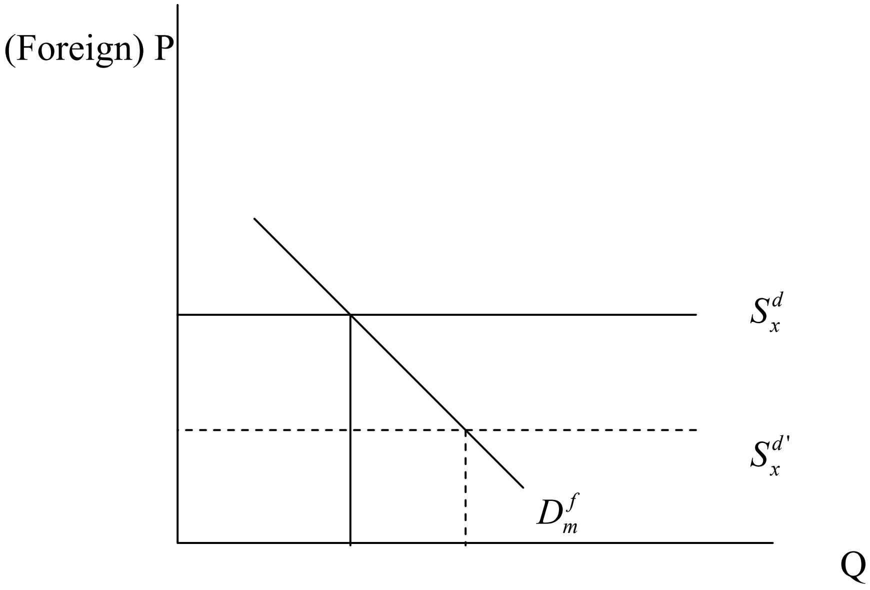


A. Domestic Demand for Imports

B. Demand for Foreign Exports

C. Demand for Domestic Exports





D. Foreign Demand for Imports

Figure 5: The Log of U.S. Real GDP

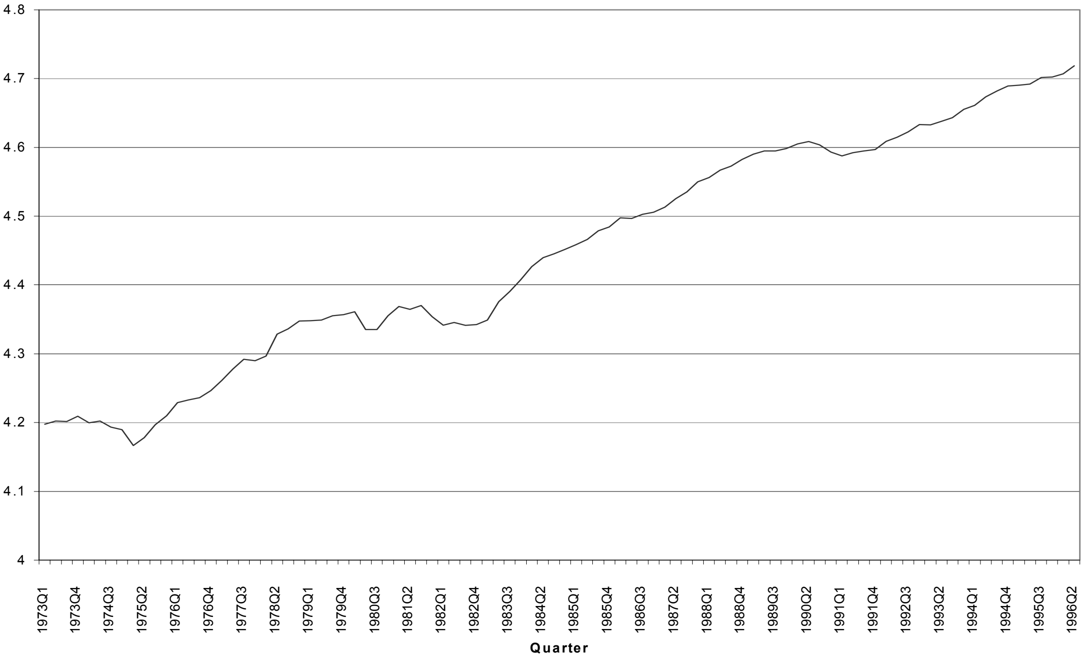


Figure 6: The Log of Canada's Real GDP

Figure 7: The Log of France's Real GDP

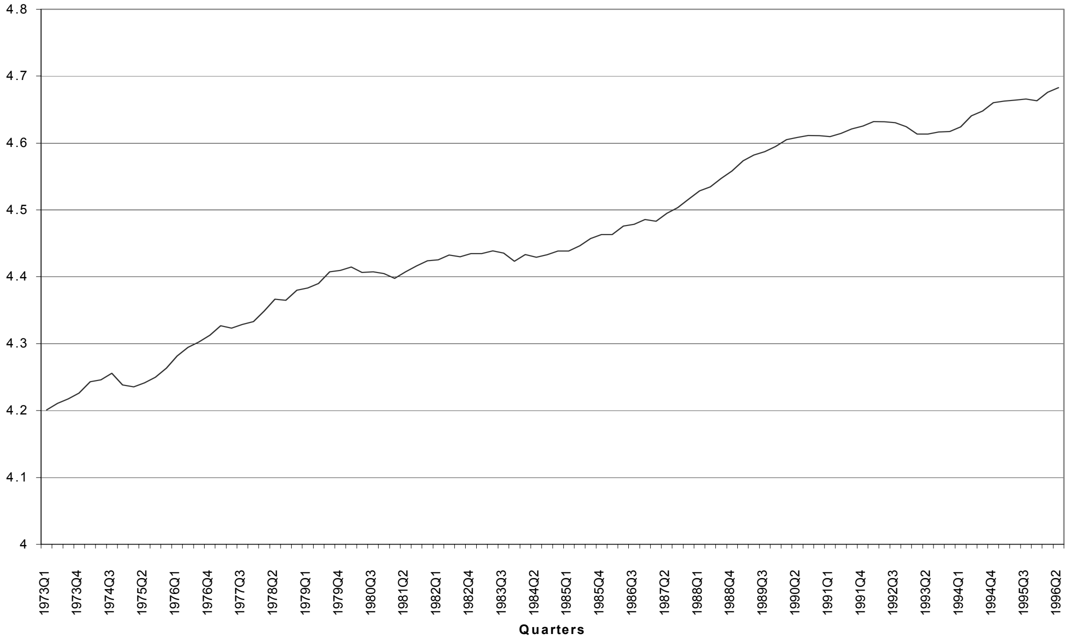


Figure 8: The Log of Germany's Real GDP

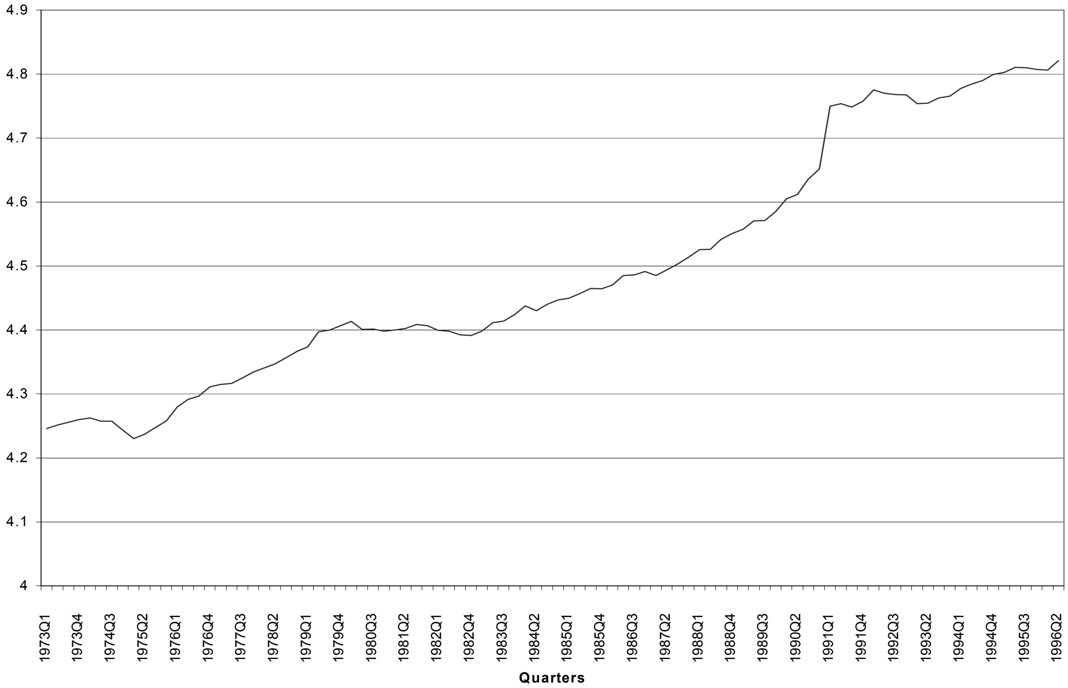


Figure 9: The Log of Italy's Real GDP

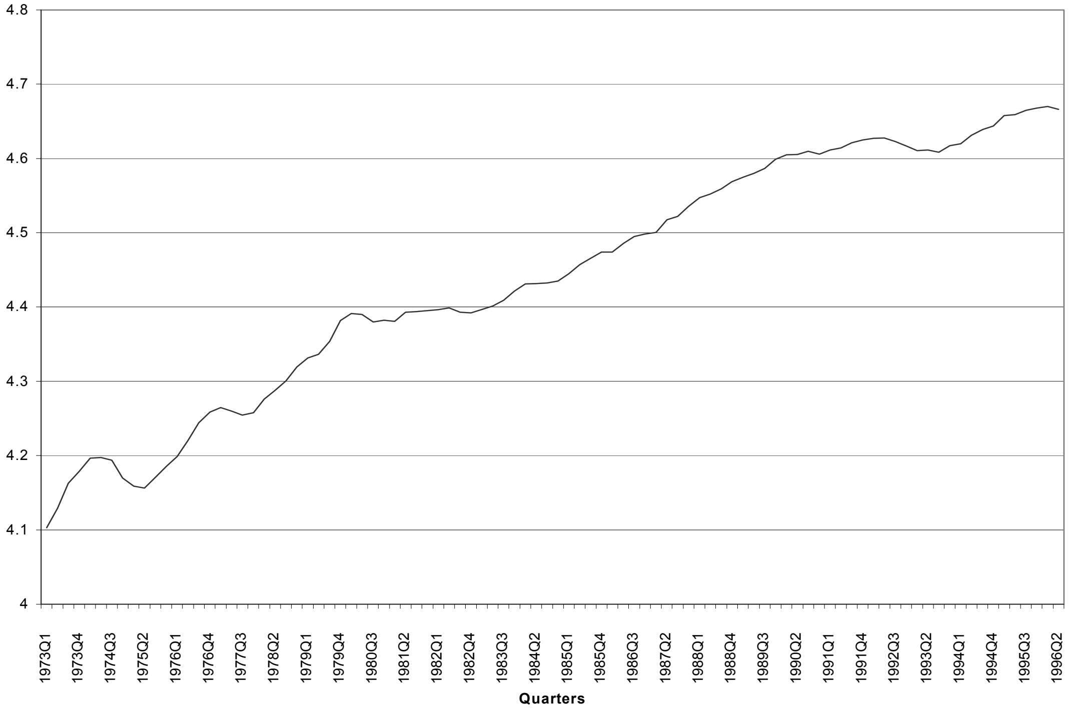


Figure 10: The Log of Japan's Real GDP

