Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Department of Economics

Analyzing and Testing the Structure of China's Imports for Cotton

- A Bayesian System Approach

Ruochen Wu

Master's thesis · 30 hec · Advanced level
European Erasmus Mundus Master Program: Agricultural Food and Environmental Policy Analysis (AFEPA)
Degree thesis No 805 · ISSN 1401-4084
Uppsala 2013

Analyzing and Testing the Structure of China's Imports for Cotton - A Bayesian System Approach

Ruochen Wu

Supervisor: Sebastian Hess, Swedish University of Agricultural Sciences (SLU), Department of Economics

Assistant supervisor: Yves Surry, Swedish University of Agricultural Sciences (SLU), Department of Economics

Examiner: Ing-Marie Green, Swedish University of Agricultural Sciences (SLU), Department of Economics

Credits: 30 hec
Level: A2E
Course title: Independent Project/degree in Economics E
Course code: EX0537
Programme/Education: European Erasmus Mundus Master Program: Agricultural Food and Environmental Policy Analysis (AFEPA)
Faculty: Faculty of Natural Resources and Agricultural Sciences

Place of publication: Uppsala
Year of publication: 2013
Name of Series: Degree project/SLU, Department of Economics
No: 805
ISSN 1401-4084
Online publication: http://stud.epsilon.slu.se

Key words: China, cotton import demand, generalized Armington Model, CDE functional form, Bayesian Bootstrap Multivariate Regression, Allen elasticities of substitution

Sveriges lantbruksuniversitet
Swedish University of Agricultural Sciences

Department of Economics

ABSTRACT

China is the biggest importer of cotton in the world, and it is of great interest to analyze its import demand system for cotton. Noteworthy is that cotton is deemed an intermediate commodity for textile production instead of a direct consumption one, hence this thesis adopts a two-stage cost minimization procedure resembling the Armington Model to study China's demand for cotton differentiated by their countries of production with a focus on the substitution effects and weak separability between various sources. The CDE functional form is utilized for the cost function to generalize the Armington settings. Unlike former works, this thesis estimates the demand system with the Bayesian Bootstrap Multivariate Regression, and report the posterior distributions of coefficients and Allen elasticities of substitution. The results demonstrate that the CDE functional form may still be too demanding to be completely consistent with the data. Three weak separable structures are tested, and it can be concluded that the assumption of different separable structures improves the consistency between the model and data to various extents. The U.S. cotton is the least sensitive to its own price changes while the cotton from Egypt and Sudan is the most sensitive. The overall substitution effects between various cotton import sources appear to be relatively small.

Keywords: China, cotton import demand, generalized Armington Model, CDE functional form, Bayesian Bootstrap Multivariate Regression, Allen elasticities of substitution

TABLE OF CONTENTS

ACKNOWLEDGEMENT

As the renowned Roman poet Virgil said, “Tempus fugit.” The past two years have been extraordinary experience for me, a combination of endeavor and enjoyment, and now, I have arrived at the closing chapter of these amazing two years in my life with the composition of my thesis. At this moment, I cannot help looking back at the two years I just spent in Europe, and would like to express my gratefulness to those who have been unselfishly backing me up with their aid, without which it would have been impossible for me to stand where I currently do.

To begin with I would like to appreciate the Erasmus Mundus AFEPA Programme hosted by the European Commission, who has not only granted me the opportunity to have a glance at the European culture and science, but also has generously offered me the funding and support in all aspects. I am also very grateful to my supervisors at SLU and University of Bonn: Dr. Sebastian Hess and Professor Thomas Heckelei, whose opinions and suggestions I could not appreciate more. This thesis could not have been accomplished without the devotion and discussion with Professor Yves Surry, who has motivated and inspired me considerably, and to whom I am genuinely thankful.

I hold deep gratitude to my parents as well, who have greatly helped me with their love along with their spiritual and mental support.

I would like to say thank you to all you have done for me.

