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Analysis of Import Demand for Lightweight Thermal Paper in the United States

Fan Zhang

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By

Fan Zhang

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By

Fan Zhang

Approved:

_____

Changyou Sun
(Major Professor)

_____

Robert K. Grala
(Committee Member)

_____

James E. Henderson
(Committee Member)

_____

Andrew W. Ezell
(Graduate Coordinator)

_____

George M. Hopper
Dean
College of Forest Resources

Name: Fan Zhang

Date of Degree: August 15, 2014

Institution: Mississippi State University

Major Field: Forestry

Major Professor: Changyou Sun

Title of Study: Analysis of import demand for lightweight thermal paper in the United States

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Candidate for Degree of Master of Science

Lightweight thermal paper (LWTP) is a noteworthy import commodity with wide usage and large import value in the United States. In this study, the trade pattern and market dynamics of the LWTP import market in the U.S. has been examined based on almost ideal demand system. The results revealed that both the trade volume and import source of LWTP had changed during last decade. Competition relationships were found among major suppliers in both the short run and long run, and the long-run competition is stronger than that in the short run. The repeal of restriction on conducting countervailing investigation against non-market economy temporarily stimulated the import of LWTP products from China, but the following antidumping/countervailing investigation and the corresponding punitive duties generated trade depression effect on the imports. In addition, positive trade diversion effect was found on German products, which raises doubt on the effectiveness of this trade remedy policy.

DEDICATION

I dedicate this study to my family.

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CHAPTER I

INTRODUCTION

The paper manufacturing industry is one of the important sectors in the U.S. forest products industry (Sun and Zhang, 2006). Compared to other sectors of forest products industry which include logging, wood product manufacturing, and furniture and related manufacturing, the paper manufacturing industry takes a leading role in both employment and total value of shipments. In 2011, the employment of paper manufacturing industry in the United States exceeded 345 thousand and the total value of shipments reached 175 billion U.S. dollars (U. S. Bureau of Census, 2011). However, although the U.S. paper manufacturing industry is so strong, the huge consumption of paper products in the U.S. is supplied by not only domestic suppliers but also many foreign ones.

The lightweight thermal paper (LWTP) product is a type of paper products with a basis weight of 70 g/m^2 or less, and has thermal active coating on one or both sides. Typically, LWTP can be used in point-of-sale applications such as credit card receipts, gas pump receipts, and retail store receipts. In the U.S., a large portion of the LWTP products consumption is met by imported products. For instance, based on the total value of shipments, the percentage of imported LWTP products in total U.S. domestic consumption is 30.91% in 2007, and the ratio between imports and domestic value of shipments is 44.73% in the same year (U.S. ITC., 2008). During last decade, the import

of LWTP products has been increased greatly in the U.S. In detail, the annual total import value of LWTP products in the U.S. increased from 160 million U.S. dollars to more than 350 million U.S. dollars in 2012. Besides the large increase in import value, the suppliers in the import market of the United States have also changed. Among traditional major suppliers, Japan and United Kingdom lost most of their market shares to Germany. China has also emerged as a new power and finally become the second largest supplier in this market during this period. Obviously, the fast increases of LWTP products imported from Germany and China generated great pressure to U.S. domestic LWTP manufacturers. Therefore, as an response to the increasing LWTP import from China and Germany, an antidumping/countervailing (AD/CVD) investigation against Chinese and German LWTP manufacturers was conducted in 2007, and various AD and CVD duties were imposed to subject products eventually in late November 2008.

The change of trade pattern of imported LWTP products in the U.S. indicates that the import demand of LWTP products in the U.S. has been affected by various factors such as competition, consumer behavior, and trade remedy policy and corresponding trade remedy measures. However, no study has been conducted in terms of the mechanism of how those factors affect the import demand of LWTP products in the U.S., which is an interesting topic that merits a detailed analysis.

Driven by the motivation to fill this knowledge gap, the overall objective of this study is to assess the growing import demand of LWTP products in the U.S. from January 2002 to June 2013 by source, and to examine the mechanism of how this import demand has been affected by relevant economic and non-economic factors. Thus, both static and dynamic specifications of the Almost Ideal Demand System (AIDS) are used to

access the results in the long run and short run, respectively. In detail, the dynamic AIDS model is constructed with techniques from time series econometrics (Enders, 2008), the Engle-Granger two-stage method has been adopted to conduct the cointegration analysis and evaluate the long run equilibrium for each supplier in this market. The product scope is determined under the Harmonized Tariff Schedule (HTS) classification system (U.S. ITC., 2013). Monthly import price and quantity of LWTP products for five major supplying countries from January 2002 to June 2013 is collected from the online data base of U.S. ITC. (2013).

In this study, the main reasons for using AIDS model as the base model are its feature as a consumer dimension model (Yang and Koo, 1994) and wide applications in evaluating market competition and import demand (Henneberry and Mutondo, 2009). Based on the AIDS model, both the economic and non-economic factors affecting this market are examined. In terms of the effects from economic factors, consumer behavior and market competition in this market are examined in this study. At first, the effects from expenditures and own-prices are examined to reveal the consumer behavior related to imported LWTP products in the U.S. Five supplying countries which take more than 85% market shares in total are considered as the major choices that U.S. consumers have. Expenditure and Marshallian own-price elasticities are calculated to evaluate the consumer choices over the different supplying countries. In this case, the results in terms of consumer behaviors become more informative by differentiating them by time-range, (i.e. short run and long run). Other than the consumer behavior, market competition among major supplier of LWTP products in the U.S. import market is measured by analyzing the calculated Hicksian cross-price elasticity (Deaton and Muellbauer, 1980).

From the estimates of cross-price elasticity, the substitutability and complement relationship between major suppliers are revealed (Feleke and Kilmer, 2007). Overall, various elasticities are calculated to examine the mechanism of how economic factors affect the import demand of LWTP products in the U.S.

Furthermore, in terms of the non-economic factors, the repeal of restriction on countervailing (CVD) investigation against Non-market economy (NME) on March 2007 and the following antidumping/countervailing (AD/CVD) investigation against LWTP products from China and Germany are considered as the two major events which affecting the import demand of LWTP products in the U.S. At first, the CVD investigation policy change was announced in the preliminary determination of the investigation against Coated Free Sheet Paper from China on March 2007 (U.S. ITC., 2007). This affirmative determination dramatically increased the possibility of being investigated for the products imported from China, especially for the paper products. This event is supposed to affect the import of LWTP products from China since importers in the U.S. may adjust their strategies of importing Chinese LWTP products in case of the possible investigation and punitive duties in the future. On the other hand, since some types of Coated Free Sheet Paper is similar to LWTP, they may be imported under the HTS classification of LWTP to avoid the punitive tariff temporally (U.S. ITC., 2007).

Other than the investigation policy change, the effects from the AD/CVD investigation six months after this policy change also need to be evaluated. As common offset measures, the AD/CVD duties are imposed to protect domestic industry by offsetting the “unfair low price” and the government subsidy given by the subject country. In general, the impositions of AD and CVD duty on a commodity have similar

outcomes of decreased import quantity from subject countries (Kelly, 2011). However, due to the flexible strategies that can be used by market participants, this duty effect may not be attainable (Staiger and Wolak, 1994). Additionally, other than the imposition of duty, the development of the investigation per se generates an impact on the import demand of a commodity due to the length of an investigation, which can be as long as 18 months. Thus, the investigation effect and the duty effect need to be evaluated together (Lloyd et al., 1998). In this study, the AD/CVD investigation has lasted for 15 months and experienced several stages. Thus, dummy variables representing three key time points are set and estimated to evaluate the effects from them. The empirical findings of the effectiveness of the U.S. trade policy for the LWTP products on the import market from this study are supposed to be informative to the policy makers and market participants, in either the supplying countries of LWTP products or the U.S. per se.

The rest of this thesis is organized as follows. An overview of the import market, relevant trade policy, and AD/CVD investigation is presented in Chapter 2. Then the detailed methodology adopted by this study is displayed in Chapter 3. The descriptions of data source and variables need to estimate are presented in Chapter 4. At last, the empirical findings are reported in Chapter 5, and conclusions and discussions are showed in Chapter 6.

CHAPTER II

OVERVIEW OF MARKET, INVESTIGATION, AND RELEVANT POLICY

2.1 Market Overview

As required materials for thermal printers which are widely used in printing receipts, the lightweight thermal paper (LWTP) products are commonly used in almost every point of sale (POS) and gas stations all over the U.S. Due to the vast demand, import of LWTP products in the U.S. has experienced a significant increase in recent years. In detail, the import value of LWTP products in the U.S. has increased from 160 million U.S. dollars in 2002 to 350 million U.S. dollars in 2012. Other than the increase in trading value, the pattern of import sources has also shifted.

Historically, the major suppliers of lightweight thermal paper in the U.S. import market are Germany, Japan, and United Kingdom. According to the detailed data reported in Table 2.1, in 2002, each of these three countries took more than 10% market share and totally took 79.58% of the market share. By ranking of import value, the first three major suppliers were Germany (62.21 million U.S. dollars), Japan (49.12 million U.S. dollars), and United Kingdom (16.34 U.S. dollars), which accounted for 38.78%, 30.62%, and 10.18% of the market share, respectively. However, in 2012, the first three major suppliers were Germany (170.68 million U.S. dollars), China (70.86 million U.S. dollars), and Japan (43.00 million U.S. dollars), and corresponding market share were 48.92%, 20.31%, and 12.31%. United Kingdom, which was the third largest supplier in

the market in 2002, only left 2.69% of the total market share and no longer existed among the top three suppliers in 2012. Similarly, even though the trade value appears steady, the market share of Japan also dropped dramatically. In contrast, with rapid growth during 2002 to 2012, Germany consolidated its position as the largest supplier of LWTP products in the U.S. import market. Specifically, the import value of LWTP products from Germany was 62.21 million U.S. dollars in 2002, but it increased to 170.7 million dollars in 2012, and the market share of German imported LWTP products in the U.S. also increased from 38.78% to 48.90% accordingly.

Table 2.1 Comparison of the U.S. LWTP Import Market in 2002 and 2012.