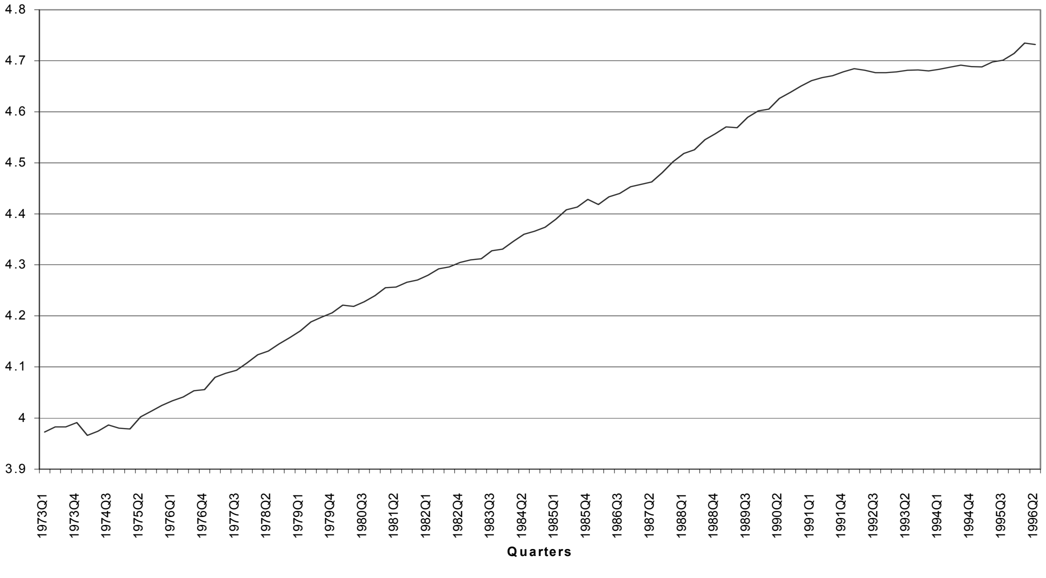


Figure 11: The Log of UK's Real GDP

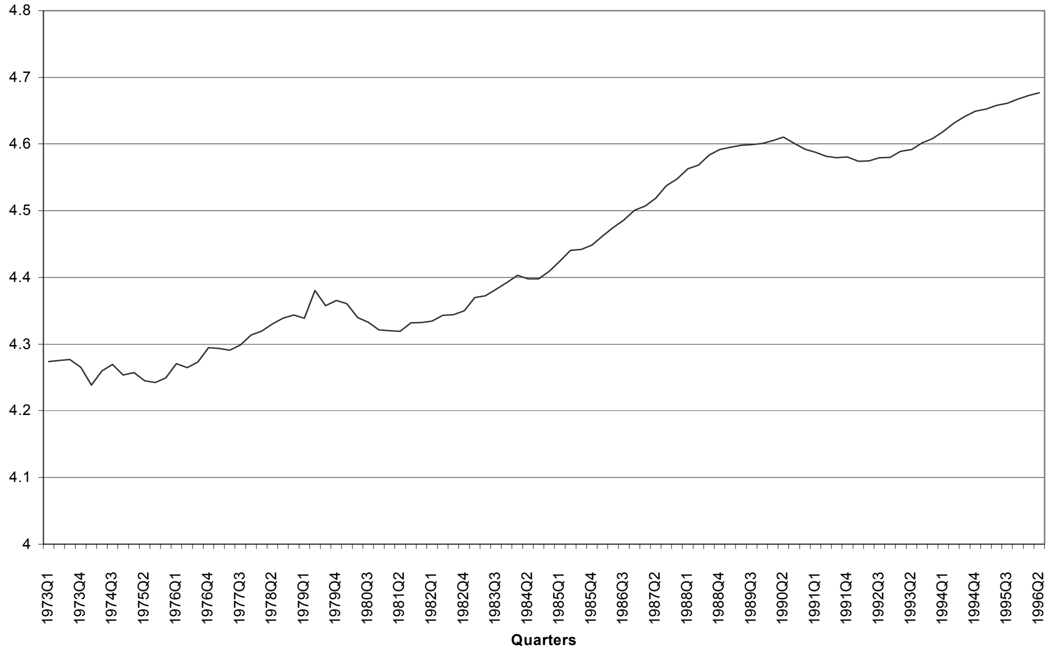


Figure 12: The Log of Real US Exports to Canada

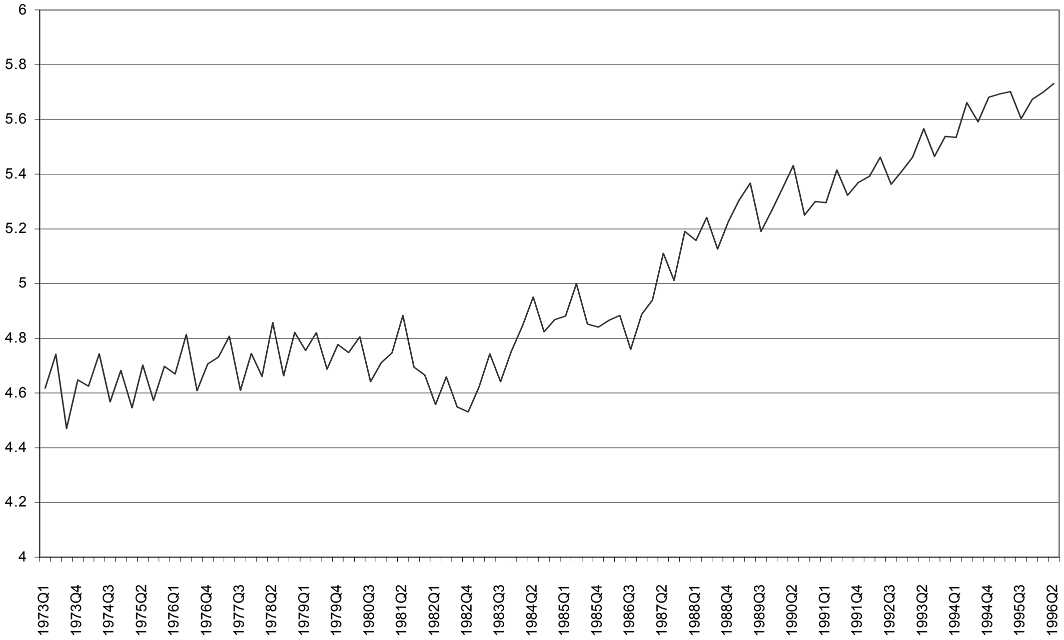


Figure 13: The Log of Real US Exports to France

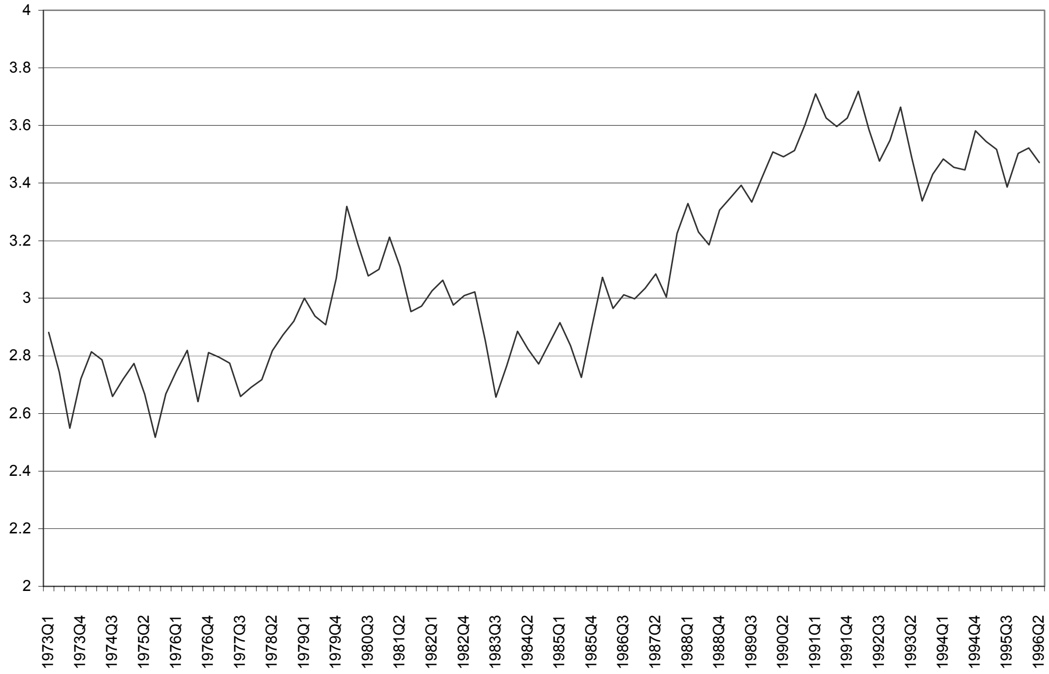


Figure 14: The Log of Real US Exports to Germany

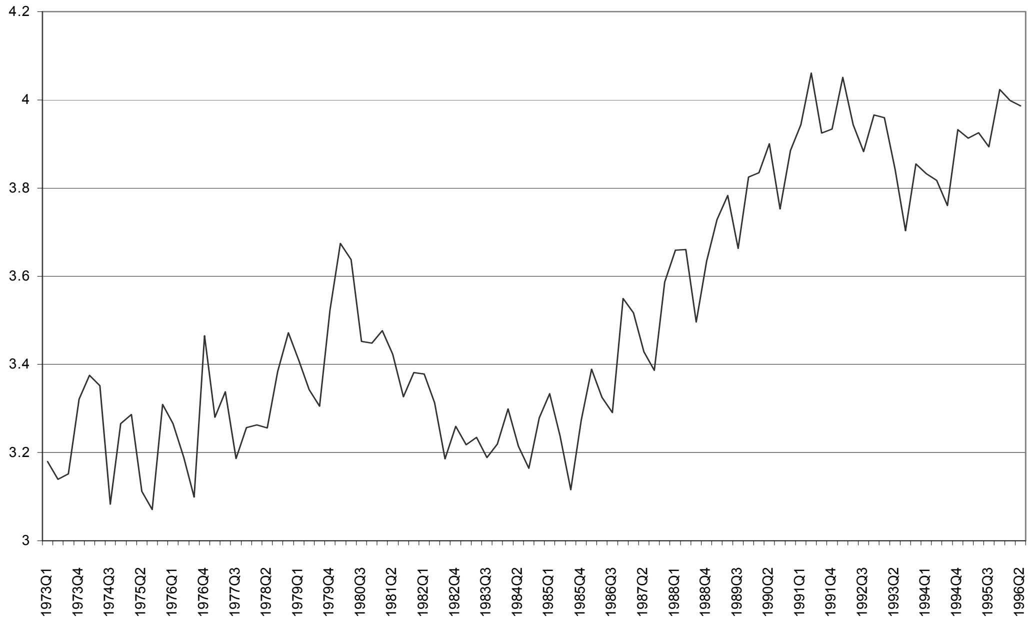


Figure 15: The Log of Real US Exports to Italy

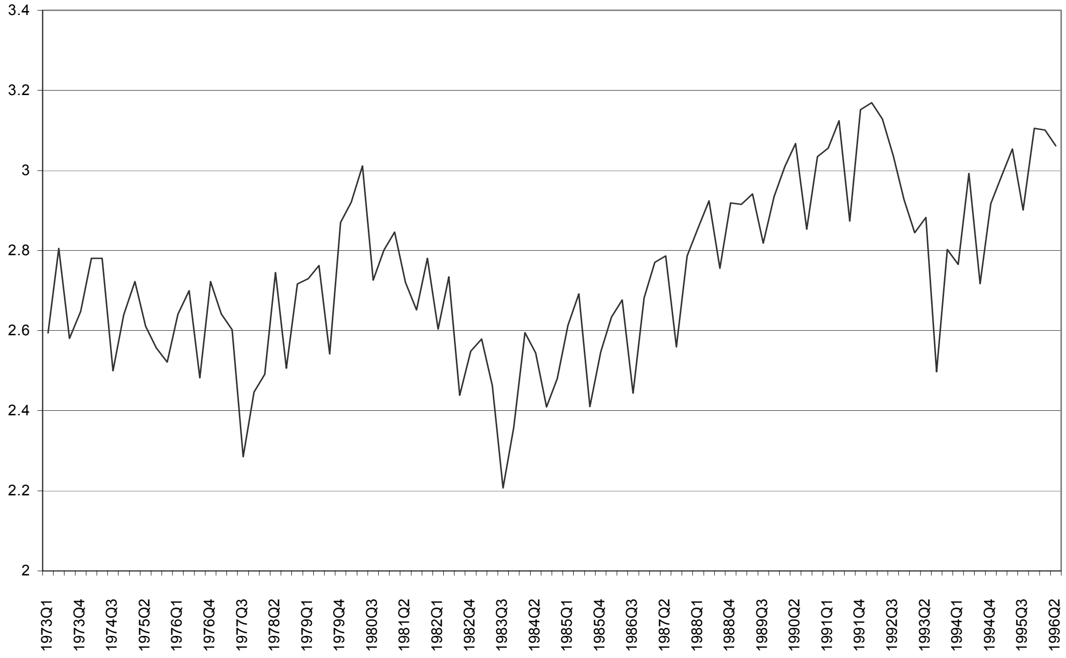


Figure 16: The Log of Real US Exports to Japan

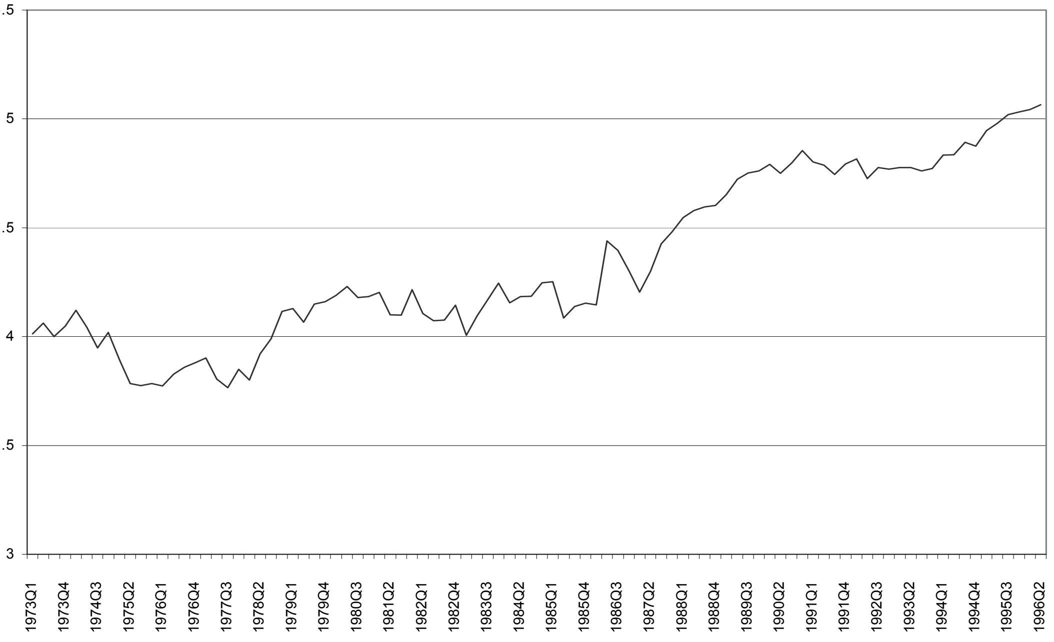