DEDICATION

To my parents: Mr. Renchun Wu and Ms. Xiufen Shen, whom I love with my full heart forever.

ABBREVIATIONS

ICAC	International Cotton Advisory Committee
WTO	World Trade Organization
STE	State Trade Enterprise
TRQ	Tariff Rate Quota
NDRC	National Development and Reform Commission
MOFCOM	Ministry of Commerce of People's Republic of China
CDE	Constant Difference of Elasticity
BBMR	Bayesian Bootstrapping Multivariate Regression
CES	Constant Elasticity of Substitution
CRES	Constant Ratios of Elasticities of Substitution
CGE	Computable General Equilibrium
USDA	United States Department of Agriculture
OLS	Ordinary Least Square
SUR	Seemingly Unrelated Regression
ROW	Rest of World
MCI	Monte Carlo Integration
AES	Allen Elasticities of Substitution
BB	Bayesian Bootstrap
2SLS	Two Stage Least Square
3SLS	Three Stage Least Square
FAO	Food and Agriculture Organization of the United Nations
HPD	Highest Posterior Density
HPDI	Highest Posterior Density Intervals

CHAPTER 1 – INTRODUCTION

1.1 Background

China is one of the fastest growing economies in the world. With a population of 1.35 billion in the end of 2011 (China Statistical Yearbook, 3-1, 2012), it is the most populated country on the globe. In the same year, its GDP is 47211.5 billion Yuan at current prices, and within the last two decades, the country maintained an annual economic growth rate of over 7% in each and every year. Currently, China is the second largest economy after only the U.S.A. The agriculture of China counts for just over 10% of the country's GDP, whilst 34.8% of the total employed population works in this sector; the industry occupies 46.6% of the GDP with 29.5% of the labor force working in the industry; the service industry tops up a portion of 43.4% in the GDP employing 35.7% of the working population.

The agricultural sector of China accounts for a relatively high proportion in the GDP and employs more than a third of the labor force while in developed countries represented by the U.S.A., agriculture takes only around 1% of GDP, and some 2% of the population works in the sector; the agricultural production module in China is labor-intensive with farmers possessing a small fraction of land with an average of 0.6 hectares per farm, compared to the U.S.A. where farms produce with a rather high level of mechanization and own large areas of land averaging 619 hectares for each individual farm (U.S. International Trade Commission, 2011). Therefore, agriculture is of great concern in China. Since the last millennium, the Chinese government has altered its fundamental agricultural policies drastically when it abolished agricultural taxes in the purpose to transfer to surplus in the agricultural sector to the industry, and initiated subsidizing agricultural production, aiming at the guaranteed national food safety. In the meantime, a stable growth in the income of Chinese households is also continually increasing the food demand, which contributes to the leaning of government policies towards agriculture (Ni, 2013).

1.2 Cotton production and import of China

Despite the largest agricultural economy in the world, China is still relying on imports in several key agricultural products, among which cotton is second only to soybeans in the value of imports. China itself is the biggest cotton producer worldwide, which produced 6.59 million tons of cotton in 2011 (China Statistical Yearbook, 2012). Figure 1.1 in Appendix A demonstrates the annual cotton production of China from 1992 to 2011. During the period, the cotton production in China fluctuated between the lowest of 3.74 million tons in 1993, the year in which a global setback in cotton harvest took place, and the highest of 7.62 million tons in 2007.