Country	Import Value ($ million)	Market Share	Ranking
2002			
Canada	4.66	2.90%	5th
China	2.82	1.76%	6th
Germany	62.21	38.78%	1st
Japan	49.12	30.62%	2nd
United Kingdom	16.34	10.18%	3rd
2012			
Canada	24.51	7.01%	4th
China	70.86	20.31%	2nd
Germany	170.68	48.92%	1st
Japan	43.00	12.31%	3rd
United Kingdom	9.43	2.69%	7th

Note: All values were the import cost-insurance-freight values of the lightweight thermal paper products with HTS code 4811.90.80. Source: U.S. ITC (2013).

Other than Germany, China is another country which gained great increase in this market. The market share of Chinese LWTP products in the U.S. increased from only 1.76% in 2002 to 20.31% in 2010. After a 15-year long journey started from 1986, China eventually joined the World Trade Organization (WTO) in December 11, 2001. Since then, as policy restrictions were released gradually, Chinese companies started to get

deeply involved in the international trade. Likewise, China began to increase its export of LWTP products to the U.S. since 2002, especially during the period between 2002 and 2004. Specifically, the import value of Chinese lightweight thermal paper was 2.82 million U.S. dollars in 2002, but during the study period this value boosted to a peak during study period of 97.95 million U.S. dollars in 2004, which has increased more than 30 times. Since then, even though there remained some fluctuations, China was always among the top three suppliers of lightweight thermal paper products in the U.S. Compared to China, the growth of Germany was more steady. Before reaching the peak of 184.5 million U.S. dollars import value in 2008, the average growth rate of the U.S. import value of German lightweight thermal paper was 25%. Specifically, Germany had displaced Japan as the largest supplier on the U.S. imported lightweight thermal paper market since 1999, and its market share exceeded 50% in 2008 (52.6%) for the first time. After that, the market share of Germany had decreased a little to 47.7% (in 2010), but it remained the largest foreign supplier of lightweight thermal paper product in the U.S. market until the end of study period. Overall, some traditional major suppliers such as Japan, Canada, and United Kingdom lost considerable market share, and this part of demand has been met by some emerging countries in this market (i.e. Germany and China). The trade pattern during study period is reported in Figure 2.1.

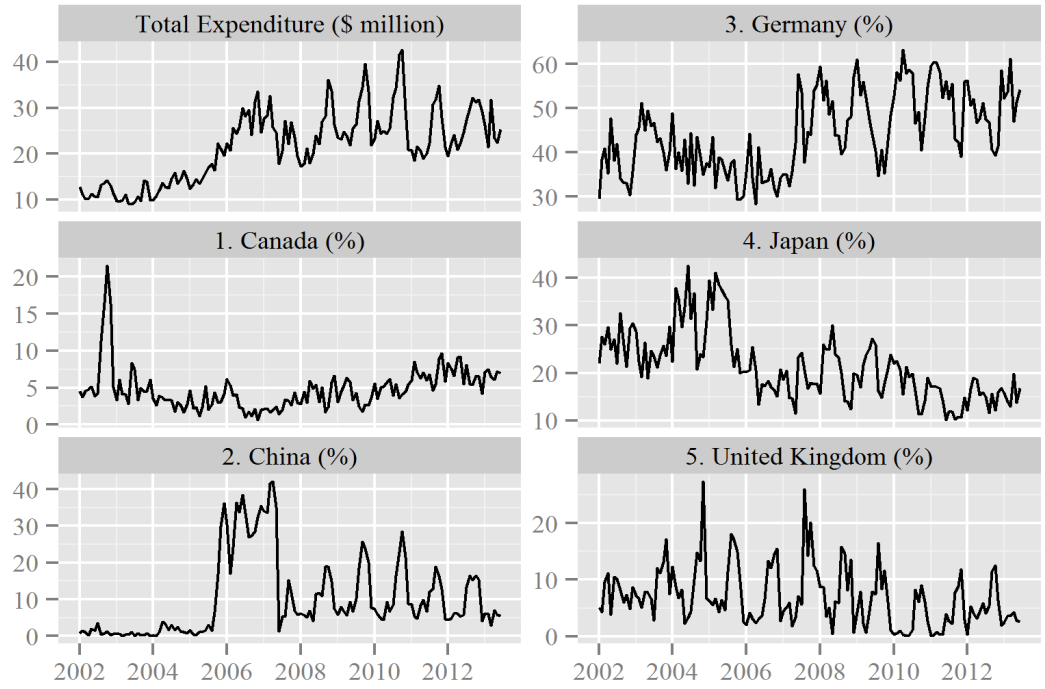

Figure 2.1 Monthly Total Expenditure of Imported LWTP in the U.S. and the Import Share by Country from January 2002 to June 2013.

2.2 Overview of Antidumping and Countervailing (AD/CVD) Investigation and Relevant Policies

Except the market per se, change has also taken place on the trade policy level, especially with regards to the protective trade policy toward some non-market economies (NMEs) such as China. Before discussing the detail of trade policy change, it is necessary to briefly summarize the concept and development of relevant policies and trade remedy measures.

In general, a variety of measures are used by nations to protect their domestic industry from the pressures of foreign competitors. Although most of them were claimed by the economists as inefficient (Blonigen and Prusa, 2003) or unjustified (Deardorff and

Stern, 2005), antidumping and countervailing (AD/CVD) duties are the most commonly used due to their special political status. In general, the AD/CVD duties are viewed as the measures which are able to correct unfair market competition by offsetting the unfair price margin and subsidization but without creating distortion in trade (Kelly, 2011). From the perspective of mechanism, countervailing duties are imposed in response to subsidies, while antidumping (AD) duties are imposed in response to "dumping", which means selling products in a foreign market at less than "fair" value (LTFV). Once the named category of imported products has been determined to be sold at LTFV in the U.S. market, such products can be subject to a punitive AD duty. Likewise, if certain imported products are found to receive a subsidy from foreign governments and materially injure or threaten the domestic industry, this product will be subject to the CVD duty. Accordingly, the punitive tariff rate will be calculated based on the margin of underselling or margin of subsidy, and expected to offset the effect of dumping or subsidization, respectively.

Theoretically speaking, the AD and CVD investigation can be conducted against any countries and these two measures have similar effects. Similarly, according to the WTO agreement, AD and CVD actions against the same set of products from the same country are permitted to be conducted simultaneously. However, during the time period between 1980 and 2007, the U.S. Department of Commerce determined that they could neither identify nor measure grants or subsides in non-market economies (NMEs). In this case, the subsidies to producer in an NME country were not countervailable because the purpose of the countervailing duty is to offset the unfair competitive advantage that foreign producers received from government subsidies (Prusa and Vermulst, 2013).

In detail, in a typical "non-market economy" country, the companies which export products are controlled or operated by the government per se, and thus the subsides were considered to be impossible to exist (Durling and Prusa, 2013). Starting in 2007, the U.S. Department of Commerce changed this policy and began to argue that a firm or industry may be viewed as "market oriented" within an NME and China was considered as the leading example in this practice. On April 9, 2007, in the Department of Commerce's preliminary countervailing duty determination for China, amended (72 FR 17484), the U.S. government officially made an affirmative determination on the countervailing duty against a NME country (China), and repealed the restriction of carrying out countervailing investigation against NME countries since then (U.S. ITC., 2007). This policy change provided another possible trade offsetting measure to Chinese products and affects the initiation of relevant investigation cases greatly. Till June 2013, since the announcement of this policy change, 28 out of 37 following AD investigations against Chinese products are filed with CVD investigations simultaneously. Obviously, this new policy stimulated American companies to initiate more countervailing duty investigation against China and put Chinese products on the volcano of being investigated, which may have generated an impact on the import pattern of either named commodity or related commodities.

2.3 The AD/CVD Investigation against LWTP Products from China and Germany

The large increase in imports from China and Germany, along with the new policy, has resulted in strong reaction among the domestic lightweight thermal paper manufacturers. Six months after the policy change, on September 19, 2007, Appleton

Paper, Inc. (“Appleton”), a U.S. domestic producer of LWTP, filed a petition in the investigation. This petition claimed that the imports of certain LWTP products from China and Germany were sold at “less than fair value (LTFV)”, and that imports of certain lightweight thermal paper from China were subsidized by the Chinese government. During the hearing stage, Kanzaki Specialty Papers, Inc. (“Kanzaki”) also appeared in support of imposition of duties. These two companies (Appleton and Kanzaki) account for all U.S. production of jumbo roll lightweight thermal paper. Besides, this petition was also supported by another 20 U.S. firms that convert jumbo rolls of LWTP into slit rolls of the product. These 20 firms account for 62.1 of the conversion activities in the U.S. in 2007 (U.S. ITC., 2008). In contrast, there were only two Chinese firms (Paper Resources, LLC, and Shanghai Hanhong Paper Co., Ltd.), and one German firm (Koehler AG Inc.) that responded to the investigation.

This AD/CVD investigation was following the typical investigation process according to U.S. Laws. However, although the results of both investigations were released at almost the same time, the AD and CVD investigations were conducted separately. Major events within this investigation include the petition filed on September 2007, the affirmative preliminary determination on December 2007, and the final imposition of duties on November 10, 2008. Based on the results collected during the period of investigation (July 1, 2006 to June 30, 2007), several conclusions had been reached through this investigation by the U.S. ITC. (2008). Both in absolute terms and relative to consumption in the U.S., the volume of subject imports was considered to be very large (U.S. ITC., 2008). Beside, even the products from Germany and China were not functionally interchangeable, and both of them have a very high substitutability with

relative U.S. domestic products. Therefore, price was the critical factors for U.S. consumers in decision-making. Additionally, the capacity utilization had been found to decrease 5.1%, and the value of operation loss for the whole U.S. domestic industry was 11.9 million U.S. dollars during the period of investigation. Therefore, the department of Commerce and the U.S. ITC concluded that the U.S. domestic lightweight thermal paper industry was materially injured, or threatened with materially injury, by reason that the imports of certain lightweight thermal paper from China and Germany which were sold at LTFV and the Chinese products were subsidized.