Figure 17: The Log of Real US Exports to UK

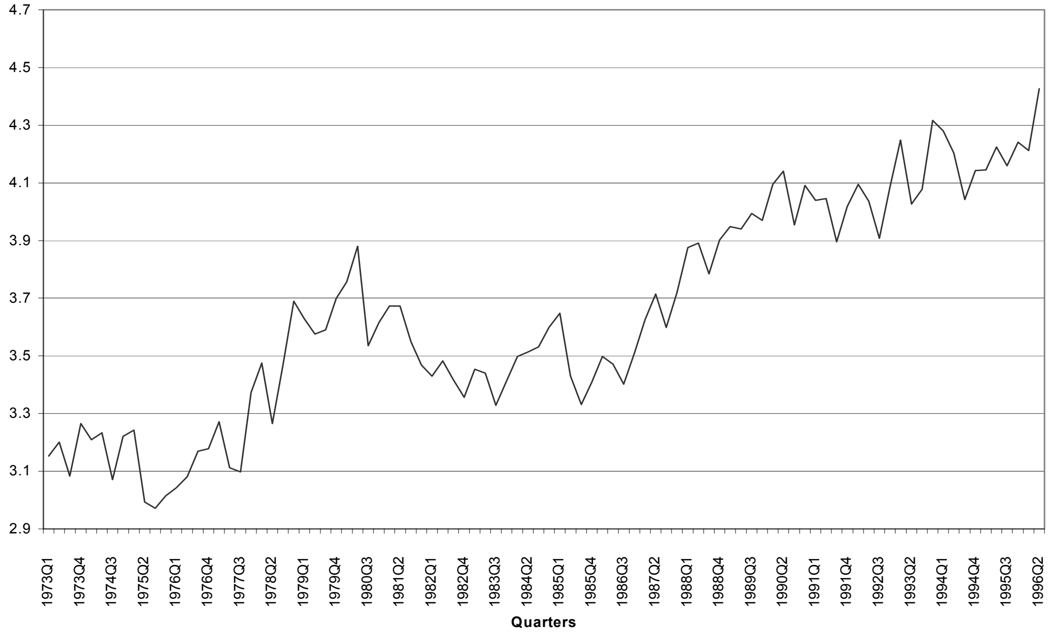


Figure 18: The Log of Real US Imports from Canada

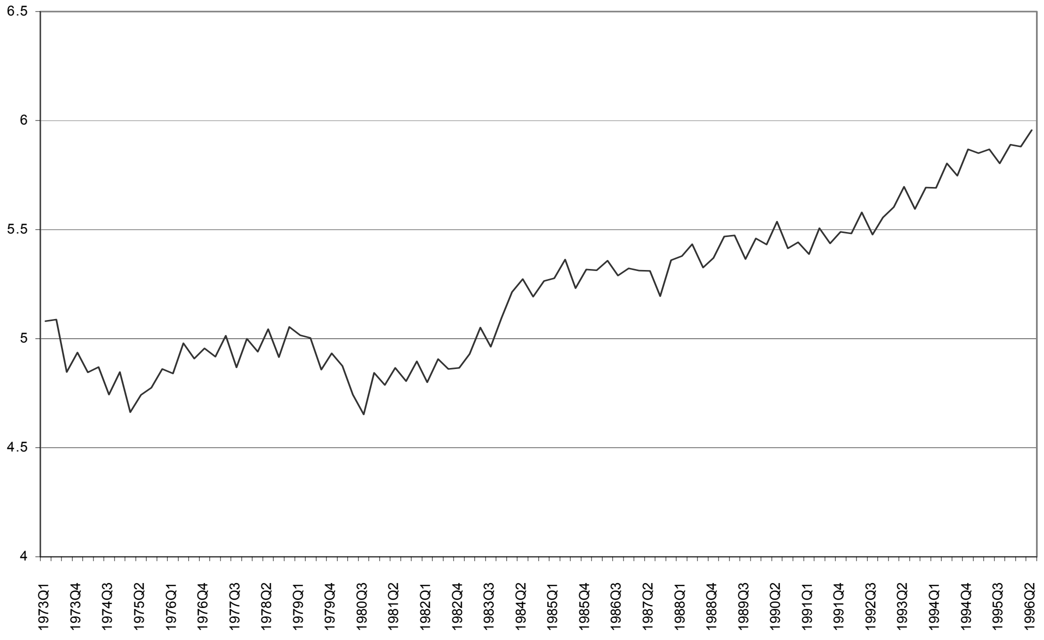


Figure 19: The Log of Real US Imports from France

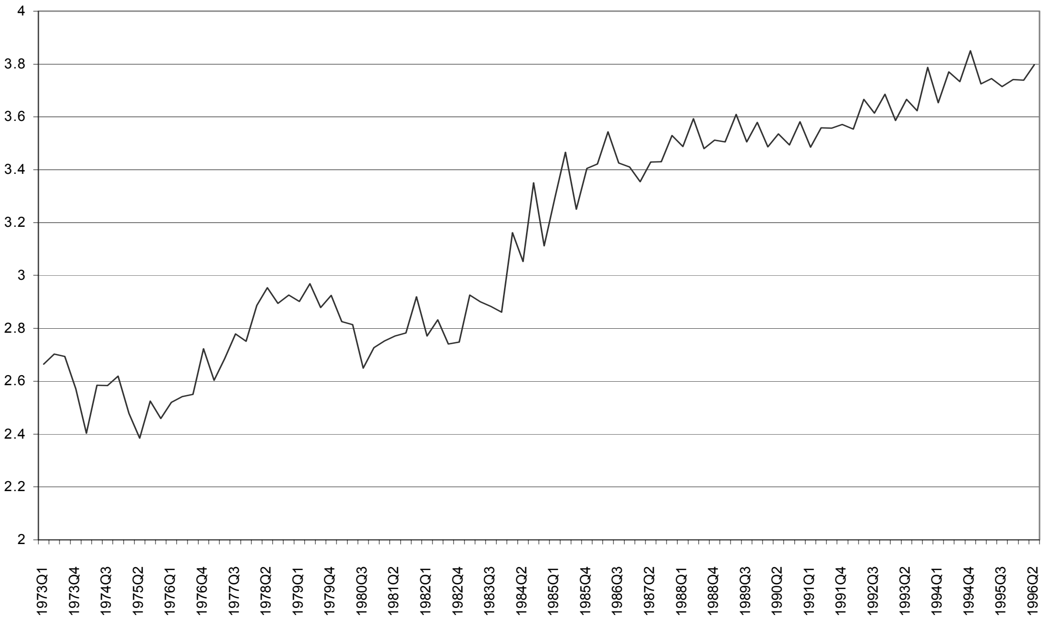


Figure 20: The Log of Real US Imports from Germany

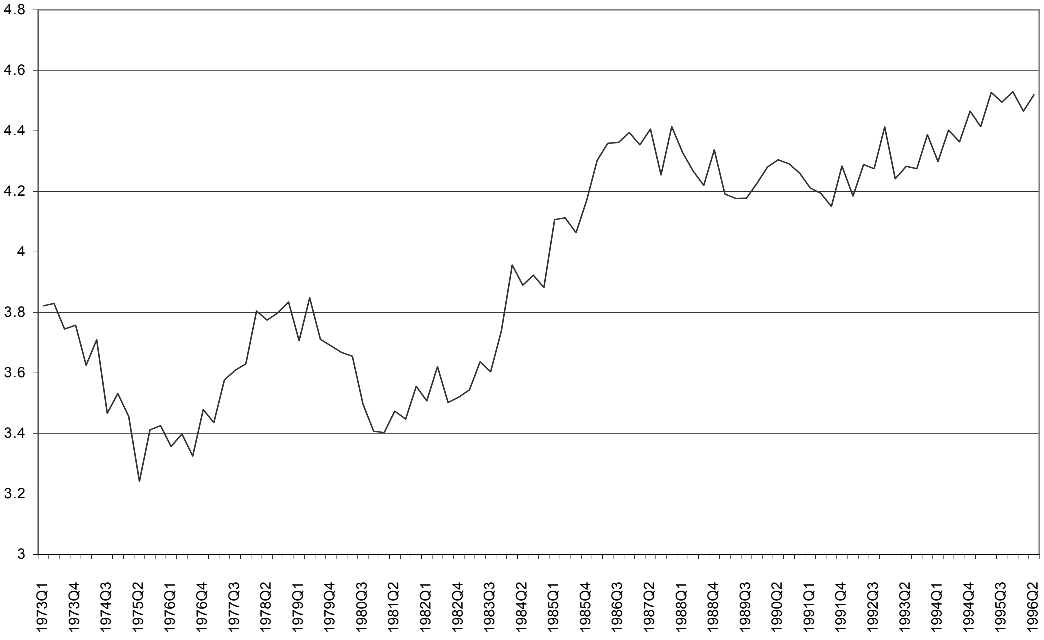


Figure 21: The Log of Real US Imports from Italy

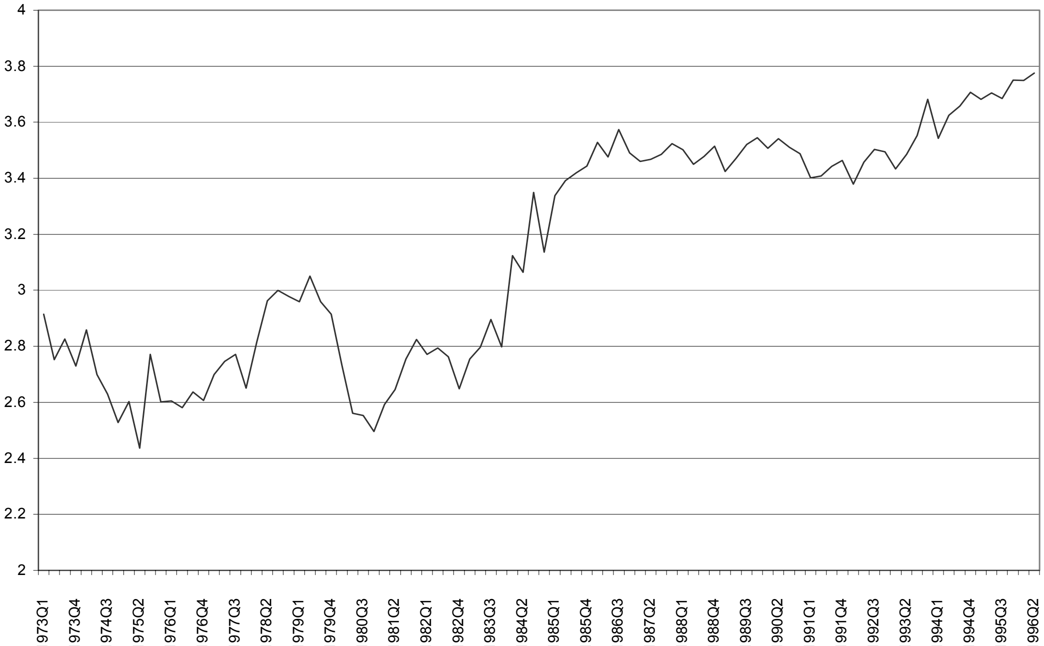


Figure 22: The Log of Real US Imports from Japan

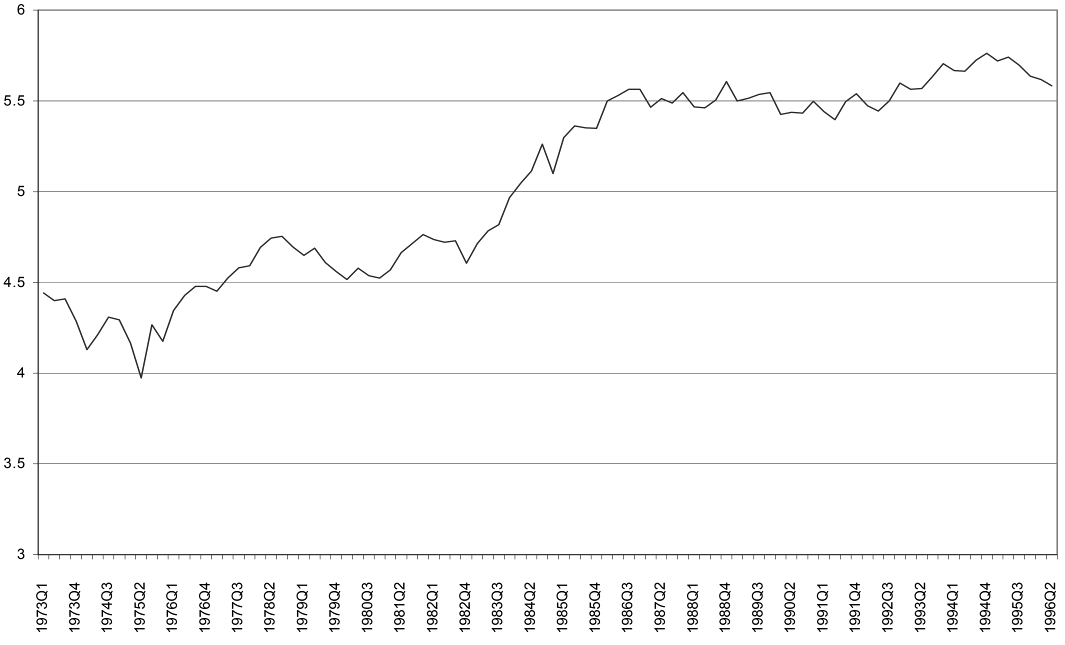


Figure 23: The Log of Real US Imports from U.K.