In the meanwhile, being the largest producer and exporter of textiles, China consumes a great amount of cotton as well. Thus, though the country itself is producing globally the most cotton, China in the meantime is also the top cotton importer, which accounted for 43% of the total world import in the year 2005/06 (Wakelyn and Chaudhry, 2010) when its import of cotton reached the highest in quantity. Since its accession to the World Trade Organization (WTO) in 2001, the quantity of cotton imported by China has risen dramatically. Currently, China counts up to one third of the world trade in cotton, as in 2011 it imported 3.57 million tons of various types of cotton with a total value of 9.47 billion U.S. Dollars, which originate from seven main sources, namely West Africa, Egypt and Sudan, Central Asia, Indo Subcontinent, Australia, U.S.A. and the rest of the world. Figure 1.2 shows the amount of cotton imported by China from 1992 to 2011 from the seven major sources and the aggregated quantity. It can be observed that within the two decades, the quantity of cotton imported by China hit the lowest of 44.7 thousand tons in 1993 when, as stated before, a worldwide shortage of supply stroke the cotton market, and reached its highest of 3.98 million tons in 2006. Figure 1.3 shows the total value of this cotton imported. The import value of China witnessed the lowest of 25.2 million dollars in 1993 and the peak of 9.68 billion dollars in 2011.

It is meaningful to look generally into the governmental policies of China with respect to cotton import. According to WTO Trade Policy Review on China (WTO Trade Policy Review Body, 2012), after the accession of China to the WTO, cotton was still listed as ‘state trade commodities’ in the formal report to the Secretariat, and authorized four state trading enterprises (STE) to import cotton into the country, namely the China National Textile Import and Export Co., the Shanghai Textile Raw Materials Co., the Tianjin Textiles Industry Supply and Marketing Co., and the Beijing Jiuda Textiles Group Co. In addition to the state trading restriction, cotton trade with China is further limited with Tariff Rate Quota (TRQ) that is managed by the National Development and Reform Commission (NDRC) and the Ministry of Commerce of People’s Republic of China (MOFCOM). According to the Trade Policy Review on China, quota for cotton import allocated to STEs accounted for 33% of the total quota that is allocated by the government in 2011. The current TRQ policy measures an average in – quota tariff of 4.8% and an out – of – quota tariff of 50.4% that applies to all exporting countries.

China is also integrating cotton into its international cooperation as the WTO China Government Report (WTO Trade Policy Review Body, 2012) stated that within the WTO framework, China has commenced its collaboration with African cotton producing countries by furnishing "superior seeds, chemical fertilizers, agricultural machinery, technologies and training of professionals to these cotton producing countries."

1.3 Problem statement

China acceded to the WTO in year 2001, and this led to an expectation that the fast growing economy will stimulate the weak cotton market with its remarkable demand for imported cotton, which was anticipated to be increased even more by the boost in trade of commodities such as textiles from the country within the WTO framework. Without doubt, the cotton import of China has skyrocketed in both quantity and value since 2001 as demonstrated in the figures in Section 1.2.

The cotton imported, and actually the domestically produced as well, is deemed as an intermediate product that mainly performs as the input to manufacture textiles, one of the major export commodities of China. As the result of state trading regime in cotton, along with the TRQ, the Chinese government has the capability to allocate higher priority to the consumption of the domestically produced cotton over that of the imported. Thus, the quantity of cotton import not only depends on the demand for textiles produced by China, but the estimated quantity of domestically produced cotton as well. A straightforward illustration is that China's import quantity of cotton climaxed in 2006 within the most recent two decades following the elimination in 2005 of the Multi-Fiber Arrangement that restricted developed countries' import of textiles from developing countries including China. Yet both the cotton import quantity and value significantly decreased in year 2009 as the global economic crisis broke out in the end of 2008, resulting in a drop of international demand of Chinese textiles. In the same year, the domestic production of cotton in China also declined, and continued to dwindle in 2010 with Chinese farmers cutting the growth of cotton in response to the shrinking demand in 2009. However, the recovery of world economy partially restored the production and export of Chinese textiles in 2010, leaving a huge gap between domestically produced cotton and the actual cotton demand, therefore the import quantity of cotton grew by almost 80% and the import value more than doubled in that year in comparison to the former one.