Based on the degree of injury to the U.S. domestic industry, the final duty rates vary by country and category. Since Koehler was the only supplier of German lightweight thermal paper in the U.S., the AD duty rate for the German firm was set at 6.50%. However, the AD duty rate for Chinese firms ranged from 19.77% to 115.29%, and CVD duties ranged from 13.17% to 137.25%. The imposition of duties affected not only the imports from China and Germany but the whole market of imported LWTP products in U.S.

Overall, the market dynamics of imported LWTP products in the U.S. raised interesting questions with regard to the consumer preference, competition among suppliers, and relevant policy effects. In addition, due to the features of this product, the development of U.S. imported lightweight thermal paper market also provide a great opportunity to conduct empirical research on these questions by using a demand system, such as Almost Ideal Demand System (AIDS).

CHAPTER III

METHDOLOGY

In this study, both static and dynamic Almost Ideal Demand Systems (AIDS) are used to analyze the consumer demand over LWTP products from various sources in the U.S. To achieve this goal, the mechanism of how the trade pattern of U.S. imported lightweight thermal paper (LWTP) can be affected by economic factors and non-economics factors is examined. Specifically, economic factors include price and total expenditure; non-economic factors include the antidumping/countervailing (AD/CVD) investigation and relevant investigation policy change in 2007. Accordingly, the effects from economic factors are measured by various calculated elasticities, and those from non-economic factors are measured by dummy variables representing those events. What's more, other than those factors outside the market, the error terms in dynamic models are used to reveal the self-adjust mechanism of the market per se.

3.1 Rationale and Application of Almost Ideal Demand System (AIDS)

As a representative consumer theory based demand system, Almost Ideal Demand System (AIDS) was first derived by Deaton and Muellbauer (1980) under the assumption of maximized consumer utility, and can be considered as the most common specification of demand systems since the 1990s (Karagiannis et al., 2000). The popularity of AIDS model comes from several inherent advantages of this model. First of all, it provides an

arbitrary first-order approximation of any demand system and allows aggregation over consumers without maintaining homothetic preferences. Therefore, theoretic properties of homogeneity and symmetry can be imposed and tested via linear restrictions on parameters (Wan et al., 2010). Moreover, AIDS has a functional form which can be linearly approximated to enable a relatively easy estimation. In additional, AIDS model can be applied combining with error correction techniques (Engle and Granger, 1987) to construct a dynamic AIDS model. This dynamic model takes the time-series properties of data into consideration and can reveal the market dynamics in the short run.

The linearization of price index remains a hot topic in model specification of AIDS model. Derived from price-independent generalized logarithm (PIGLOG) expenditure function, the original form of AIDS has a problem of nonlinearity-in-the-parameter which was caused by existence of the translog price index on the right hand side of the function. Thus, in many cases economists have used a linear price index to approximate the real price index. Deaton and Muellbauer (1980) recommended using the Stone price index to replace the original translog price index. Although there remains a problem of simultaneity because either right or left side of the model has the budget share parameter (Eales and Unnevehr, 1994), this approximation won't cause any problems in either model specification or estimation. Indeed, many studies revealed that the demand elasticities derived from the linearized AIDS are able to approximate the "true" elasticities perfectly (Alston et al., 1990; Buse, 1994; Chen, 1998). Therefore, in this study, the Stone price index is used to replace the real price index.

Another problem that merits more attention is the incorporation of dynamic factors in the AIDS model. According to the economic theory, the consumer behavior can

be considered as always in equilibrium in the long run. In this case, the static model is enough to generate reliable results, and valid to be estimated by conventional regression methods such as Ordinary Least Square (OLS). However, in the short run, many factors such as consumer habit persistence, imperfect information, and incorrect expectation will lead to the problem of "out of equilibrium" until a full adjustment has been imposed (Anderson and Blundell, 1983). This means that assumptions of static AIDS model no longer exist in short run. In this case, the static AIDS model is not reliable enough due to lack of dynamic elements (Chambers and Nowman, 1997). Moreover, due to the properties of time-series data, directly using conventional regression methods to estimate a model with non-stationary time-series data set would lead to a spurious regression and biased results.

To overcome these shortages of the static AIDS model, the concept of cointegration was introduced into the AIDS model by Balcombe and Davis (1996) for the first time. Since then, the error-correction of almost ideal demand system (EC-AIDS) or dynamic AIDS has been developed and widely adopted in recent years. For example, Karagiannis et al. (2000) presented an empirical study based on error-correction AIDS models and estimated the demand elasticities of various meats in Greece, both in short run and long run. Gil et al. (2004) analyzed the import demand for virgin olive oil in the European Union by imposing dynamic technologies upon a linearized AIDS model. Additionally, in the forest economics area, a study conducted by Wan et al. (2010) is a representative study conducted with EC-AIDS model. In which paper, the static and dynamic AIDS models were imposed together to access the import demand for wooden beds in the U.S. in the long run and short run, respectively. In general, in most of the

relevant studies concerning dynamic econometrics, both short run and long run conditions have been analyzed and reported together because the residuals from the long run static model need to be imported into the short run dynamic model to serve as error-correction terms.

3.2 The Static Model

The static form of AIDS model in this study can be presented as follows:

$$w_{it} = \alpha_i^s + \beta_i^s \ln\left({m_t}/{P_t^*}\right) + \sum_{j=1}^{N} \gamma_{ij}^s \ln p_{jt} + \sum_{k=1}^{K} \varphi_{ik}^s D_{kt} + \sum_{h=1}^{H} Q_{ih} q_{ht} + u_{it} \qquad (3.1)$$

where w_{it} is the budget share for country *i* in time period *t*; m_t is the total expenditure for imported LWTP in time *t*; P_t^* refers to the Stone price index in time *t*; p_{jt} refers to the average unit price of LWTP from source *j* in time *t*; D_{kt} represent the policy dummy variables imposed in the model. Q_{ih} denote the seasonality dummy variables in quarter. u_{it} is the disturbance terms, and α_i^s, β_i^s, γ_{ij}^s, and φ_{ik}^s are parameters, the superscripts *s* denotes static AIDS model. In this study, *i* and *j* represent the name of source from 1 to 6 (five countries plus the rest of world as a whole supplier), but *j* is different from *i* because it is specially set for unit price variables. Furthermore, the range of *t* is from 1 to 138 (monthly data from January 2002 to June 2013), the range of *k* is from 1 to 4 (One policy change dummy variable plus three investigation dummy variables), and the range of *h* is from 1 to 3 to represent the seasonal effect from the first three quarter of a year.

In terms of the definition of variables, the total expenditure m_t is defined as the sum of the product of price and quantity from each source: $m_t = \sum_{i=1}^{N} p_{it}\, q_{it}$, in which q

is the quantity of LWTP in *kg*. In addition, the stone price index is calculated as $\ln P_t^* = \sum_{j=1}^{N} w_{jt} \ln p_{jt}$.

To be consistent with economic theory, some constraints need to be applied on the static AIDS system, which includes:

(1) Adding-up: $\sum_{i=1}^{N} \alpha_i = 1, \sum_{i=1}^{N} \beta_i^s = 0, \sum_{i=1}^{N} \gamma_{ij}^s = 0, \sum_{i=1}^{N} \varphi_{ij}^s = 0$, those restrictions indicate that the total expenditures must equal to the sum of expenditures on all the goods.

(2) Homogeneity: $\sum_{j=1}^{N} \gamma_{ij}^s = 0$, which means demands are homogenous of degree of 0 in price and income.

(3) Symmetry: $\gamma_{ij}^s = \gamma_{ji}^s$, which means the system satisfies Slutsky symmetry.

During the estimation process, restrictions (1) can be satisfied by dropping one equation (Feleke and Kilmer, 2007), and restriction (2) and (3) are imposed through likelihood ratio tests (Wan et al., 2010).

3.3 The Dynamic Model

The static AIDS model assumes that the consumer behavior is considered to be always in equilibrium. In long run condition, this assumption is true. However, when it comes to the short run condition, this consumer equilibrium will no longer exist and the static model would be inaccurate to represent the reality. Moreover, there is a high possibility of non-stationary for time-series data, which means using conventional estimation technologies would become inappropriate. Therefore, deployment of dynamic econometrics is required in this situation.

Engle and Granger (1987) proved that once all variables in consideration are cointegrated, an error-correction model can be established. This can be used in analyzing short run market behavior. Therefore, the first step of dynamic AIDS is to ensure if the cointegration relationship exists by imposing a cointegration test. Generally speaking, Engle-Granger two-stage approach and Johansen approach (Johansen, 1988) are two most common cointegration analysis methods. Specifically, the Engle-Granger two-stage approach focusing on the time-series property of the residuals from the static model is relatively easy to carry out (Enders, 2008), whereas the Johansen approach is concentrating on the relationship between the rank of matrix and its characteristic roots in a vector auto-regression system, and is good at handling multiple cointegration relationships. According to previous research, for an auto regression system with a moderate number of observations, the Johansen approach is only able to reach convergence for systems with no more than three groups (usually countries in trade research) and can handle no more than four commodities (Kaabia et al., 2001). Since the proposed study is an analysis of competition between different suppliers of single commodity, the Engel-Granger approach is more suitable than the Johansen approach in imposing cointegration test because it can handle more import sources.

The Engel-Granger approach starts by checking the stationarity of the data used in the static model. Augmented Dickey-Fuller (ADF) test is conducted in this study to serve as the unit root test to examine if the data is stationary. Specifically, in order to eliminate the possible serial correlation problem in the regression residuals, the start number of lags in the ADF test is chosen following the method provided by Schwert (1989), and the actual lags used are selected according to the Akaike Information Criterion (AIC) in this

study. If these variables are found to be integrated in the same order, a cointegration test should be used to check whether the residual terms collected from the static model are stationary. Once stationarity in residuals is confirmed, the long run equilibrium and cointegration relationship are proved to be exist (Karagiannis and Mergos, 2002), and the error-correction model (ECM) can be constructed by importing residuals from the static model as the error-correction terms.