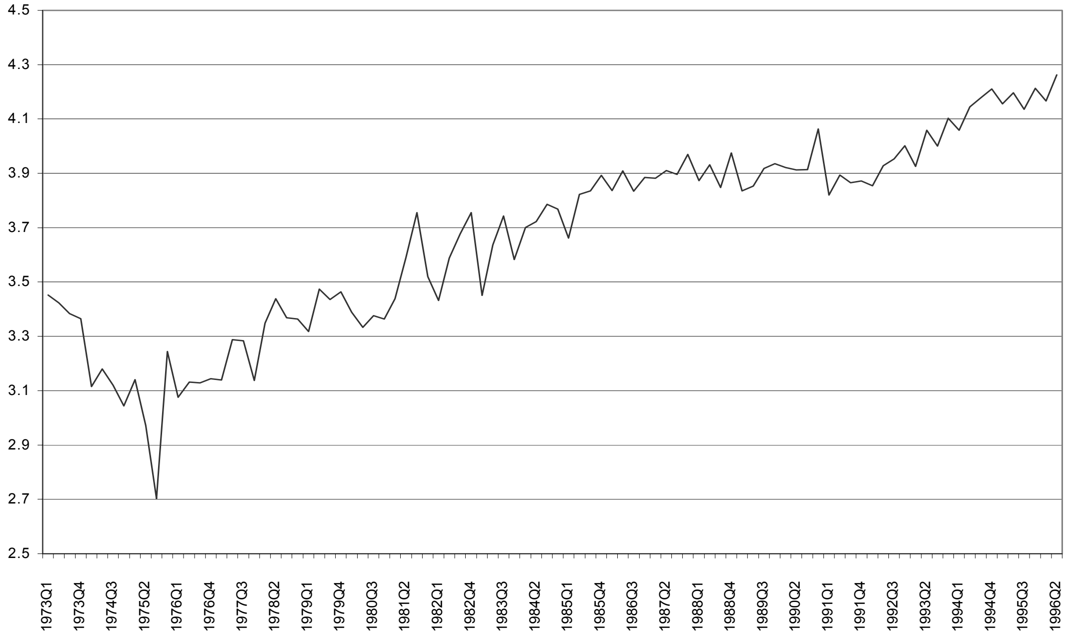


Figure 24: The Log of the Real U.S. Bilateral Exchange Rate with Canada

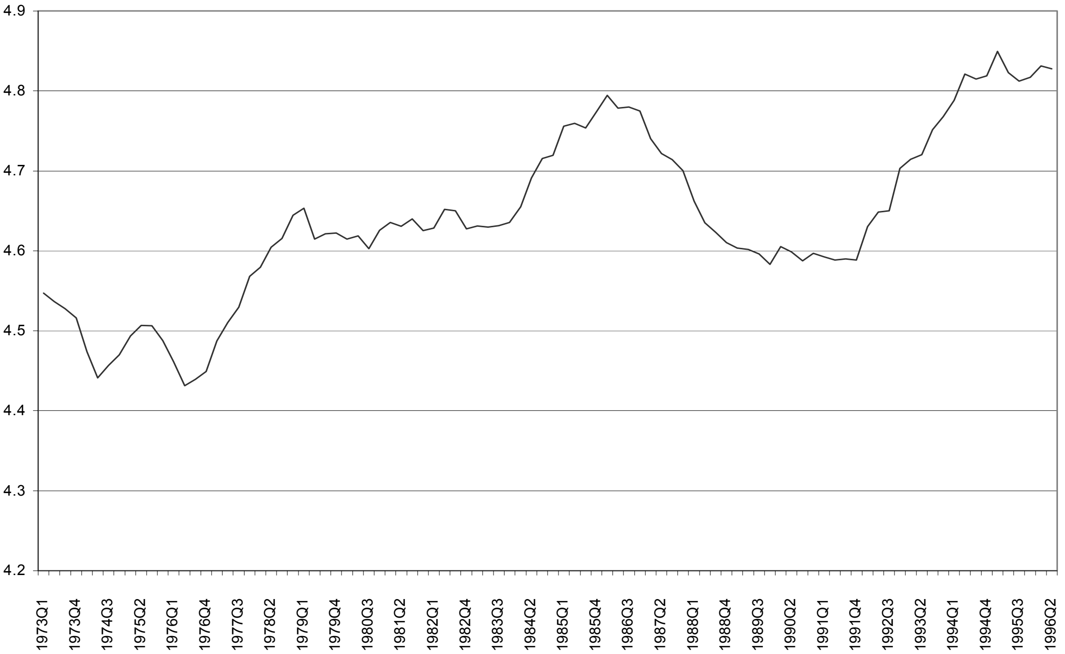


Figure 25: The Log of the Real U.S. Bilateral Exchange Rate with France

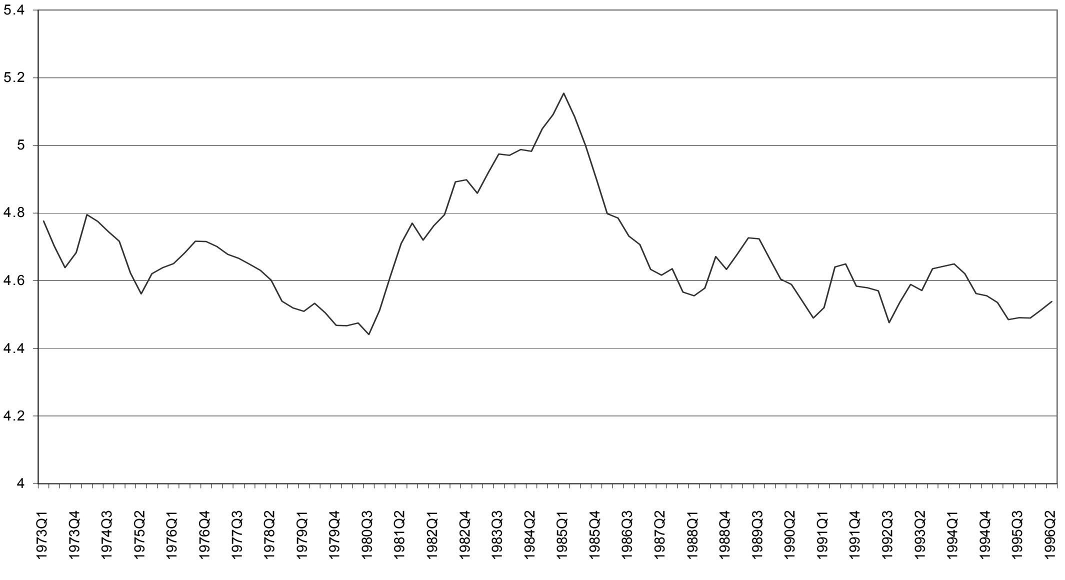


Figure 26: The Log of the Real U.S. Bilateral Exchange Rate with Germany

Figure 27: The Log of the Real U.S. Bilateral Exchange Rate with Italy

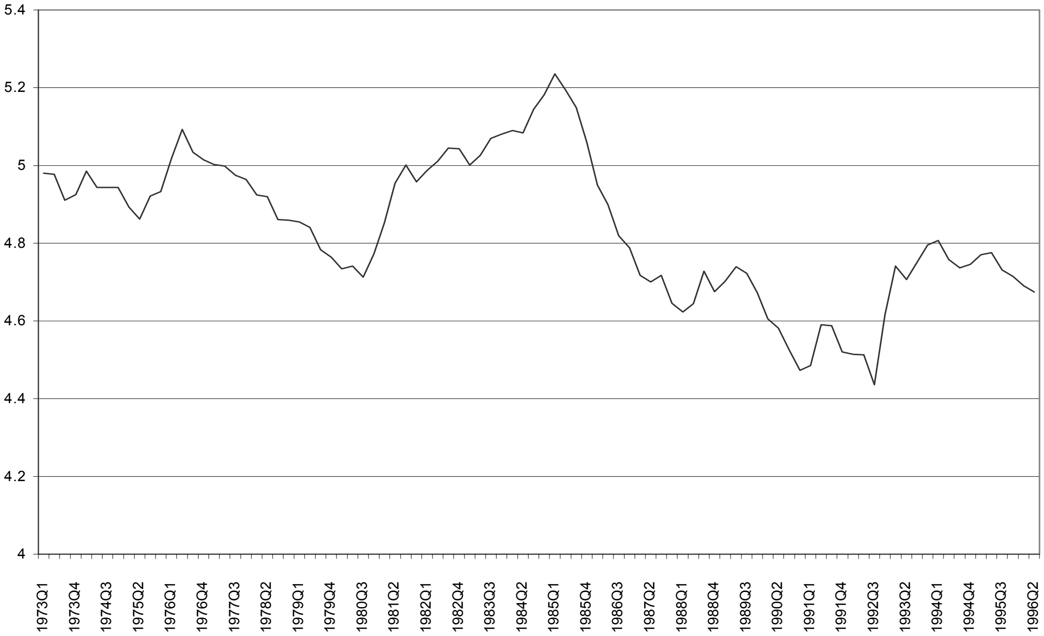


Figure 28: The Log of the Real U.S. Bilateral Exchange Rate with Japan

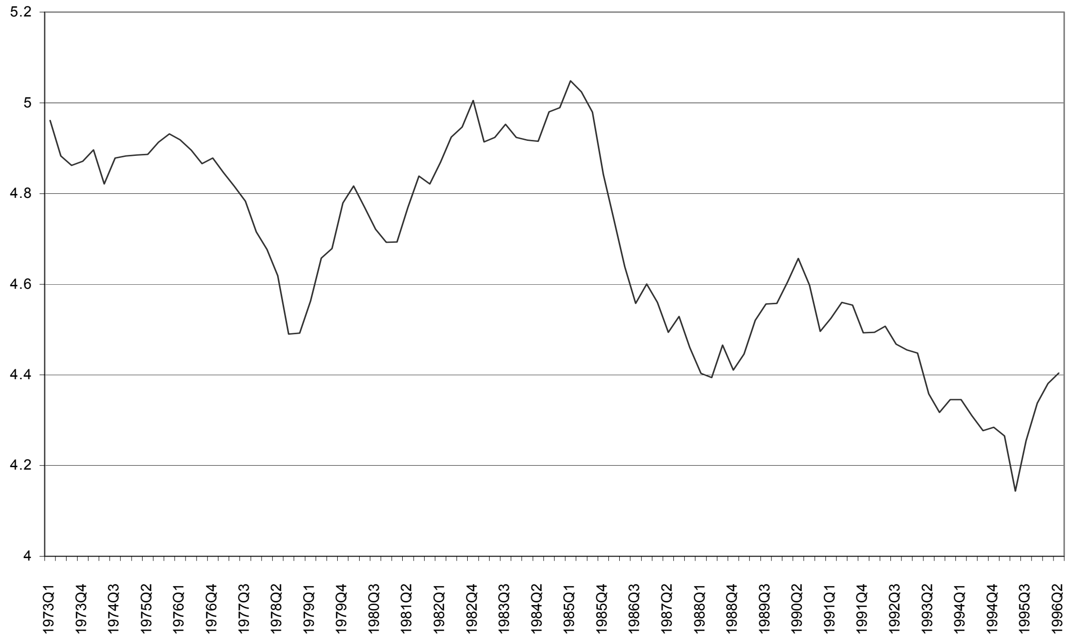


Figure 29: The Log of the Real U.S. Bilateral Exchange Rate with UK

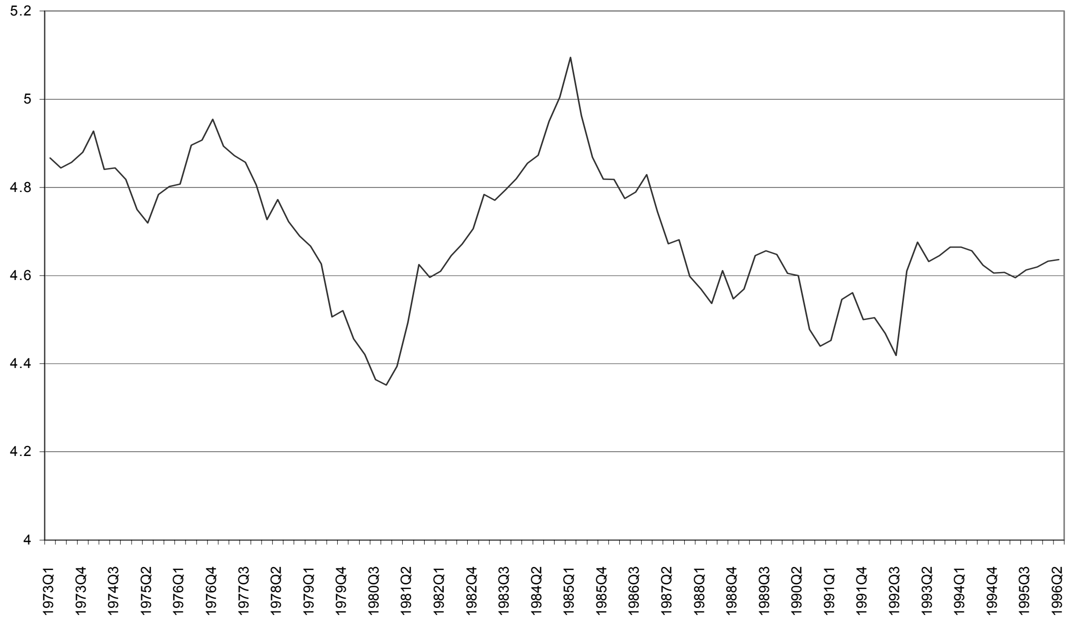