What is interesting to follow is the cotton import structure of China, which could be depicted with the share of expenditure on importing from each source, as the Figures 1.4 reveals. It is clear that the expenditure shares of different sources of import varied considerably both with different sources of import and overtime in the two decades from 1992 to 2011. Thus, the question is then raised on what the relationship is between the cotton produced and exported by the seven major sources; how the price of cotton from one source affects the amount imported by China from another; whether weak separability exists among different sources and if so, what the separable structure is. To carry out such analysis involves estimating a demand system for imported cotton. In addition, institutional affairs such as the major global shortage in supply of cotton in 1993, China's accession to WTO in 2001 and the elimination of the Multi-Fiber Arrangement in 2005 are also to be taken into consideration. Integrating these patterns, the demand structure of China for imported cotton from various sources, and the substitutability and separability among them are to be investigated into.

1.4 Research hypothesis

The research assumes that the cotton imported by China are differentiated regarding the sources of export, which is justified as the quality and characters do vary between different cotton exporting countries according to the report released by the International Cotton Advisory Committee (ICAC) on the overall technology, production and marketing of cotton in the world (Wakelyn and Chaudhry, 2010). In order to perform the analysis described in Section 1.3, based on policy patterns and economic theories on the cotton market of China are the following research hypotheses:

1) The cotton, be it domestically produced or imported, is put into textile manufacture as an input because the main use of cotton is in that area and other applications of it in industries such as medicine, defense and mobile industry account for only a trivial ratio in total cotton consumption of China.
2) The cotton import is controlled by the Chinese Government for it is listed as a state trade commodity under TRQ limitation.
3) The Chinese Government utilizes imported cotton to fill the gap between the domestic production and the actual cotton need following the strategy of minimizing the total cost of importing cotton subject to the restriction that the total supply of cotton meets the total

demand.

1.5 Objectives

This thesis intends to analyze the demand structure of China. As stated in Section 1.4, an Armington-type origin differentiation is assumed, yet this study will take one step further to adopt a more generalized form than that of the Armington Model by relaxing the restriction that the elasticity of substitution among all the import sources is constant. Moreover, to institutional affairs mentioned in Section 1.3, a number of dummy variables are to be included in the model, leaving the degrees of freedom troublesome as the dataset of 20 annual data is relatively short in time series. Fortunately, the Constant Difference of Elasticity (CDE) functional form first introduced by Hanoch (1975) is suitable in this situation as it has relatively few coefficients. Another fact noteworthy is that with the frequentist econometric approach, some of the coefficients fail to satisfy the restrictions of validity laid by the CDE, and hence Bayesian Bootstrap Multivariate Regression (BBMR) algorithm developed by Heckelei and Mittelhammer (2003) is utilized to estimate the posterior distribution of the coefficients with the restriction of validity as the prior information. The specific objectives of this thesis are as following:

1) To estimate China's demand structure for imported cotton from different sources systematically;
2) To estimate the posterior mean and variance of coefficients with the Bayesian bootstrapping;
3) To estimate the probability with which the global validity restrictions are satisfied;
4) To estimate the substitutability and separability among various sources of imports;
5) To compare the performance of different separable structure.

1.6 Organization of the thesis

The remainder of the thesis is organized as following. In the second chapter, former work on Chinese cotton import demand will be briefly reviewed. In the third, the theoretical and empirical model will be determined. In the fourth, Bayesian econometrics and Bayesian bootstrap multivariate regression will be introduced. In the fifth, data and econometrical results will be explained and discussed. Finally in the sixth chapter, conclusion remarks will be addressed.

CHAPTER 2 – LITERATURE REVIEW

In this chapter, the literature relative to this thesis will be briefly reviewed. The chapter will be divided into four parts: the first will brief the researches on demand system and agricultural trade models; the second will review the studies about the international cotton market in a more general view; the third will include works concerning the cotton trade of China; the last will recall former investigations into cotton import demand.