The dynamic form of AIDS model used in this study is showed as follow:

$$\Delta w_{it} = \psi_i \Delta w_{i,t-1} + \lambda_i \hat{u}_{i,t-1} + \beta_i^d \Delta \ln\left({m_t}/{P_t^*}\right) + \sum_{j=1}^{N} \gamma_{ij}^d \Delta \ln p_{jt} + \sum_{k=1}^{K} \varphi_{ik}^d D_{kt} + \sum_{h=1}^{H} Q_{ih} q_{ht} + \xi_{it} \quad (3.2)$$

where Δ denotes the first difference of certain variable, $\hat{u}$ is the residual imported from the static AIDS model to serve as the error-correction term. All other variables have same definitions as the static model. Other than β, γ, and φ, there are other two parameters, i.e. ψ and λ, need to be estimated in dynamic model. Accordingly, ψ indicates the relationship between current consumption and past consumption, thus the consumer behavior can be assessed by determining the sign of this variable. Usually, this sign is expected to be negative for durable goods and positive for nondurable goods. The parameter λ measures the speed of adjustment backing to equilibrium in the short run. Moreover, similar to static model, the superscript *d* here in this specification indicates that they are parameters in dynamic model. What's more, dynamic AIDS also need to satisfy the theoretical restrictions of adding-up, homogeneity, and symmetry as well as the static model. The requirement of adding-up is fulfilled by dropping the "rest of world" equation, the homogeneity and symmetry restriction are imposed on the

parameters and then tested by likelihood ratio tests.

3.4 Estimation and Diagnostic Tests

In this study, both the static and dynamic AIDS models are estimated by the seemingly unrelated regression (SUR) using software R (R Develop Core Team, 2013). The SUR adjusts for cross-equation contemporaneous correlation and consequently takes the optimization process behind the demand system into account (Karagiannis et al., 2000). Six suppliers including five major countries exporting LWTP to the U.S. and the rest of world as one single group ("ROW") are incorporated in this system, but the rest of world group was dropped during the estimation process for the purpose of imposing the adding-up restriction.

Since the left hand side of AIDS model is constructed by using budget share which may correlated with the expenditure term, a problem that commonly comes with the AIDS model is endogeneity of the expenditure terms (LaFrance, 1991). Once the expenditure terms are correlated with the error terms, estimates of AIDS models will be biased and inconsistent. Therefore, an endogeneity test must be performed to determine whether the expenditure terms are exogenous in the model, and the Durbin-Wu-Hausman test is often adopted to conduct this test (Henneberry et al., 1999). An auxiliary regression was run as the first step of this test, which regressing the expenditure term on a set of instrumental variables. In this study, the instrumental variables include personal consumption expenditures for nondurable goods in the U.S., the first difference of expenditure term, and the import price variables by source. Then the residuals of this auxiliary regression were included in the static AIDS model as an additional explanatory variable in each equation. Afterward, a likelihood ratio test is imposed to test the null

hypothesis that whether the parameters of the residuals are jointly equal to zero. If this null hypothesis can be rejected, the residual term is confirmed to be correlated with the expenditure term and the endogeneity problem exists in the model. In this case, the endogeneity problem is corrected by replacing the real total expenditure terms with the predicted value from the auxiliary regression.

In addition, several diagnostic tests are adopted on both static and dynamic models to assess the adequacy of the model specification (Shukur, 2002). Specifically, the Breusch-Godfrey (BG) test is adopted to test the hypothesis of no serial correlation in the variables (Edgerton and Shukur, 1999). The heteroskedasticity is examined by the Breusch-Pagan (BP) test (Holgersson and Shukur, 2004). The functional misspecifications are examined by Ramsey's Regression Specification Error Test (RESET) (Shukur and Edgerton, 2002). Finally, the normality of error term is tested by Jarque-Bera (JB) LM test (Holgersson and Shukur, 2001).

3.5 Demand Elasticities

To examine the effect from economic factors, various elasticities are calculated both in static and dynamic models. In this study, expenditure elasticity, Marshallian own-price elasticities, and Hicksian cross-price elasticities are calculated to explore the effects from the additional expenditure, the price of product from this source itself, and the price of products from other sources, respectively. In detail, for the static AIDS model, the long run elasticities are calculated as following:

$$\eta_i^s = 1 + (\beta_i^s / \overline{w}_i) \tag{3.3}$$

$$\varepsilon_{ij}^s = -\delta_{ij} + \left(\gamma_{ij}^s / \overline{w}_i\right) - (\beta_i^s \, \overline{w}_j / \overline{w}_i) \tag{3.4}$$

$$\rho_{ij}^{s} = -\delta_{ij} + \left(\gamma_{ij}^{s}/\overline{w}_i\right) + \overline{w}_j \quad (3.5)$$

where η, ε, and ρ are the expenditure elasticity, Marshallian own-price elasticity, and Hicksian cross-price elasticity, respectively; β and γ are parameters, and δ_{ij} is the Kronecker delta which equal to 1 when $i = j$ (own-price elasticity) and 0 if $i \neq j$ (cross-price elasticity). $\overline{w}_i$ is the average budget share of LWTP from source i in the U.S. import market over the study period from January 2002 to June 2013. The elasticities for dynamic AIDS model can be calculated in the similar way, and the only difference is that the variables in static models with superscript s need to be replaced with the variables in the dynamic models with superscript d. What's more, delta method (Greene, 2003) is employed for both static and dynamic model to compute the standard errors of the elasticities calculation.

CHAPTER IV

DATA SOURCES AND VARIABLES

According to the scope of merchandise investigated by the United States International Trade Commission (U.S. ITC.), the lightweight thermal paper (LWTP) products are defined as the thermal paper with a basis weight of 70 grams per square meter (g/m^2) (with a tolerance of 4.0 g/m^2) or less. Within the framework of Harmonized Tariff Schedule (HTS), although certain lightweight thermal paper products may have been entered under HTS subheading 4811.90.90, 4811.59.20, or even 3703.10.60, HTS subheading 4811.90.80 is the legal subheading covering majority of certain lightweight thermal paper products involved in the trade dispute. Therefore, the commodity considered in this study is certain LWTP products with the HTS subheading 4811.90.80. Both import value and quantity data of such commodity are available on the website of the U.S. ITC. (2013).

The period between January 2002 and June 2013 is selected as the study period for several reasons. Foremost, China joined the World Trade Organization in December 2001, and started to deeply participate in the international trade since then. Consequently, the pattern of international trade was greatly affected since 2002, so does the LWTP products. Since 2002, the annual average cost-insurance-freight (CIF) value (import value) of import LWTP products exceeds 100 million U.S. dollars. Due to the repaid increase in imports, corresponding antidumping/countervailing (AD/CVD) investigation

happened within this study period. Specifically, the period of investigation ("POI") for those investigations were concentrated between January 2006 and June 2007, and slightly varied by case and country. In addition, the import market for the LWTP products in the U.S. has undertaken a dramatic change during this study period. Some traditional foreign suppliers such as Japan and United Kingdom lost much of their market share to China and Germany. Particularly, China boosted from a small supplier holding of less than 2% market share to be the second largest foreign supplier of LWTP products in the U.S. The market share of Chinese LWTP products ever reached 40% at the peak during this period, and then fell to a current stage of lower than 20% after the AD/CVD case. On the contrary, Germany kept holding the position of the largest foreign suppliers of LWTP products in the U.S., as both the import value and market share gained additional increases during this study period.

Major suppliers are selected according to the statistical data from U.S. ITC. (2013). The aggregated import value of the top five suppliers represents more than 85% of the total import during the study period of January 2002 to June 2013. These countries are 1- Canada (4.757%), 2- China (10.382%), 3- Germany (44.387%), 4-Japan (21.347%), and 5-United Kingdom (6.900%). All other countries are aggregated into a group called the 6-Rest of World (12.281%).

The data of monthly cost-insurance-freight (CIF) values in U.S. dollars and quantities in kilogram (kg) by country are collected from the website of U.S. ITC. (2013).The variables of import shares, gross import prices, total expenditure, and aggregated price index were calculated by using these data. The descriptive statistics of these variables are reported in Table 4.1. In aggregate, the monthly average import value

by the U.S. is $21.514 million U.S. dollars over the study period. The LWTP products imported from Japan are most expensive with an average price of $4.513/kg. On the contrary, the lightweight thermal paper products from Germany are the cheapest with an average price of $1.957/kg. The price range for LWTP from other countries is between $2.335/kg and $3.358/kg. The price variation may be due to the type and grade of such commodity produced by different countries.

Table 4.1 Descriptive Statistics for Lightweight Thermal Paper Product from January 2002 to June 2013

Variable	Mean	Stand Deviation	Minimum	Maximum
w_{1t}	4.757	2.879	0.649	21.527
w_{2t}	10.328	10.936	0.073	42.132
w_{3t}	44.387	8.927	28.388	63.256
w_{4t}	21.347	7.172	10.117	42.636
w_{5t}	6.900	5.157	0.098	27.372
w_{6t}	12.281	5.261	3.552	38.095
p_{1t}	2.335	0.656	0.960	5.481
p_{2t}	3.003	1.169	0.947	7.034
p_{3t}	1.957	0.147	1.673	2.353
p_{4t}	4.513	2.297	0.848	8.978
p_{5t}	3.358	1.669	1.465	13.294
p_{6t}	2.583	0.755	1.332	5.015
m_t	21.514	7.803	9.046	42.703

Note: Variable units are percentage for import shares (w_{it}), $/kilogram for import prices (P_{jt}), and $ million for total expenditure (m_t). The subscripts of country i and j refer to 1 - Canada; 2 – China; 3 – Germany; 4 – Japan; 5 – United Kingdom; and 6 – the rest of world.