Figure 30: CUSUM Test for Export Demand with Canada

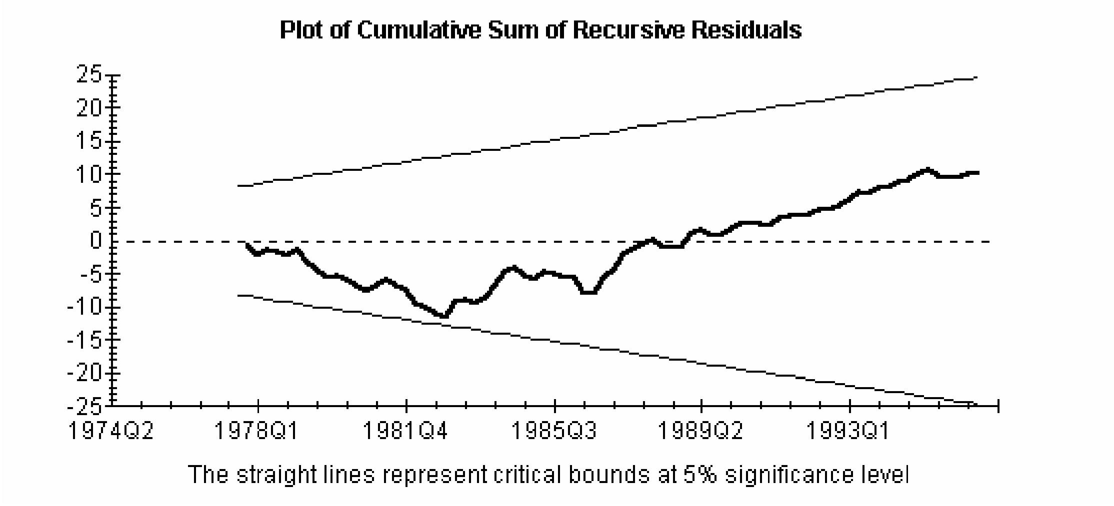


Figure 31: CUSUMSQ Test for Export Demand with Canada

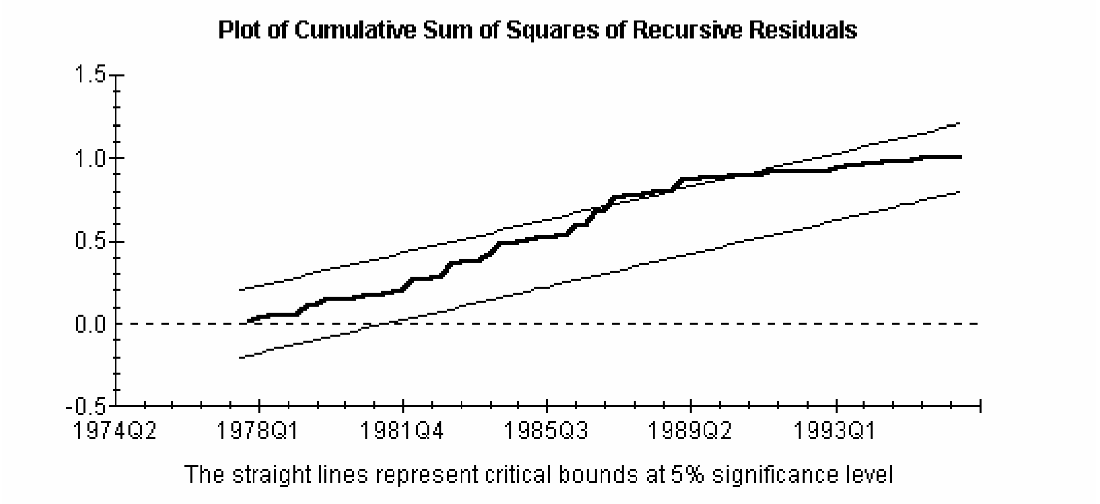


Figure 32: CUSUM Test for Import Demand with Canada

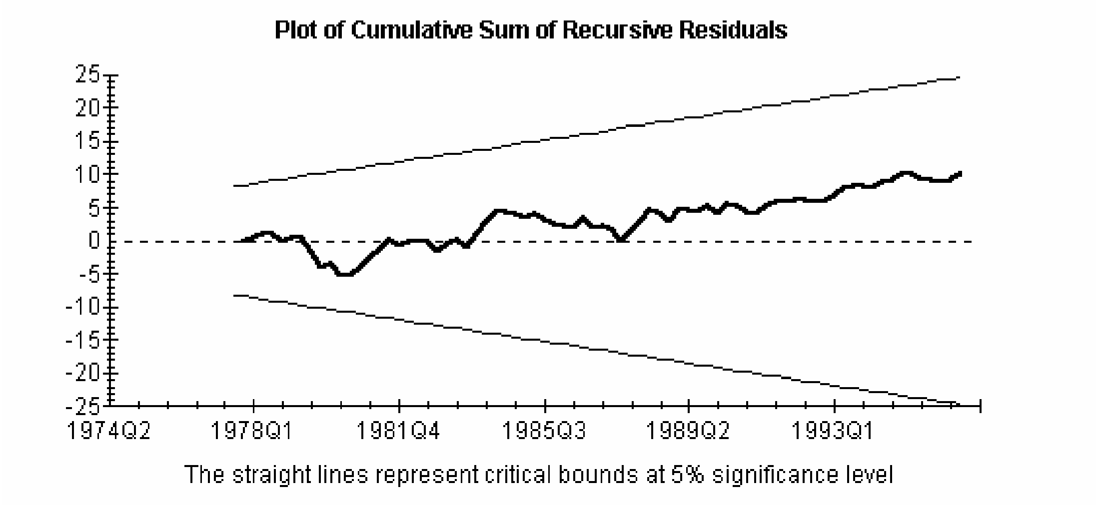


Figure 33: CUSUMSQ Test for Import Demand with Canada

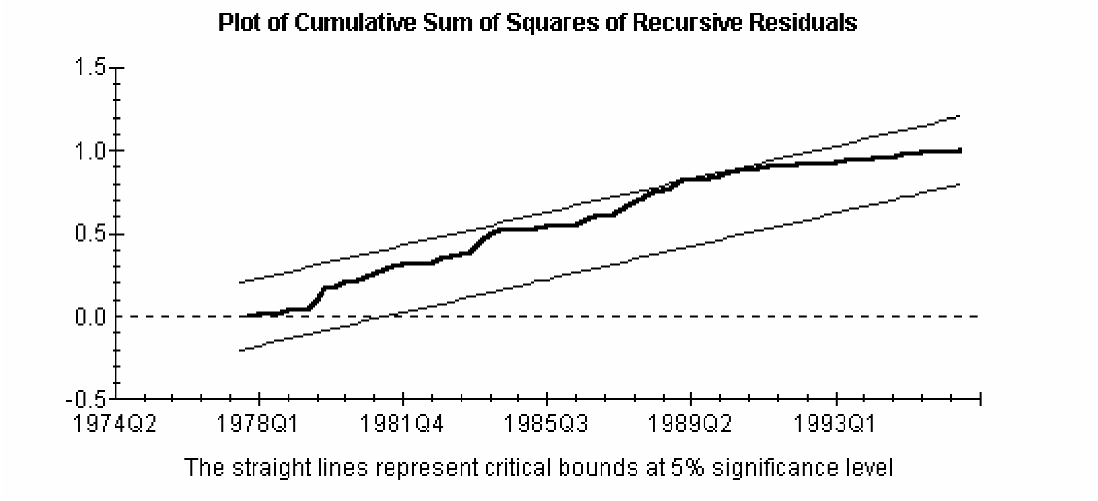


Figure 34: CUSUM Test for Export Demand with France

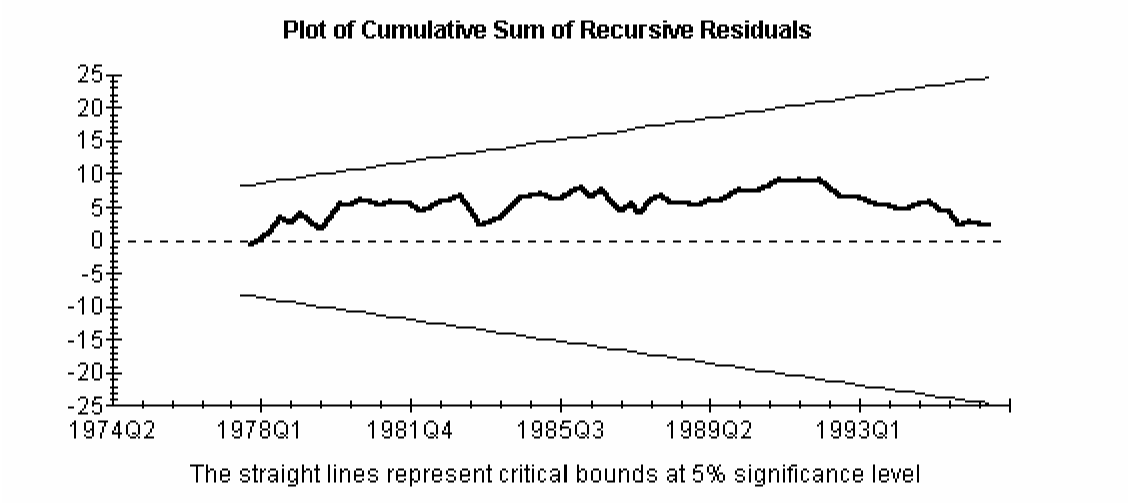


Figure 35: CUSUMSQ Test for Export Demand with France

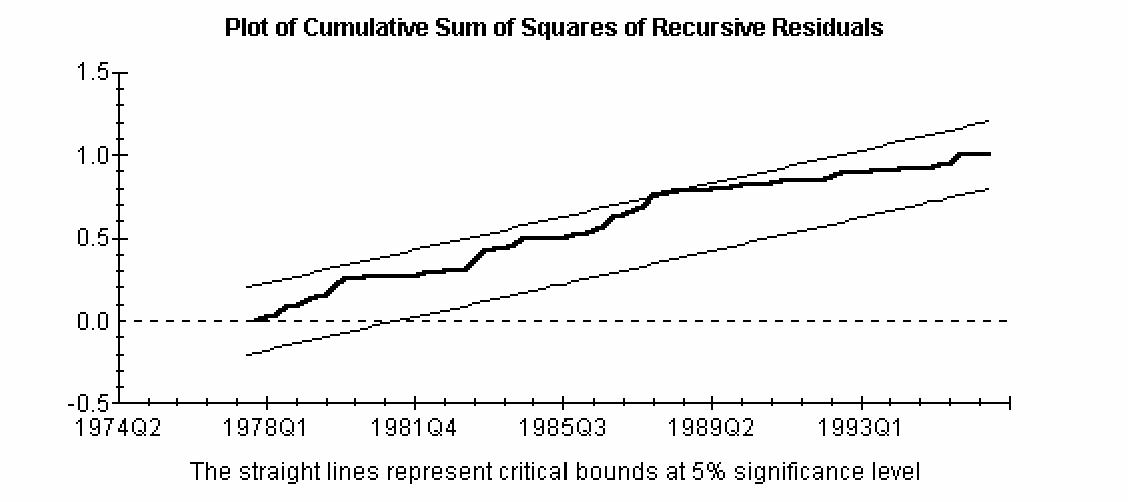
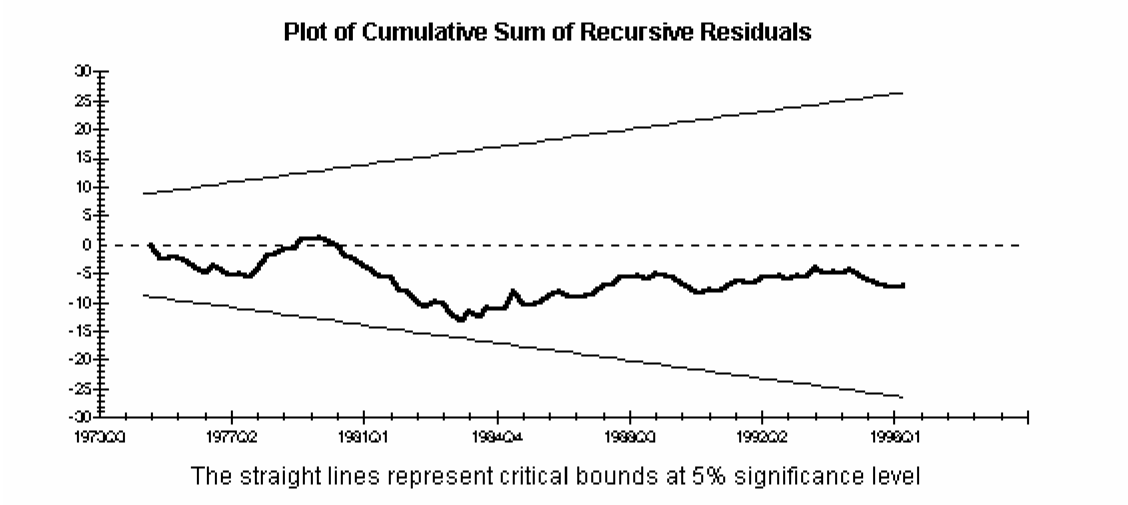


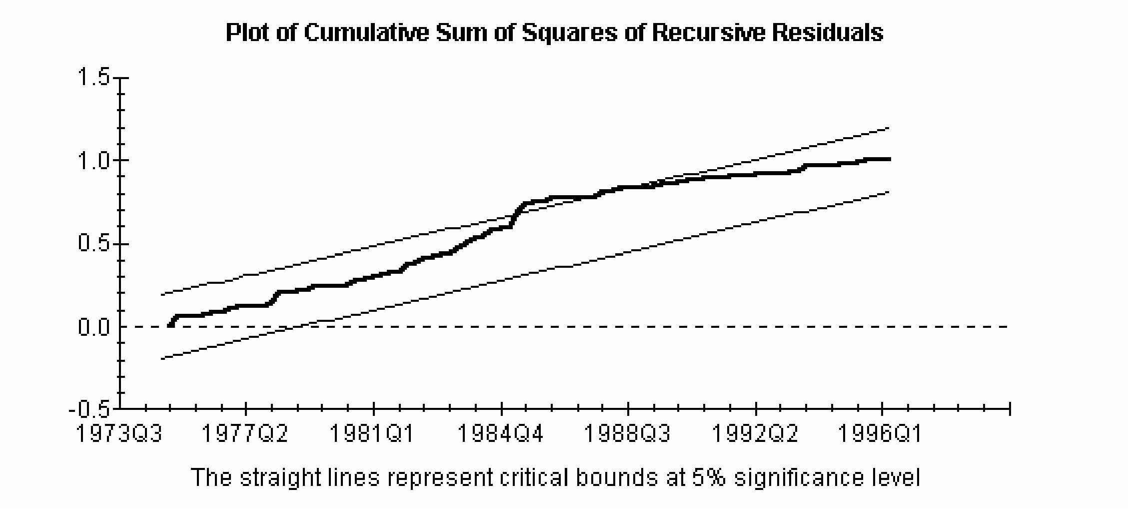
Figure 36: CUSUM Test for Import Demand with France