2.1 Models for demand systems and the trade in agricultural products

The selection of functional forms and specification of demand systems could be traced back to Stone (1954), and after that, sets of models continued to be developed. Among them, the Rotterdam Demand System developed by Theil (1965) and Barten (1966) is one of the most promising demand models. It was so named as both Theil and Barten were in Rotterdam during the 1960s. The initiative of this model is that the demand system deems the expenditure share as a probability with which the consumers or producers will spend their one dollar on a commodity of input, delighted by the information theory and that the expenditure shares resemble probabilities for they are non-negative and can be summed up to one over all products or inputs. Then the demand function is formulated with the expenditure shares, prices as well as the quantity demanded for each individual commodities or inputs. The linear approximation to the Almost Ideal Demand System (LA/AIDS) model is also commonly used in demand analysis. It was introduced by Deaton and Muellbauer (1980) who based their specification of the demand functions on a particular family of preference, namely the PIGLOG class allowing "exact aggregation over consumers", instead of the fundament of an arbitrary utility or cost functions taken by the second-order approximation flexible demand systems, be it direct or not.

Both the Rotterdam Model and the AIDS Model have witnessed great numbers of applications, and many works then focused on the comparison of the two models. Alston and Chalfant (1993) discovered that in many cases, the two models ended up with similar results, and they furthered their study by developing a test for these two models and recovered that the U.S. meat demand rejected the LA/AIDS Model but not the Rotterdam Model. The authors emphasized that this is by no means evidence of superiority of Rotterdam over LA/AIDS as the test may as well lead to opposite results with another dataset, but this study did provide a rational standard to choose one of the two models against the other.

Concerning the more specific application of import demand structures in a trading perspective, Sarker and Surry (2006) gave a constructive review of literature in the intra-industry trade and differentiated products typically common in agricultural products, claiming that the neoclassical trade models such as the Hecksher-Ohlin-Samuelson model focused more on the supply side of international trading with homogeneity assumptions and thus had difficulties in explaining in trade of heterogeneous products and the intra-industry trade. Then the paper reviewed New Trade Theory coping with the challenges, and also introduced models dealing with differentiated products including the Armington Model and its generalization, as well as horizontal and vertical differentiation represented by Lancaster models.

The most common differentiation in trading agricultural products is featured by their nations of production. One of the most widely used models in empirical research in this area is the Armington Model first introduced by Armington (1969). In his inspiring paper, a two stage process modeled the demand for a product of the consumers whose utility function is assumed to be homogeneously weakly separable. In the first stage, the consumers maximize their utility by determining the consumption of each product subject to the income restriction; in the second stage, with the total quantity of the interested product decided, the allocation of the total consumption of it among various goods from different sources of origin is carried out referring to a demand function taking the Constant Elasticity of Substitution (CES) form.

After the Armington Model was introduced, countless empirical researches have been based on it, yet this model still has deficiencies. To begin with, as pointed out by Alston et al. (1990), the settings in the Armington Model were rejected by both the dataset from wheat imported by China, Brazil, Egypt, the former U.S.S.R and Japan, which accounted up to 51% of the total wheat import in 1984/85, and that from cotton imported by France, Italy, Japan, Taiwan and Hong Kong, by then the top five importing nations and regions of cotton. Thus the authors cast doubt on the appropriateness of taking the Armington restrictions for granted in studies on international trade.

Further more, Ito et al. (1990) examined Armington assumptions with the dataset from international rice trade with the importers aggregated into one and the exporters clustered into seven. The results of this study demonstrated that the homotheticity hypothesis in the Armington Model was rejected, along with the CES demand function that implies income elasticities equal to one. Yet this paper proposed potential adjustments that may save the Armington model from total rejection in studies concerning the trading of agricultural products, which opened the curtain of a series of researches attempting to modify and improve this model. Three major modifications were raised including: i) to estimate an extra aggregated import demand function before moving on to the second stage instead of estimating merely the demand function including both domestically produced and imported products; ii) to substitute the market share of different types of goods for the pure quantity in the second stage regression and iii) to specify the model properly so that the homotheticity and CES assumptions are satisfied. Improvement of the Armington Model in similar approaches can also be seen in studies such as Yang and Koo (1993).