The impacts from the non-economic factors are evaluated by corresponding policy dummy variables. The new investigation policy which repealed the restriction of conducting countervailing (CVD) investigation on non-market economy (NME) was revealed in the preliminary determination of AD/CVD investigation against Chinese coated free paper products on late March 2007 then publicized on April 2007. Thus, a

short step dummy variable from March 2007 to April 2007 is set to represent the extensive effect generated from this policy change. Other than this investigation policy change, the real AD/CVD investigation against certain LWTP products from China and Germany is considered as another main non-economic factor affecting the import demand of LWTP products in the U.S. This AD/CVD investigation lasted from September 2007 to November 2008. Due to the duration of the investigation period, this investigation has been divided into several different stages, and the effect from each stage of the investigation is revealed individually. To consider both the investigation effect and duty effect, three pulse dummy variables are set to account for the major events within this AD/CVD investigation, which are the initiation of the petition in September 2007, the affirmative preliminary determination in December 2007, and final imposition of the AD/CVD duties in December 2008. Specifically, the dummy variable representing the initiation of the petition is equal to one in September 2007 and zero for other months. The dummy variable representing the affirmative preliminary determination is equal to one in December 2007 and zero for other months. Similarly, the dummy variable accounts for the final imposition of the AD/CVD duties is equal to one in December 2008 and zero for other time period.

CHAPTER V

EMPIRICAL FINDINGS

5.1 Model Fit and Diagnostic Tests

Due to the requirement of constructing the most appropriate form of dynamic (error-correction) model, the properties of the time-series variables need to be examined beforehand. In this study, the results of Augmented Dickey-Fuller (ADF) test reported in Table 5.1 shows that the null hypothesis that all variables including price, expenditure, and budget share in the equation contain at least one root was failed to be rejected at 10% level. However, when first differences are used, the null hypothesis of unit root non-stationary was able to be rejected at 1% level, which means that the level of all the variables are an I(1) process but the series of their first differences is an I(0) process. Afterward, the cointegration test has been conducted following the Engle-Granger methodology, and the results are reported in Table 5.1 as well as the unit root test. According to the results of Engle-Granger cointegration test on residuals, the null hypothesis of nonexistence of cointegration relationship can be rejected which indicates the long-run equilibrium relationship exist in this market. Therefore the dynamic AIDS model can be constructed to exam the short run dynamics.

Table 5.1 Results from Unit Root Test and Cointegration Test

Variable	Unit root test		Cointegration Test	
	Level	First difference	Variable	
sCA	-0.581 (7)	-8.372 (6)	Resid.CA	-5.798
sCN	-1.576 (3)	-8.422 (2)	Resid.CN	-5.781
sGE	0.214 (13)	-3.676 (12)	Resid.GE	-6.201
sJP	-0.889 (9)	-6.371 (8)	Resid.JP	-5.406
sUK	-0.782 (13)	-4.552 (12)	Resid.UK	-6.423
ToExp	1.062 (10)	-4.145 (9)		
lnpCA	-0.276 (12)	-3.864 (11)		
lnpCN	-0.799 (2)	-10.476 (1)		
lnpGE	-0.251 (2)	-11.547 (1)		
lnpJP	-1.138 (3)	-12.209 (2)		
lnpUK	-0.319 (11)	-5.648 (10)		

Note: ADF test with constant by equation, critical value are -3.51 at 1%, -2.89 at 5%, and -2.58 at 10%, respectively. *sCA, sCN, sGE, sJP, sUK* represent the market share variables of Canada, China, Germany, Japan, and United Kingdom, respectively. *ToExp* represents the variable of Total Expenditure of imported LWTP in the U.S. *lnpCA, lnpCN, lnpGE, lnpJP, lnpUK* represent the log values of the gross price of LWTP products from Canada, China, Germany, Japan, and United Kingdom.

Another common problem associated with the AIDS model is the endogeneity of the model, which will lead to biased results. In this study, the Durbin-Wu-Hausman test (Hausman test) has been conducted to test the endogeneity problem of model, and the results are reported in Table 5.2. Accordingly, the results of Hausman test reveal that the null hypothesis of all the residuals are jointly equal to zero can be rejected at the 10% level, which means the error terms are correlated with the expenditure variables and the endogeneity problem exists in this model. Thus, the predicted values of the total expenditure imported from the auxiliary regression of the Durbin-Wu-Hausman test have been used to replace the real values of total expenditures to correct the problem of endogeneity.

Table 5.2 Results from Durbin-Wu-Hausman Test and Likelihood Test

Durbin-Wu-Hausman Test								
Estimated Coefficients:								
Intercept	*Lagexp*	*lnpCA*	*lnpCN*	*lnpGE*	*lnpJP*	*lnpUK*	*lnpRW*	*ndg*
6.369	0.751	-0.019	-0.159	-0.151	-0.115	0.057	-0.125	-0.257
Likelihood Test on Residuals:								
Test Statistic		P (> Chisq)						
10.566*		0.0607						

Note: *lagexp* represents represent the lagged value of total expenditure, *ndg* represents the personal consumption expenditures for nondurable goods in the U.S. *LnpCA*, *lnpCN*, *LnpGE*, *LnpJP*, and *lnpRW* represent the log values of the gross price of LWTP products from Canada, China, Germany, Japan, United Kingdom, and the rest of world, respectively.

In addition, some diagnostic tests have been conducted on the estimated model and the results of them are reported in Table 5.3. For the Breusch- Godfrey (BG) test of no serial correlation, only one equation passed the test from five equations of static AIDS model, but all five equations of the dynamic AIDS model passed the test. For the Breusch- Pagan (BP) test for heterogeneity, four out of five equations passed the test in static AIDS model while three out of five equations passed the test in dynamic model. For the Ramsey's Regression Specification Error Test (RESET) for the functional misspecification, there are two equations in static model passed the test but only one equation passed the test in dynamic model. Additionally, for the Jarque-Bera (JB) test of normality in error terms, three passed in static model while two in dynamic model. Overall, compared to the static model, the specification of dynamic AIDS model shows significant improvement in serial correlation problem, but shows no improvement in other perspectives.

Table 5.3 Results from Diagnostic Tests on the Static and Dynamic Almost Ideal Demand Systems

Equation	BG		BP		RESET		JB	
	Statistic	p-Value	Statistic	p-Value	Statistic	p-Value	Statistic	p- Value
Static AIDS:								
Canada	46.242	0.00	23.152	0.06	3.301	0.04	1208.830	0.00
China	9.301	0.00	28.519	0.01	27.683	0.00	0.005	1.00
Germany	1.169	0.28	11.313	0.66	1.575	0.21	1.516	0.47
Japan	16.107	0.00	15.362	0.35	4.554	0.01	5.666	0.06
UK	0.609	0.44	20.922	0.10	0.220	0.80	41.724	0.00
Dynamic AIDS:								
Canada	0.660	0.42	35.071	0.00	5.266	0.01	271.898	0.00
China	6.881	0.01	34.069	0.00	18.307	0.00	204.457	0.00
Germany	0.152	0.70	13.244	0.58	0.697	0.50	1.840	0.40
Japan	0.009	0.92	10.377	0.80	4.966	0.01	5.581	0.06
UK	0.226	0.63	14.757	0.47	4.547	0.01	20.550	0.00

Note: The null hypothesis is no serial correction for the Breusch-Godfrey (BG) test, no heteroskedasticity for the Breusch-Pagan (BP) test, no functional misspecification for the Ramsey's Regression Specification Error Test (RESET) test, and normality of the error terms for the Jarque-Bera (JB) LM test.

5.2 Results from Estimated Coefficients

Coefficient estimation results of the static AIDS model are presented in Table 5. 4 and the results for dynamic AIDS model are reported in Table 5.5. For the coefficients of real total expenditure, all five estimates are significant in the static model and two are significant in dynamic models. For the price variable, due to symmetry restriction, 20 estimated coefficients are presented and the results for the rest-of-world equations are omitted. Among those coefficients, eight are significant for the static model and six are significant for the dynamic model. Based on these estimates for expenditure and price variables, the elasticities are calculated and more detailed information can be provided for the competition and consumer behavior of lightweight thermal paper in U.S. import market.

Table 5.4 Estimated Parameters from the Static Almost Ideal Demand Systems for Imported Light Weight Thermal Paper Products

Parameter	Canada	China	Germany	Japan	UK
α_i	0.371***	-1.701***	-0.103	0.930***	0.467***
	(-2.930)	(-8.947)	(-0.392)	(-5.043)	(-2.949)
β_i^s	-0.019**	0.116***	0.033**	-0.049***	-0.023**
	(-2.479)	(-10.002)	(-2.053)	(-4.362)	(-2.394)
γ_{i1}^s	0.012	0.004	0.016	-0.020***	-0.005
	(-1.209)	(-0.557)	(-1.202)	(-3.479)	(-0.903)
γ_{i2}^s	0.004	-0.116***	0.066***	0.033***	-0.006
	(-0.557)	(-10.702)	(-4.251)	(-4.242)	(-0.793)
γ_{i3}^s	0.016	0.066***	-0.039	-0.074***	0.006
	(-1.202)	(-4.251)	(-1.125)	(-6.305)	(-0.540)
γ_{i4}^s	-0.020***	0.033***	0.074***	0.056***	0.011*
	(-3.479)	(-4.242)	(-6.305)	(-6.395)	(-1.719)
γ_{i5}^s	-0.005	-0.006	0.006	0.011*	0.001
	(-0.903)	(-0.793)	(-0.540)	(-1.719)	(-0.060)
γ_{i6}^s	-0.006	0.019**	0.024	-0.006	-0.007
	(-0.853)	(-2.304)	(-1.591)	(-0.776)	(-0.983)
φ_{i1}^s	-0.005	0.149***	-0.048	-0.058	-0.002
	(-0.230)	(-4.229)	(-1.207)	(-1.623)	(-0.074)
φ_{i2}^s	-0.018	0.062	-0.031	-0.009	0.056
	(-0.671)	(-1.296)	(-0.570)	(-0.180)	(-1.290)
φ_{i3}^s	-0.023	-0.086*	0.116**	0.002	0.029
	(-0.836)	(-1.789)	(-2.100)	(-0.039)	(-0.652)
φ_{i4}^s	0.010	-0.133***	0.152***	0.057	-0.078*
	(-0.360)	(-2.760)	(-2.773)	(-1.176)	(-1.782)
Q_{i1}^s	-0.007	-0.044***	0.084***	0.027**	-0.054***
	(-0.947)	(-3.722)	(-6.069)	(-2.258)	(-4.998)
Q_{i2}^s	-0.006	-0.043***	0.066***	0.035***	-0.058***
	(-0.865)	(-3.641)	(-4.858)	(-2.890)	(-5.440)
Q_{i3}^s	-0.007	-0.012	0.026*	-0.001	-0.005
	(-1.020)	(-1.013)	(-1.886)	(-0.118)	(-0.447)
R^2	0.246	0.829	0.669	0.597	0.377

Note: ***, **, * denote significance at the 1%, 5%, and 10% level, respectively. *t* ratios are in parentheses. See text for parameter definitions.