Plot of Cumulative Sum of Recursive Residuals

The straight lines represent critical bounds at 5% significance level

Figure 37: CUSUMSQ Test for Import Demand with France



Plot of Cumulative Sum of Squares of Recursive Residuals

The straight lines represent critical bounds at 5% significance level

Figure 38: CUSUM Test for Export Demand with Germany

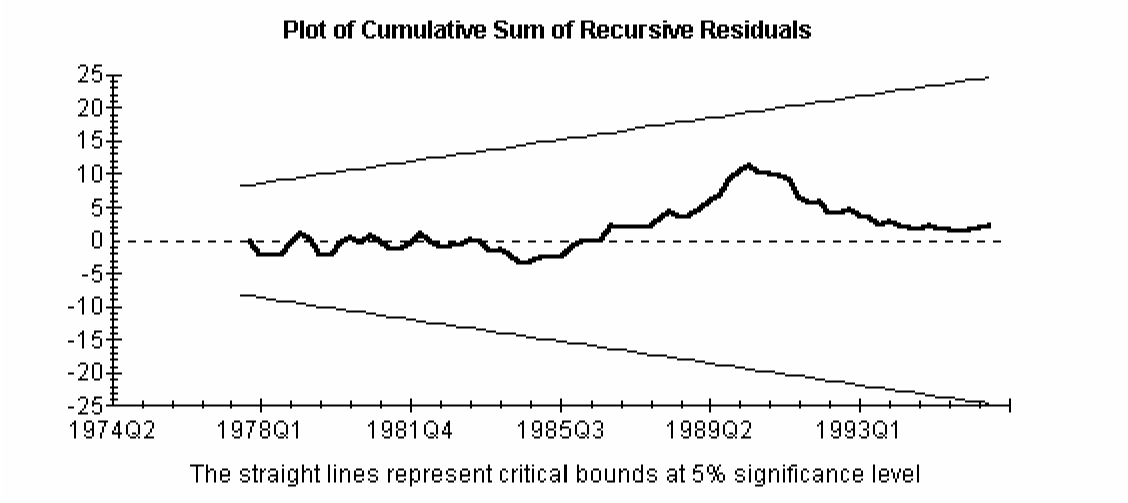


Figure 39: CUSUMSQ Test for Export Demand with Germany

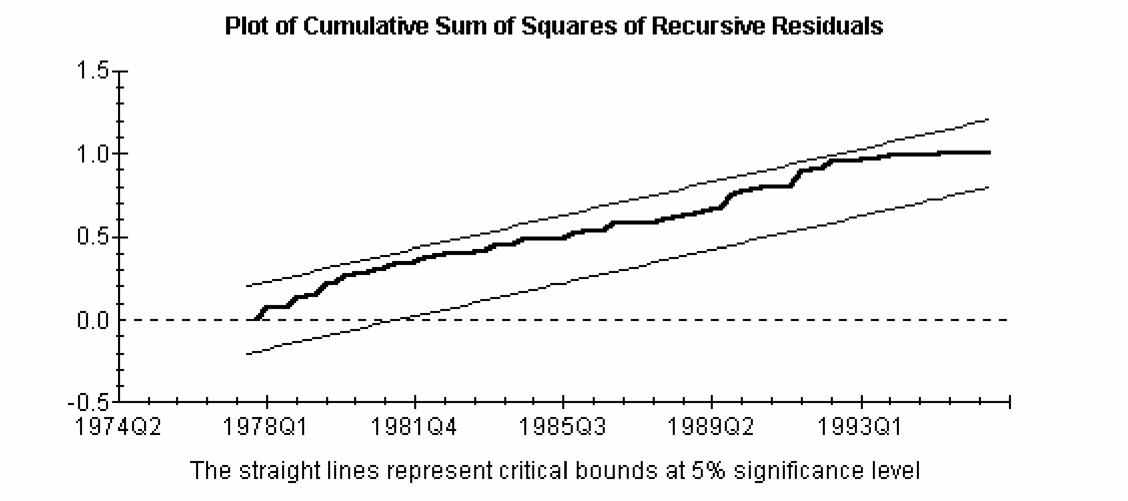


Figure 40: CUSUM Test for Import Demand with Germany

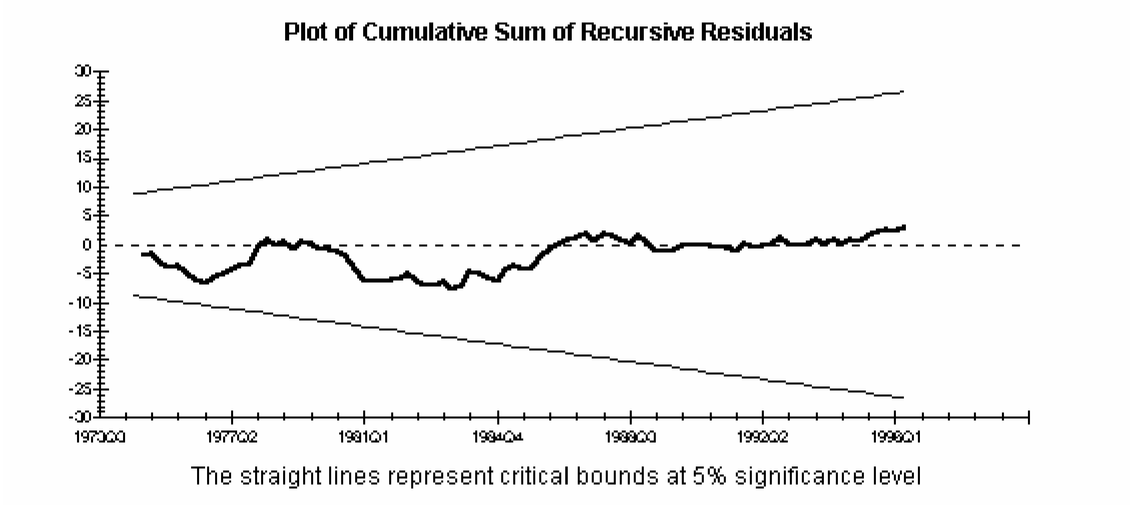


Figure 41: CUSUMSQ Test for Import Demand with Germany

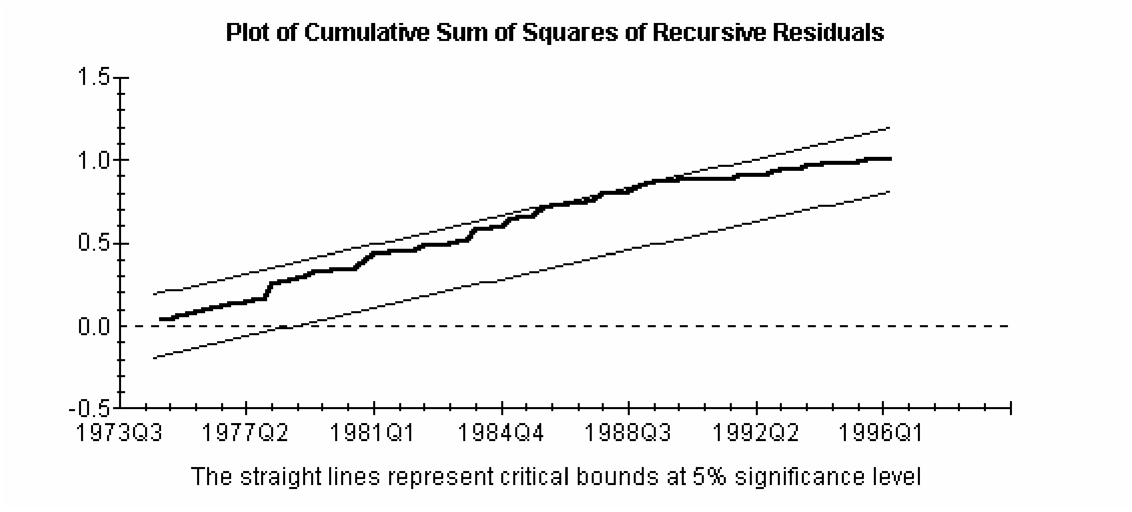
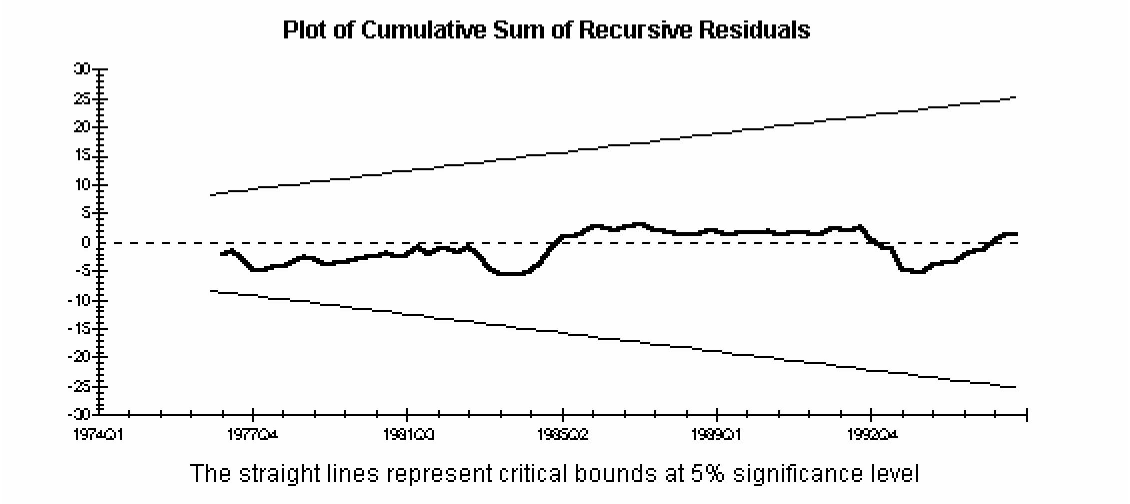
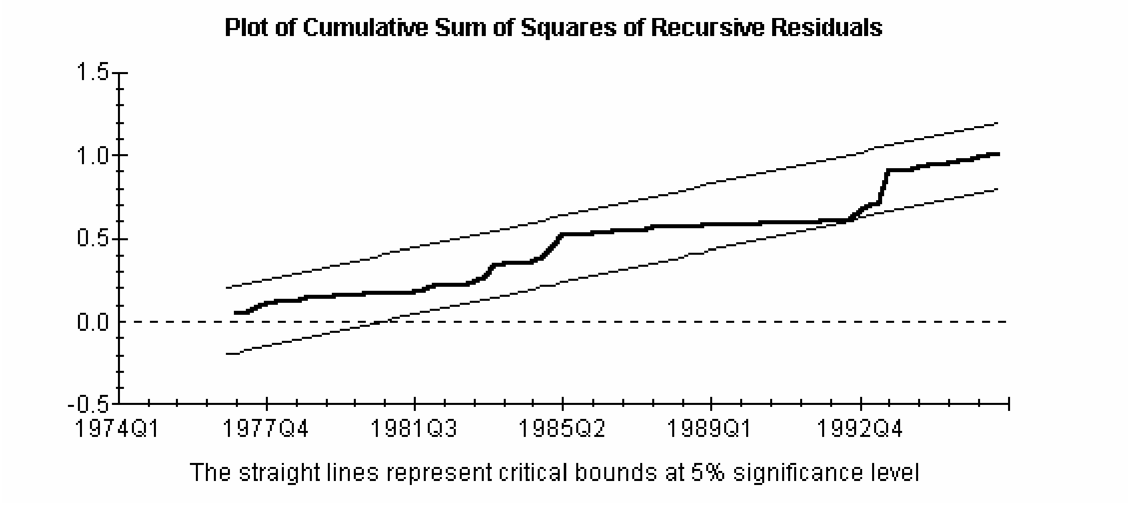


Figure 42: CUSUM Test for Export Demand with Italy


Plot of Cumulative Sum of Recursive Residuals

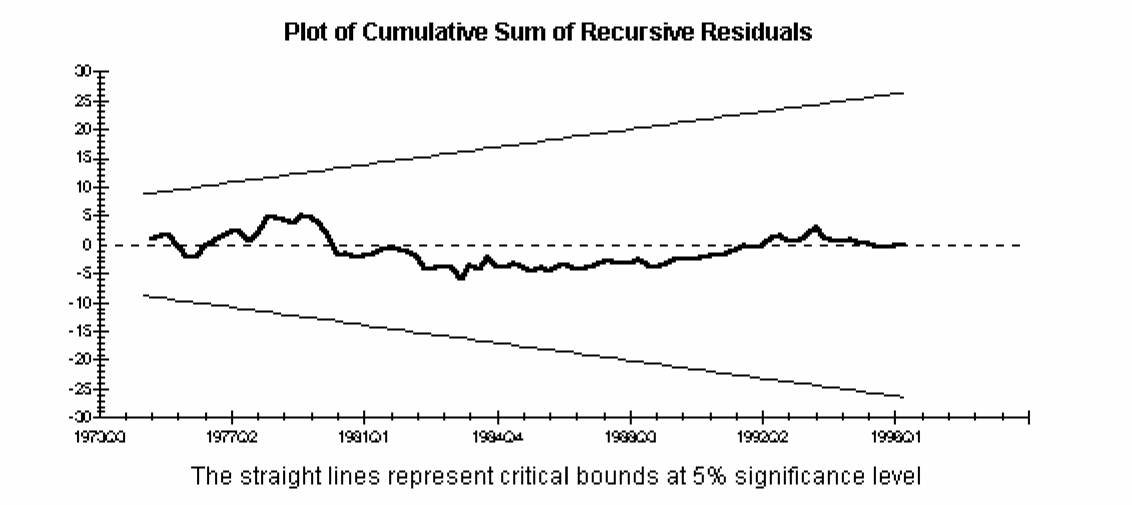
The straight lines represent critical bounds at 5% significance level

Figure 43: CUSUMSQ Test for Export Demand with Italy


Plot of Cumulative Sum of Squares of Recursive Residuals

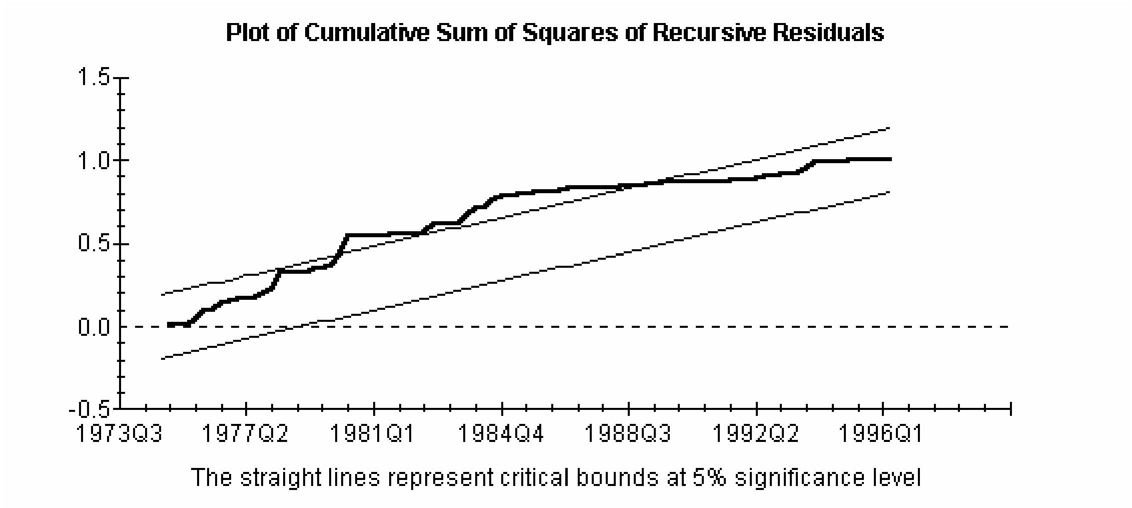
The straight lines represent critical bounds at 5% significance level

Figure 44: CUSUM Test for Import Demand with Italy


Plot of Cumulative Sum of Recursive Residuals

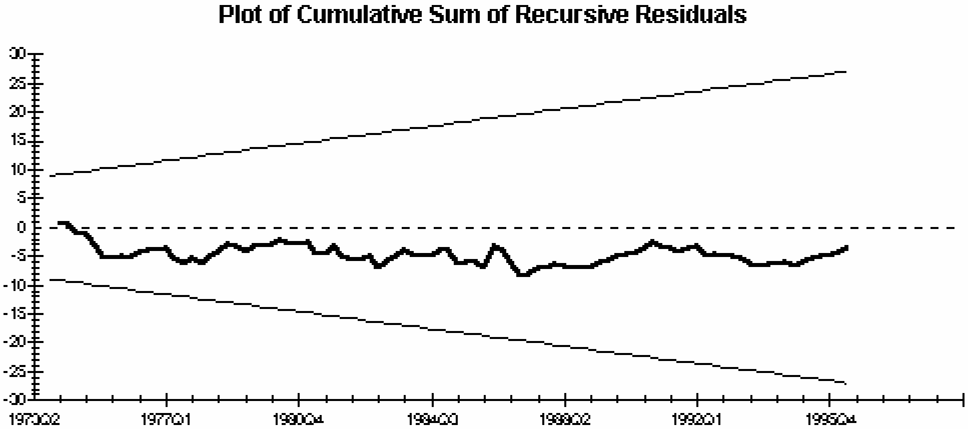
The straight lines represent critical bounds at 5% significance level

Figure 45: CUSUMSQ Test for Import Demand with Italy


Plot of Cumulative Sum of Squares of Recursive Residuals

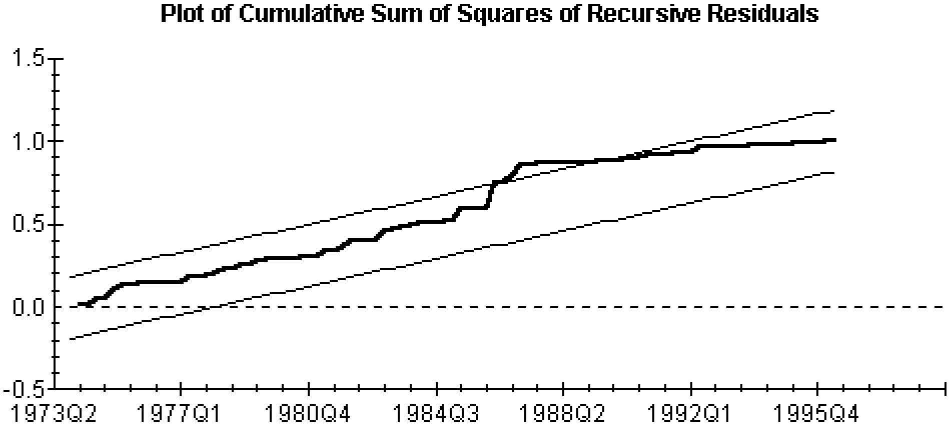
The straight lines represent critical bounds at 5% significance level

Figure 46: CUSUM Test for Export Demand with Japan



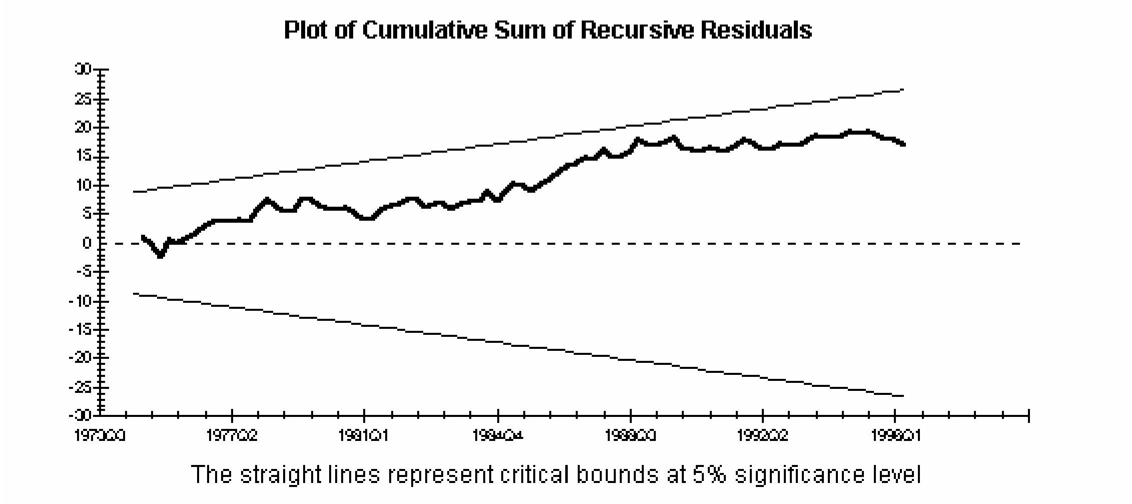
The straight lines represent critical bounds at 5% significance level

Figure 47: CUSUMSQ Test for Export Demand with Japan



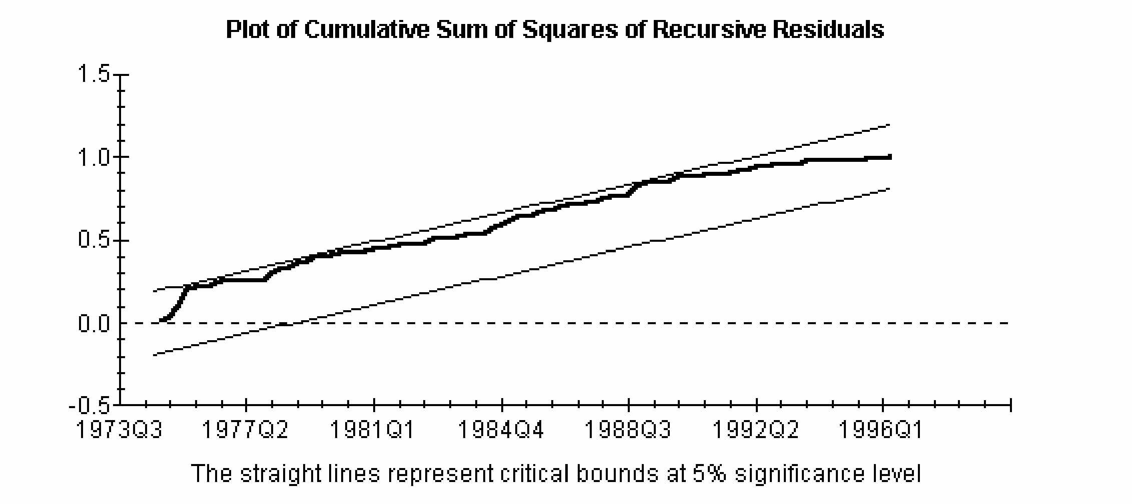
The straight lines represent critical bounds at 5% significance level

Figure 48: CUSUM Test for Import Demand with Japan


Plot of Cumulative Sum of Recursive Residuals

The straight lines represent critical bounds at 5% significance level

Figure 49: CUSUMSQ Test for Import Demand with Japan


Plot of Cumulative Sum of Squares of Recursive Residuals

The straight lines represent critical bounds at 5% significance level

Figure 50: CUSUM Test for Export Demand with U.K.

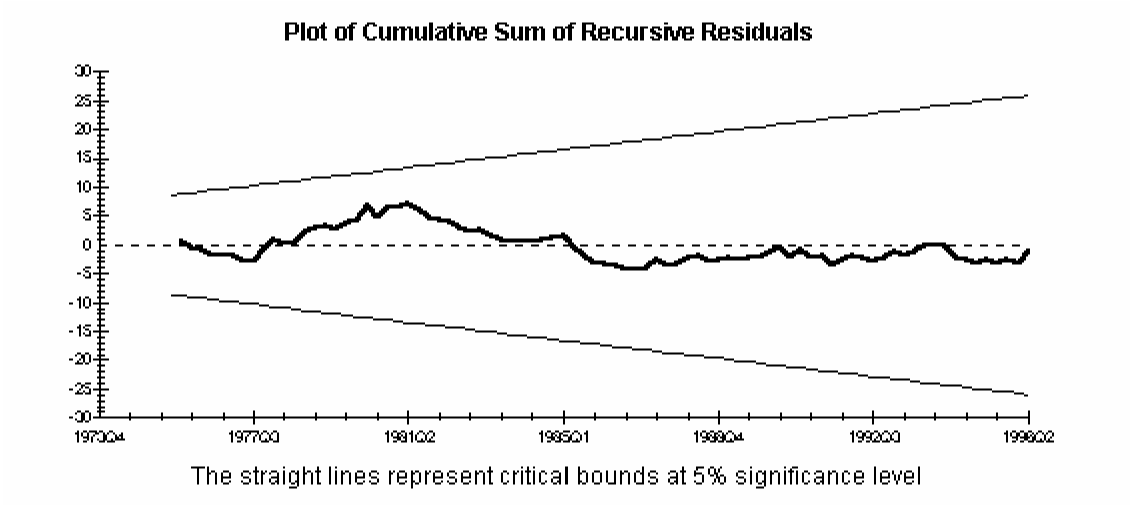


Figure 51: CUSUMSQ Test for Export Demand with U.K.

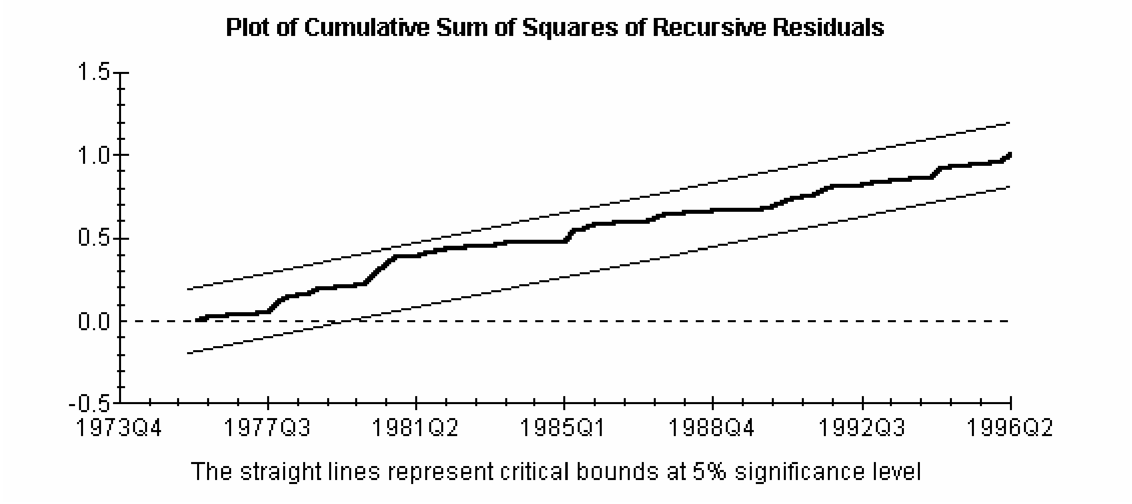


Figure 52: CUSUM Test for Import Demand with U.K.