Table 5.5 Estimated Parameters from the Dynamic Almost Ideal Demand Systems for Imported Light Weight Thermal Paper Products

Parameter	Canada	China	Germany	Japan	UK
ψ_i	0.162**	0.026	-0.116*	-0.112*	-0.162**
	(-1.996)	(-0.399)	(-1.907)	(-1.656)	(-2.161)
λ_i	-0.502***	-0.502***	-0.484***	-0.480***	-0.495***
	(-7.357)	(-7.370)	(-6.907)	(-7.047)	(-5.792)
β_i^d	0.009	0.104***	-0.107***	-0.009	0.006
	(-0.623)	(-3.200)	(-2.839)	(-0.319)	(-0.213)
γ_{i1}^d	0.016**	0.003	-0.012	-0.002	-0.008*
	(-2.246)	(-0.476)	(-1.148)	(-0.447)	(-1.806)
γ_{i2}^d	0.003	-0.051***	0.032**	0.025***	-0.006
	(-0.476)	(-3.823)	(-2.192)	(-2.707)	(-0.820)
γ_{i3}^d	-0.012	0.032**	-0.002	-0.041***	0.008
	(-1.148)	(-2.192)	(-0.065)	(-3.063)	(-0.725)
γ_{i4}^d	-0.002	0.025***	-0.041***	0.014	0.001
	(-0.447)	(-2.707)	(-3.063)	(-1.118)	(-0.091)
γ_{i5}^d	-0.008*	-0.006	0.008	0.001	0.012
	(-1.806)	(-0.820)	(-0.725)	(-0.091)	(-1.329)
γ_{i6}^d	0.004	-0.002	0.016	0.005	-0.006
	(-0.550)	(-0.161)	(-1.060)	(-0.511)	(-0.884)
φ_{i1}^d	-0.005	0.059*	-0.009	-0.038	-0.001
	(-0.352)	(-1.937)	(-0.252)	(-1.347)	(-0.023)
φ_{i2}^d	-0.004	0.064	0.034	-0.028	-0.035
	(-0.183)	(-1.429)	(-0.609)	(-0.656)	(-0.791)
φ_{i3}^d	-0.030	-0.042	0.069	0.008	0.008
	(-1.490)	(-0.977)	(-1.317)	(-0.189)	(-0.191)
φ_{i4}^d	0.005	-0.104**	0.108**	0.076*	-0.091**
	(-0.271)	(-2.434)	(-2.092)	(-1.889)	(-2.250)
Q_{i1}^d	0.002	-0.002	0.009	0.008	-0.013*
	(-0.452)	(-0.235)	(-0.994)	(-1.145)	(-1.754)
Q_{i2}^d	0.000	-0.006	-0.002	0.003	0.000
	(-0.077)	(-0.849)	(-0.285)	(-0.388)	(-0.006)
Q_{i3}^d	0.000	0.012	-0.013	-0.017**	0.023***
	(-0.056)	(-1.606)	(-1.350)	(-2.375)	(-3.061)
R^2	0.254	0.407	0.418	0.375	0.420

Note: ***, **, * denote significance at the 1%, 5%, and 10% level, respectively. *t* ratios are in parentheses. See text for parameter definitions.

Other than the estimates for price and expenditure, policy dummy variables are set to explain the effect from policy change in CVD duty, the AD/CVD investigation. At first, the dummy variable for the new policy announced on 2007 which released the restriction of imposing countervailing duty investigation on China is showed to generate significant positive effect on the market share of China in both static (0.149) and dynamic (0.059) model. On the other hand, for the three investigation dummy variables, the announcement of preliminary affirmative decision has a negative effect on China (-0.133); and the final implementation of the AD and CVD duties on November 2008 generates significant effect on trade pattern of most countries except Canada. Specifically, in the dynamic AIDS model, the final implementation of duties has a negative effect on China (-0.104) and United Kingdom (-0.091), and a positive effect on Germany (0.108) and Japan (0.076) in the dynamic AIDS model, and also shows a similar significant effect on China (-0.133) and Germany (0.152) in static AIDS model. However, the formal initiation of the investigation on September 2007 doesn't show any significant effect on the trade pattern of LWTP products on the U.S. import market. In addition, the seasonal dummy variables of the first quarter and second quarter are significant for all the major suppliers except Canada.

Overall, the impacts from the policy and investigation are effective in both the short run and long run. Firstly, for the policy change announced in March 2007 which allowed simultaneous CVD and AD actions again the same set of products from a non-market economy (NME) country like China, the positive effect from this event may come from two reasons: the expectation of the highly possible investigation on this product imported from China, and some similar products may be imported under the HTS

subheading of LWTP temporarily. For example, U.S. ITC. (2008) indicated that coated free paper were found to enter the U.S. custom under the HTS subheading of LWTP products, especially when coated free paper product is subject to punitive tariff but LWTP still not. According to the estimates of dummy variables related to the AD and CVD investigation, trade depression effect occurs to China and United Kingdom, but trade diversion effect takes place to Germany and Japan at the same time, even though Germany is also a named country in the AD/CVD investigation and subject to the punitive AD duty. This may be due to the fact that the punitive tariff rates for German companies are far lower than their Chinese competitors who suffered from the high punitive tariff rate together with additional countervailing duty. In reality, this fact could benefit Germany and cause trade diversion happened on it. In general, these findings through dummy variables are consisting with the economic theories about investigation effect and trade diversion effect. They are also compatible with the real trade pattern over the time period covered by this study, as presented in Figure 2.1.

Furthermore, the coefficients of lagged share variable and the error correction terms also deserve explanation in detail. The coefficient estimates of the lagged share variable in the dynamic AIDS model indicate the inventory adjustment effect in consumer behavior. In this study, the coefficients for four out of five countries are significant and three of them are negative as expected in theory, i.e., Germany (-0.116), Japan (-0.112), and United Kingdom (-0.162). Which means the inventory adjustment effect exists in consumer behavior for the products imported from these three countries. What's more, the coefficient of error correction terms serves as an important indicator of market equilibrium and reveals the speed of adjustment toward the market equilibrium.

Consisting with the theory, all of the five estimates are negative and significant at 1% level. The speed of adjustment varies by countries but similar in general. The coefficient for each countries are close to -0.5, which indicates it will take about two months (1/0.5 $\approx$ 2) to get back to the market equilibrium. Therefore, this fact suggests that the U.S. import market for lightweight thermal paper products is very stable and the deviation from the long-run equilibrium for each country can be adjusted back to the equilibrium status in a very short time.

5.3 Results from Calculated Elasticities

The results of calculated long-run and short-run expenditure elasticities are reported in the Table 5.6. According to the results, all the estimates of expenditure elasticity are significant in 1% level, both in long run and short run. Specifically, the long-run elasticities for all the listed countries are positive as expected and the elasticity estimates for China (2.115) and Germany (1.073) are larger than one, while the elasticity estimates for Canada (0.599), Japan (0.770), and United Kingdom (0.663) are less than one. Besides, as for the short run elasticities, the estimates for Canada (1.188), China (1.996), and United Kingdom (1.086) are positive and larger than one and the estimates for Germany (1.073) and Japan (0.957) are positive but smaller than one. The magnitudes for the estimates in the short run are smaller than that in the long run for China and Germany, but are larger for Canada, Japan, and United Kingdom. In addition, in either long run or short run, China's expenditure elasticities are largest among all the countries and significantly larger than its competitors on the market. Overall, the results of expenditure elasticities indicate that the more consumers spend on the imported

lightweight thermal paper products, the more money will be spent on imported from China and Germany and less from Canada, Japan, and United Kingdom in the long run. The large expenditure elasticities indicate the fierce market competition of the LWTP product from China and Germany in the long run, and also consistent with what the trade pattern shows.

Table 5.6 Estimates of the Expenditure Elasticity (η_i) and Marshallian Own-Price Elasticity (ε_{ii})

	Long-Run		Short-Run	
Country	η_i	ε_{ii}	η_i	ε_{ii}
Canada	0.599***	-0.737***	1.188***	-0.680***
	(-3.706)	(-3.602)	(-3.937)	(-4.654)
China	2.115***	-2.227***	1.996***	-1.599***
	(-18.974)	(-22.734)	(-6.413)	(-12.945)
Germany	1.073***	-1.119***	0.760***	-0.898***
	(-30.056)	(-12.895)	(-9.005)	(-10.567)
Japan	0.770***	-0.687***	0.957***	-0.927***
	(-14.571)	(-19.374)	(-7.150)	(-15.129)
UK	0.663***	-0.968***	1.086***	-0.837***
	(-4.714)	(-6.530)	(-2.690)	(-6.273)

Note: ***, **, * denote significance at the 1%, 5%, and 10% level, respectively. t ratios are in parentheses. See text for parameter definitions.

For better understanding of the effect of price change of imported lightweight thermal paper, the Marshallian own-price elasticities were calculated and presented in the Table 5.6 as well as the expenditure elasticities. As expected as theory, all the estimates for Marshallian own-price elasticity are negative, and all of them are significant in 1% level in both long run and short run. In the long run, the own-price elasticities for most countries are inelastic except China (-2.227) and Germany (-1.119). In the short run, China (-1.599) is the only one country still have elastic own-price elasticity. This result reveal that consumption of imported lightweight thermal paper from China is very

changeable in both long run and short run, and consistent with the unstable import pattern of China which is sensitive to trade interventions. In additional, Germany has inelastic short-run own-price elasticity (-0.898) and elastic long-run elasticity (-1.119). Besides, the results also indicate that the market standing of Germany is stable in short run but flexible in the long run, which is consistent with the trade pattern within the research period. What's more, the inelastic price elasticity of the lightweight thermal paper imported from Japan, Canada, and United Kingdom suggest that the products from those countries are more necessary and relatively difficult to be substituted by other sources.

The Hicksian cross-price elasticities in both long run and short run are calculated to show the market competition among major suppliers, the results are reported in Table 5.7. According to the definition, positive cross-price elasticity between the products imported from two countries means they are substitute and a negative value indicates complements. Among the 10 pairs of cross-price elasticities among the five main suppliers, even though the signs and significance are same, the magnitudes, however, can be different. For example, as the price of LWTP products imported from China increase by 10%, the import demand for German product will increase by 2.53%. However, when the price of LWTP products imported from Germany increases by 10%, the imports demand for Chinese LWTP product will increase by 10.08%, which is a far larger than the prior one.

Table 5.7 Estimates of Long-Run and Short-Run Hicksian Cross-Price Elasticity (ρ_{ij})

Quantity of a Country	Price of a Country				
	Canada	China	Germany	Japan	United Kingdom
Long-Run:					
Canada	—	0.183	0.791***	-0.209*	-0.043
	—	(-1.288)	(-2.748)	(-1.721)	(-0.349)
China	0.084	—	1.083***	0.527***	0.013
	(-1.288)	—	(-7.216)	(-7.127)	(-0.189)
Germany	0.085***	0.253***	—	0.046*	0.083***
	(-2.748)	(-7.216)	—	(-1.735)	(-3.169)
Japan	-0.047*	0.257***	0.096*	—	0.122***
	(-1.721)	(-7.127)	(-1.735)	—	(-3.960)
United Kingdom	-0.030	0.020	0.536***	0.377***	—
	(-0.349)	(-0.189)	(-3.169)	(-3.960)	—
Short-Run:					
Canada	—	0.161	0.191	0.162	-0.089
	—	(-1.343)	(-0.867)	(-1.394)	(-1.015)
China	0.074	—	0.750***	0.452***	0.010
	(-1.343)	—	(-5.389)	(-5.133)	(-0.133)
Germany	0.020	0.175***	—	0.121***	0.086***
	(-0.867)	(-5.389)	—	(-3.977)	(-3.681)
Japan	0.036	0.220***	0.251***	—	0.072**
	(-1.394)	(-5.133)	(-3.977)	—	(-2.137)
United Kingdom	-0.061	0.015	0.554***	0.223**	—
	(-1.015)	(-0.133)	(-3.681)	(-2.137)	—

Note: ***, **, * denote significance at the 1%, 5%, and 10% level, respectively. t ratios are in parentheses.

In the long run, seven out of ten pairs of Hicksian cross-price elasticities at the upper triangle of the panel are significant at below 10% level. Most of them are positive indicate a substitution relationship except that the products from Canada and United Kingdom are complement. Among them, the largest cross-price elasticity is 1.083 between China and Germany. Meanwhile, the cross-price elasticity between Canada and United Kingdom is -0.043, which is a small value and not statistically significant and indicates the complement, even really exists, is very weak. Overall, in the long run, the

prices of Germany and United Kingdom have larger impacts on the demand of the imported LWTP from other countries.

For the estimate results of Hicksian cross-price elasticity in the short run, five out of ten estimates in the upper triangle are significant. Similar to the long run results, except United Kingdom and Canada, cross-price elasticities among all other countries are negative indicates there is some degree of substitution between each pair of them. Specifically, the largest cross-price elasticity is 0.750 between China and Germany. Overall, the price of LWTP products imported China and Germany have larger impact on the demand for products from other countries, and the competition between these two suppliers is the strongest among all major suppliers. Besides, the comparison between long-run and short-run results indicates that the overall degree of substitution is smaller in the short run than in the long run.

CHAPTER VI

CONCLUSIONS

In recent decade, the import of lightweight thermal paper products in the U.S. has increased significantly as the annual import value of LWTP products by the U.S. was more than doubled. In 2012, the total import value of LWTP products in the U.S. exceeded 350 million U.S. dollars. Besides, other than the large increase in import, the pattern of import sources of LWTP products has also been greatly changed. Some of the traditional major suppliers of LWTP products such as Japan and United Kingdom have lost their market shares to Germany and China. Since 2002, the imports of LWTP from Germany and China have increased faster than from other countries. Due to the rapid increase of import, an antidumping/countervailing investigation against the LWTP products from Germany and China was conducted from September 2007 to December 2008. Consequently, various AD and CVD duties have been imposed on German and Chinese LWTP manufacturers since December 2008. To evaluate this market dynamic, both economic and noneconomic factors which affecting the market have been analyzed and the results in terms of consumer behavior, market competition, and effectiveness of policy are obtained through static and dynamic AIDS models. Monthly disaggregate data for the top five suppliers from January 2002 to June 2013 are used as the data to analyze in this study.

Several conclusions have been reached in terms of the consumer behavior, market competition, and policy effectiveness in the import market of LWTP products. First of all, the long run equilibrium in this market has been proved to be present by the Engle-Granger cointegration test. Once this equilibrium has been broken temporally, the equilibrium status in this market can also be regained by short-run adjustments of each supplier. The expenditure elasticities show that when U.S. consumers spend more money on imported LWTP, they buy more from China and less from Canada, Japan, and United Kingdom, and buy more German LWTP products in the long run but less in the short run. Therefore, China has the potential to lead the market in the future. In the long run, as indicated by the Marshallian Own-price elasticities, the imported quantities from China and Germany are sensitive to their prices. However, in the short run, China is the only supplier that has elastic own-price elasticity, which indicates its response is more sensitive to price change among all suppliers.

Other than expenditure and own-price elasticity, the cross-price elasticities have revealed the competition among those countries. The imports among most countries can be substituted by each other, except that the LWTP products from Canada and United Kingdom are found to be complementary. However, all the cross-price elasticities are inelastic indicating moderate to low magnitudes, and implying most of them are far from perfect substitution. This fact indicates that the imported LWTP from different countries are meant to be differentiated to meet the diversity in preferences of the U.S. consumers. Overall, the analysis on effect from the economic factors shows the market competition on the LWTP import market in the U.S. will be continued in the future. Due to the relatively high competition level, the market will be even more changeable in the long

run. Thus, all suppliers will be needing to face both opportunity and risk together in the future.

Severing as an impact from the non-economic perspective, the investigation policy change in 2007 did generate significant effect on LWTP products from China. In reality, this policy, which was supposed to be restrictive, stimulated the import of LWTP from China temporarily. This may be because of conducting faster contracts under risk of potential investigation, a rush by U.S. buyers to get more products to avoid potential price increase in the future, and the increase of coated free paper under the name of LWTP to avoid punitive tariff. On the other hand, the AD/CVD investigation against China and Germany as trade remedy instrument, however, has limited effects in reducing the import growth of LWTP products from these two countries. Specifically, the initiation of the investigation didn't generate any significant impact on the import of LWTP. The affirmative preliminary determination and the final imposition of the duties generate negative impact on China as expected, but trade diversion effect took place on Japan and Germany, even though German LWTP products are also subject to punitive tariff. This pattern is consistent with the fact that the market share of Chinese LWTP products dropped after the investigation while Germany continue to hold the largest market share on this market. Apparently, the effectiveness of this AD/CVD investigation on Germany need to be questioned because it didn't really reduce the import of LWTP to protect domestic industry as expected. In another word, the one who benefit from this trade offset measure may not be U.S. domestic industry but German LWTP manufacturers which is supposed to be punished in this case. Besides, the righteousness of AD/CVD duty is another extensive topic merits further investigation. Especially for the case comes with

AD and CVD investigations together, the problem of "double remedies" can be even more controversial.

In conclusion, this study analyzed the consumer behavior in purchasing imported LWTP products in the U.S. as well as the trade pattern, market competition, and policy impacts in this market based on a demand system. It makes an important contribution to analyzing the import market of LWTP products with a differentiation of short run and long run consumer behavior. It also produces empirical evidence of the temporary stimulate and trade diversion in the paper manufacturing industry when there is an AD/CVD investigation or relevant policy event.