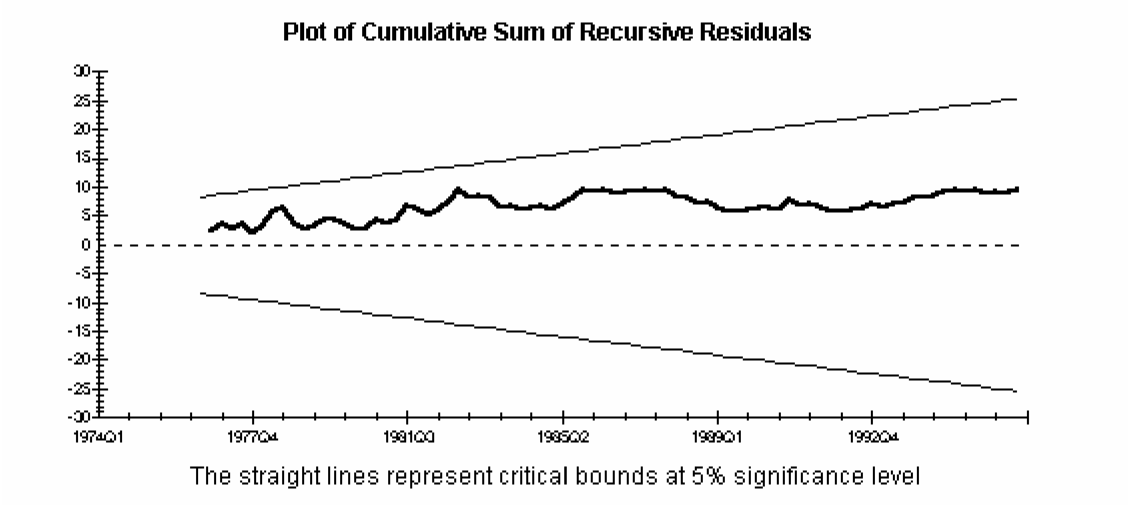
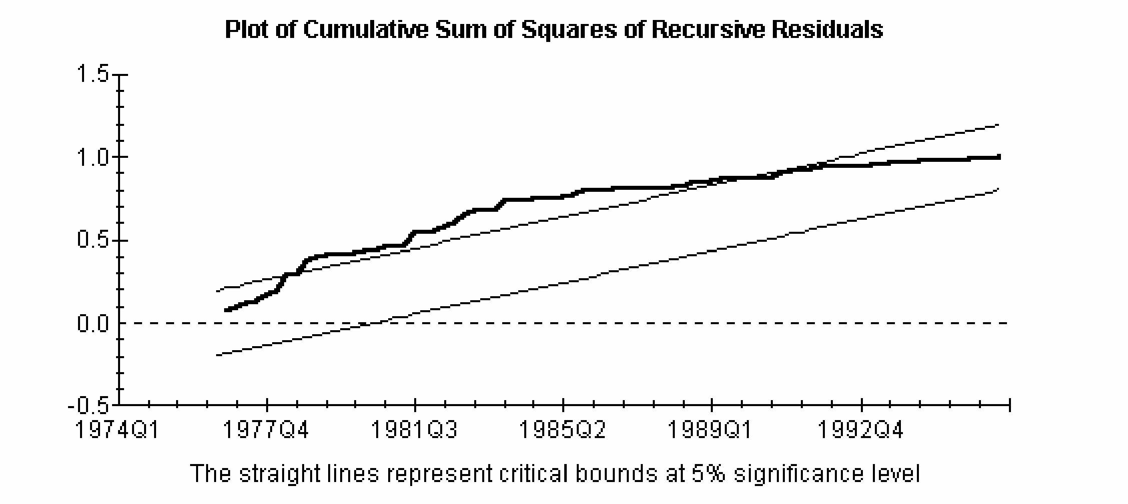


Figure 53: CUSUMSQ Test for Import Demand with U.K.



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Appendix A: Mathematical Derivation of the Marshall-Lerner Condition.

The following derivation follows from Stern (1973). The trade balance in foreign currency terms is:

$$B_f \equiv p_{fx}X - p_{fm}M \tag{A.1}$$

The change in the trade balance after a depreciation can be denoted as:

$$\Delta B_f \equiv (p_{fx}\Delta X + X\Delta p_{fx}) - (p_{fm}\Delta M + M\Delta p_{fm}) \tag{A.2}$$

If we indicate the initial value of export and imports as follows:

$$V_{fx} \equiv p_{fx}X \qquad \text{Foreign value of exports} \tag{A.3}$$

$$V_{fm} \equiv p_{fm}M \qquad \text{Foreign value of imports} \tag{A.4}$$

Then rearranging terms and substituting (A.3) and (A.4) into (A.2) yields:

$$\Delta B_f \equiv V_{fx}\left(\frac{\Delta X}{X} + \frac{\Delta p_{fx}}{p_{fx}}\right) + V_{fm}\left(-\frac{\Delta M}{M} - \frac{\Delta p_{fm}}{p_{fm}}\right) \tag{A.5}$$

The elasticities of demand and supply of exports and imports are defined below. Note that traditionally negative demand elasticities are expressed so as to enter in positively into the expression.

$$e_x \equiv \frac{\Delta X}{X} \Big/ \frac{\Delta p_{hx}}{p_{hx}} \qquad \text{Home export supply elasticity} \tag{A.6}$$

$$\eta_x \equiv -\frac{\Delta X}{X} \Big/ \frac{\Delta p_{fx}}{p_{fx}} \qquad \text{Foreign export demand elasticity} \tag{A.7}$$

$$e_m \equiv \frac{\Delta M}{M} \Big/ \frac{\Delta p_{fm}}{p_{fm}} \qquad \text{Foreign import supply elasticity} \tag{A.8}$$

$$\eta_m \equiv -\frac{\Delta M}{M} \Big/ \frac{\Delta p_{hm}}{p_{hm}} \qquad \text{Home import demand elasticity} \tag{A.9}$$

Since foreign currency and home currency prices are related by the exchange rate, r we have:

$$p_{fm} \equiv p_{hm} r \tag{A.10}$$

Assuming that the home currency is depreciated by some proportion, k, then the home currency is worth $r(1-k)$ units of foreign currency. Then the corresponding price changes can be written as :

$$p_{fm} + \Delta p_{fm} = (p_{hm} + \Delta p_{hm}) r (1-k) \tag{A.11}$$

$$\Delta p_{fm} = (p_{hm} + \Delta p_{hm}) r (1-k) - p_{hm} r \tag{A.12}$$

$$\Delta p_{fm} = p_{hm} r - p_{hm} rk + \Delta p_{hm} r - \Delta p_{hm} rk - p_{hm} r \tag{A.13}$$

$$\Delta p_{fm} = -p_{hm} rk + \Delta p_{hm} r - \Delta p_{hm} rk \tag{A.14}$$

$$\frac{\Delta p_{fm}}{p_{fm}} = -k + \frac{\Delta p_{hm}}{p_{hm}}(1-k) \tag{A.15}$$

$$\frac{\Delta p_{fx}}{p_{fx}} = -k + \frac{\Delta p_{hx}}{p_{hx}}(1-k) \tag{A.16}$$

Using the elasticity definitions given in (A.6)-(A.9) and substituting into equations (A.15) and (A.16) yields the following:

$$\frac{\Delta X}{X} = e_x \frac{\Delta p_{hx}}{p_{hx}} \tag{A.17}$$

$$\frac{\Delta X}{X} = \frac{e_x \left(\frac{\Delta p_{hx}}{p_{hx}} + k \right)}{(1-k)} \tag{A.18}$$

$$\frac{\Delta X}{X} = e_x \frac{\left(-\frac{\Delta X}{X} \right)}{(1-k)\eta_x} + e_x \frac{k}{(1-k)} \tag{A.19}$$

$$\frac{\Delta X}{X}=\frac{e_x\dfrac{k}{(1-k)}}{1+\dfrac{e_x}{(1-k)\eta_x}} \qquad \text{(A.20)}$$

$$\frac{\Delta X}{X}=\frac{ke_x\eta_x}{e_x+(1-k)\eta_x} \qquad \text{(A.21)}$$

$$\frac{\Delta p_{fx}}{p_{fx}}=-\frac{ke_x}{e_x+(1-k)\eta_x} \qquad \text{(A.22)}$$

$$\frac{\Delta M}{M}=\frac{ke_m\eta_m}{\eta_m+e_m(1-k)} \qquad \text{(A.23)}$$

$$\frac{\Delta p_{fm}}{p_{fm}}=\frac{k\eta_m}{\eta_m+e_m(1-k)} \qquad \text{(A.24)}$$

Substituting equations (A.21)-(A.24) into equation (A.5) expresses the change in the foreign currency value of the trade balance in terms of demand and supply elasticities.

$$\Delta B_f=k\left[V_{fx}\frac{e_x(\eta_x-1)}{e_x+\eta_x(1-k)}+V_{fm}\frac{\eta_m(e_m+1)}{\eta_m+e_m(1-k)}\right] \qquad \text{(A.25)}$$

assuming that the proportion of the depreciation, k is small then:

$$\Delta B_f=V_{fx}\frac{\eta_x-1}{1+(\eta_x/e_x)}+V_{fm}\frac{\eta_m[1+(1/e_m)]}{(\eta_m/e_m)+1} \qquad \text{(A.26)}$$

I. This is generally referred to as the Bickerdike-Robinson-Metzler condition, herein (BRM). If prices are fixed in seller's currencies, then the supply elasticities are infinitely elastic, which is expressed in equation (A.27).

$$e_x=e_m=\infty \qquad \text{(A.27)}$$

Then we have:

$$\Delta B_f = V_{fx}(\eta_x - 1) + V_{fm}(\eta_m) \tag{A.28}$$

Furthermore if we assume that trade was initially balanced so that the foreign currency value of exports equals the foreign currency value of imports then we have equation (A.29).

$$V_{fx} / V_{fm} = 1 \tag{A.29}$$

Then the foreign currency value of the trade balance improves

$$\Delta B_f > 0 \tag{A.30}$$

if the sum of the import and export demand elasticities is greater than unity

$$\eta_x + \eta_m > 1 \tag{A.31}$$

This is known generally as the Marshall-Lerner condition, herein (M-L). It may be of additional value if the assumption of initially balanced trade, made in equation (A.29), is relaxed. First we will consider the case where the trade balance is in surplus. So:

$$V_{fx} / V_{fm} > 1 \tag{A.32}$$

Then the foreign currency value of the trade balance improves

$$\Delta B_f > 0 \tag{A.33}$$

if the sum of the export demand elasticity and the "weighted" import demand elasticity are greater than unity, where the weight is the foreign currency value of imports divided by the foreign currency value of exports.

$$\eta_x + \frac{V_{fm}}{V_{fx}} \eta_m > 1 \tag{A.34}$$

It can be seen that when the trade balance is in surplus the M-L condition is no longer a sufficient condition. If we turn to the final case where there is a trade deficit initially, we have:

$$V_{fx} \big/ V_{fm} < 1 \qquad \text{(A.35)}$$

then:

$$\Delta B_f > 0 \qquad \text{(A.36)}$$

if

$$\eta_x + \frac{V_{fm}}{V_{fx}} \eta_m > 1 \qquad \text{(A.34)}$$

Now the M-L condition becomes a sufficient and not a necessary condition, as the "weighted" import demand elasticity can be much smaller and still insure an improvement in the trade balance. This is one explanation for the different findings in the J-curve literature. The M-L condition is more stringent then necessary to insure a depreciation improves the trade balance.

Appendix B: Data Sources

All data are quarterly covering the period from 1973:I - 1996:II. The log of real GDP for the US is LY_{us}, and it has been converted to index form where the base is 1990:I. The log of real GDP for each of the remaining countries is LY_i where i denotes the country. These variables are also in index form with the base year 1990:I. The data, except Germany's real GDP, come from *International Financial Statistics of the International Monetary Fund, CD- ROM*. The GDP data for Germany come from the *OECD Economic Indicators.*

The real bilateral exchange rate, $LREX_i$, is the log of the average nominal exchange in country i’s currency units per dollar, multiplied by the ratio of the US GDP deflator to country i’s GDP deflator. The GDP deflators are calculated from the nominal and real GDP's for each country found in the International Financial Statistics CD-ROM. The nominal bilateral exchange rate, is the average spot rate for the quarter, as reported in the IFS CD-ROM.

The log of US imports, LM_i, is the log of nominal US imports from country i divided by the unit value price index of imports for the US. Similarly the log of US exports, LX_i, is the log of nominal exports to country i divided by the unit value price index of exports for the US. The unit value price indices come from the IFS CD-ROM, and the trade data come from the *Direction of Trade Statistics of the International Monetary Fund*, various issues.

There are several sources of concern or rather caution about the data. One source involves the unit value index for imports and exports used to deflate the nominal trade. They potentially introduce a source of error since these indices are calculated based on aggregate trade and not bilateral trade. If bilateral trade is commodity specific, we might not accurately be capturing real quantity changes when deflating the nominal data. Leamer and Stern (1970) also point to the potential problems when using unit value indices rather then price indices.

VITA

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