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APPENDIX A

R CODES FOR THIS STUDY

```
# Title: R Program code for Fan Zhang's Thesis (2014)
# Date: May 29, 2014

# --- Brief contents
# 0. Set up the working space
# 1. Data preparation
# 2. Static AIDS model estimation and Hausman test
# 3. Dynamic AIDS models estimation and elasticities calculation
# 4. Export results
# 5. Figure plot by ggPlot

# ------------------------------------------------------------------------
-----
# 0. Set up the working space
library(RODBC); library(erer)
setwd("C:/a. STUDY/0. Thesis/Code"); getwd()

# ------------------------------------------------------------------------
-----
# 1 Data Preparation
# 1.1 Import raw data in MS Excel format
dat   <- odbcConnectExcel('LWTPmain.xls')
sheet <- sqlTables(dat); sheet$TABLE_NAME
impo  <- sqlFetch(dat, "dataImport")
expe  <- sqlFetch(dat, "dataExp")
odbcClose(dat)

# 1.2 Expenditure data for Hausman test
ex  <- ts(expe[, -1], start = c(1991, 1), end = c(2013, 6), freq = 12)
Exp <- window(ex, start = c(2002, 1), end = c(2013, 6), freq = 12)
bsStat(Exp[, 1:7])

# 1.3 Raw import data and date selection
LWTPRaw <- ts(impo[, -c(1, 2)], start = c(2002, 1), end = c(2013, 6),
  freq = 12)

# 1.4. Transformed data for AIDS model
label <- c("CA", "CN", "GE", "JP", "UK")
imp6 <- aiData(x = LWTPRaw, label = label, label.tot = "WD",
  prefix.value = "v", prefix.quant = "q",
  start = c(2002, 1), end = c(2013, 6), freq = 12)
daSum <- cbind(imp6$share * 100, imp6$price, imp6$m / 1000000)
colnames(daSum) <- c(paste("s", label, sep = ""), "sRW",
  paste("p", label, sep = ""), "pRW", "Expenditure")
table.1 <- bsStat(daSum, two = TRUE, digits = 3)$fstat
dat6 <- imp6$out

# 1.5 Setting Dummy variables
# 1.5.1 Setting investigation and policy dummies
dum  <- ts(0, start = start(dat6), end = end(dat6), freq = 12)
dum1 <- replace(dum, time(dum) >= 2007 + (3 - 1) / 12 &
                     time(dum) <= 2007 + (4 - 1) / 12, 1)
dum2 <- replace(dum, time(dum) == 2007 + (9 - 1) / 12, 1)
dum3 <- replace(dum, time(dum) == 2007 + (12 - 1) / 12, 1)
dum4 <- replace(dum, time(dum) == 2008 + (12 - 1) / 12, 1)
```

```
# 1.5.2 Setting quarterly dummies
mon <- as.numeric(format(as.Date(time(dum)), format = "%m"))
q1 <- ts(ifelse(mon %in% 1:3, 1, 0), start = start(dum), end =
end(dum),
  freq = 12)
q2 <- ts(ifelse(mon %in% 4:6, 1, 0), start = start(dum), end =
end(dum),
  freq = 12)
q3 <- ts(ifelse(mon %in% 7:9, 1, 0), start = start(dum), end =
end(dum),
  freq = 12)

# 1.5.3 Combine Dummy Varibales into the main dataset
LWTP <- ts.union(dat6, dum1, dum2, dum3, dum4, q1, q2, q3)
colnames(LWTP) <- c(colnames(dat6), "dum1", "dum2", "dum3", "dum4",
  "q1", "q2", "q3")
head(LWTP); tail(LWTP)

# ------------------------------------------------------------------
-----
# 2 Static AIDS model estimation and Hausman test
# 2.1 Estimation of the static AIDS model
Sh <- c("sCA", "sCN", "sGE", "sJP", "sUK", "sRW")
pr <- c("lnpCA", "lnpCN", "lnpGE", "lnpJP", "lnpUK", "lnpRW")
du <- c("dum1", "dum2", "dum3", "dum4", "q1", "q2", "q3")
rSta <- aiStaFit(y = LWTP, share = sh, price = pr, shift = du,
  expen = "rte", omit = "sRW", hom = TRUE, sym = TRUE)
summary(rSta)

# 2.2 The final Hausman test and new data
ndg <- Exp[, "ndg"]
rHau <- aiStaHau(x = rSta, instr = ndg, choice = FALSE)
names(rHau); colnames(rHau$daHau)
colnames(rHau$daFit); rHau
two.exp <- rHau$daFit[, c("rte", "rte.fit")]
bsStat(two.exp, digits = 4)
plot(data.frame(two.exp)); abline(a = 0, b = 1)
daLWTPFit <- rHau$daFit

# ------------------------------------------------------------------
-----
# 3 Dynamic AIDS models estimation and elasticities calculation
# 3.1 ADF Unitroot test and Engle-Granger Cointegration test
# 3.1.1 ADF test
ur.level.stat <- ur.level.lag <- ur.fd.stat <- ur.fd.lag <- list()

for (i in 1:13) {
  level <- ur.df2(type = 'none', lags = 13, y = LWTP[, i],
    selectlags = "AIC")
  ur.level.stat[i] <- round(level$teststat, 3)
  ur.level.lag[i] <- level$lag.used
}
```

```
for (i in 1:13) {
  fd <- ur.df2(type = 'none', lags = 13, y = diff(LWTP[, i]),
    selectlags = "AIC")
  ur.fd.stat[i] <- round(fd$teststat, 3)
  ur.fd.lag[i] <- fd$lag.used
}

adf <- cbind(ur.level.stat, ur.level.lag, ur.fd.stat, ur.fd.lag)
colnames(adf) <- c('level', 'lag used', 'First difference', 'lag
used')
rownames(adf) <- c('sCA', 'sCN', 'sGE', 'sJP', 'sUK', 'sRW', 'ToExp',
  'lnpCA', 'lnpCN', 'lnpGE', 'lnpJP', 'lnpUK', 'lnpRW')
table.2a <- adf

# 3.1.2 Engle-Granger Cointegration test on residual terms
resid <- ts(residuals(rSta$est), start = c(2002, 1), frequency = 12)
colnames(resid) <- paste("resi.", rSta$share[-rSta$nOmit], sep = "")
eg.stat <- list()

for (i in 1:5) {
  eg <- ur.df2(resid[, i], type = c("none"), lags = 1)
  eg.stat[i] <- round(eg$teststat, 3)
}

resd.stat <- cbind(eg.stat)
colnames(resd.stat) <- c('test statistics')
rownames(resd.stat) <- c('Resid.CA', 'Resid.CN', 'Resid.GE',
  'Resid.JP', 'Resid.UK')
table.2b <- resd.stat

# 3.2 Diagnostics and coefficients
hSta  <- update(rSta, y = daLWTPFit, expen = "rte.fit")
hSta2 <- update(hSta, hom = FALSE, sym = FALSE)
hSta3 <- update(hSta, hom = FALSE, sym = TRUE)
hSta4 <- update(hSta, hom = TRUE,  sym = FALSE)
lrtest(hSta2$est, hSta$est)
lrtest(hSta2$est, hSta3$est)
lrtest(hSta2$est, hSta4$est)

hDyn  <- aiDynFit(hSta)
hDyn2 <- aiDynFit(hSta2); lrtest(hDyn2$est, hDyn$est)
hDyn3 <- aiDynFit(hSta3); lrtest(hDyn2$est, hDyn3$est)
hDyn4 <- aiDynFit(hSta4); lrtest(hDyn2$est, hDyn4$est)

(table.2 <- rbind(aiDiag(hSta), aiDiag(hDyn)))
(table.3 <- summary(hSta))
(table.4 <- summary(hDyn))

# 3.3 Elasticity calculation
es <- aiElas(hSta); esm <- es$marsh
ed <- aiElas(hDyn); edm <- ed$marsh
esm2 <- data.frame(c(esm[1:2, 2], esm[3:4, 3],
  esm[5:6, 4], esm[7:8, 5], esm[9:10, 6], esm[11:12, 7],
  esm[13:14, 8], esm[15:16, 9]))
edm2 <- data.frame(c(edm[1:2, 2], edm[3:4, 3],
```

```
  edm[5:6, 4], edm[7:8, 5], edm[9:10, 6], edm[11:12, 7],
  edm[13:14, 8], edm[15:16, 9]))
eEM <- cbind(es$expen, esm2, ed$expen[2], edm2)
colnames(eEM) <- c("Country", "LR.expen", "LR.Marsh",
  "SR.expen", "SR.Marsh")
(table.5  <- eEM[-c(15:16), ])
(table.6a <- es$hicks[-c(15:16), -9])
(table.6b <- ed$hicks[-c(15:16), -9])

# ------------------------------------------------------------------------
-----
# 4 Export results
output.tables <- listn(table.1, table.2, table.2a, table.2b, table.3,
  table.4, table.5, table.6a, table.6b)
write.list(z = output.tables, "Newout.csv")

# ------------------------------------------------------------------------
-----
# 5 Figure plot by ggPlot
# 5.1 Data preparation: ggplot need a data frame
str(LWTPRaw); str(LWTP)
tot <- window(LWTPRaw[, "vWD"], start = c(2002, 1), end = c(2013,
6))/10^6
sha <- LWTP[, c('sCA', 'sCN', 'sGE', 'sJP', 'sUK')] * 100
y <- ts.union(tot, sha); colnames(y) <- c('TotExp', colnames(sha))
windows(width = 5.5, height = 5) # Traditional graph
plot(x = y, xlab = "", main = "", oma.multi = c(2.5, 0, 0.2, 0))

# 5.2 Data for ggplot
var.x  <- as.Date(time(y), format = "%Y-%m-%d")
wrap.n <- c('Total Expenditure ($ million)', '1. Canada (%)',
  '2. China (%)', '3. Germany (%)', '4. Japan (%)',
  '5. United Kingdom (%)')
daFig <- NULL
for (i in 1:6) {
  hh <- data.frame(VAR.x = var.x, VAR.y = c(y[, i]), wrap = wrap.n[i])
  daFig <- rbind(daFig, hh)
}
daFig$wrap <- factor(x = daFig$wrap, levels = wrap.n[c(1,4,2,5,3,6)],
  ordered = TRUE)
levels(daFig$wrap)
daFig1 <- daFig[daFig$wrap %in% wrap.n[1:3], ]
daFig2 <- daFig[daFig$wrap %in% wrap.n[4:6], ]
break.x <- c(2002, 2004, 2006, 2008, 2010, 2012)

# 5.3 Create a graph in ggplot
library(ggplot2)
fa <- ggplot(data = daFig) +
  geom_line(aes(x = VAR.x, y = VAR.y)) +
  facet_wrap( ~ wrap, nrow = 4, scales = 'free_y') +
  scale_x_date(name = '', labels = as.character(break.x),
    breaks = as.Date(paste(break.x, "-1-1", sep = ""),
    format = "%Y-%m-%d")) +
  scale_y_continuous(name = '') +
  theme(axis.text.x  = element_text(size = 9, family = 'serif')) +
```

```
  theme(axis.text.y  = element_text(size = 9, family = 'serif')) +
  theme(axis.title.x = element_text(size = 9, family = 'serif')) +
  theme(axis.title.y = element_text(size = 9, family = 'serif')) +
  theme(strip.text.x = element_text(size = 9, family = 'serif')) +
  theme(strip.text.y = element_text(size = 9, family = 'serif'))

fb <- fa +                                      # no gray background
  theme(panel.grid.minor = element_blank() ) +
  theme(panel.grid.major = element_blank() ) +
  theme(panel.background = element_rect(fill = "white", color =
"black"))+
  theme(strip.background = element_rect(fill = "grey85", color=
"grey70"))+
  theme(strip.text.x = element_text(size = 9, color = "black"))

# 5.4 Show the graph on a screen device
windows(width = 5.5, height = 4); fa

# 5.5 Save the graph on a file device
ggsave(filename = "LWTPshare.png", plot = fa, width = 5.5, height=4,
  dpi=300)
```