Yet another critical defect of the Armington Model is that it permits no possibility to analyze separability among diverse sources of imports because it includes a CES function that restricted elasticities of substitution among all pairs of products to be the same and constant. Three different concepts of separability have been developed (Goldman and Uzawa, 1964), namely strong separability, weak separability and Pearce separability. To study the separable structure, the products in the demand system are further divided into subsets. Strong separability introduced by Gorman (1959) and Strotz (1959) indicates that the marginal rate of substitution between two products from any two subsets, including the case where the two subsets are the same, is independent on the quantity of consumption of products excluded from the two subsets. A second concept of separability is the weak separability defined by Strotz (1957) stating that the rate of substitution between two products in the same subset is independent on the quantity consumed of products out of it. The last separability is the Pearce separability introduced by Pearce (1961), which requires the marginal rate of substitution between two products in the same subset to be independent on the consumed quantity of any other product, be it in the same subset or not. Though the application of separability leads to loss of information caused by the restrictions of cross effect, it may still be beneficial to use separability for the possibility provided by it to ignore the cross effect with products out of the subset, but this conclusion must be established upon that plausible structures are introduced (Edgerton 1997).

The shortcomings mentioned above were fixed by the introduction of the CDE functional form developed by Hanoch (1975). The motivation of the new functional form is to maintain the flexibility of the so-called "second-order approximation" models such as the translog model developed by Christensen et al. (1973), while simplify them as their number of coefficients are proportional to the square of n, the number of products considered resulting in the boost of computational costs with the increase of n, which aggravates their performance rapidly. Hanoch assumed "implicit additivity" in his new model indicating that "the indifference or isoquant surfaces are strongly separable (additive) with respect to the n quantities, or the n unit-cost prices" (Hanoch, 1975, pp396). With this assumption, the model still uses relatively few coefficients, the number of which is proportional to n, instead of n^2 in the "second-order approximation" models, whilst exempts the more restrictive hypotheses in the CES framework of homotheticity and the same constant elasticity of substitution for all products, thus enabling an analysis of separable structures. Moreover, the model nests the CES form and other more restrictive models such as the non-homothetic CES model. Finally, unlike the case with flexible functional forms where only local validity of curvature can be satisfied, straightforward global and local validity restrictions are laid on the elasticities of substitution in the CDE model. Thus, the CDE functional form provides more possibilities in modeling importers' demand structures than the CES form used in Armington Model.

Several researches after have used the CDE functional form. Dar and Dasgupta (1985) estimated the production frontier of U.S. manufacture with Constant Ratios of Elasticities of Substitution (CRES) also introduced by Mukerji (1963) and CDE forms as well as their homothetic counterparts, CRESH (Hanoch, 1971) and CDEH, respectively. What was interesting was that both CRES and CDE reported similar results, and in the meanwhile, underwent similar problems such as insignificant estimates of coefficients. In the homothetic setting, the CRESH and CDE models ended up with almost equivalent estimates of elasticities of substitutions among inputs including labor, capital, materials and energy.

Surry (1993) studied the European Community animal feed with the CDE function and concluded that the CDE function form can be extended to a simultaneous estimation of the input demand coupled by the outputs supply function with a multi-input, multi-output technology. Furthermore, it can also substitute for the CES function in Computable General Equilibrium (CGE) models, which generalize the model for both production and consumption in international trade.

Surry et al. (2002) provided an application of CDE function in processed food demand in France where the original Armington Model was rejected. The study nicely reviewed the advantages of CDE functional form. Then it proposed an Armington style two-stage procedure to model the import demand system where the products were differentiated by their place of production, yet unlike in the Armington model, based on non-homothetic preference of consumers with regard to products originating from different sources. Similar framework will also be hired in this thesis to model the cotton import demand system of China.

2.2 Cotton markets and policies with an international perspective

Cotton is one of the major agricultural products with its vital role in textile and other industries, and it is also a critical source of income for a number of developing countries and their main exporting commodity. In this section, an attempt is made to outline the cotton market within the scope of international trade by briefly introducing the literature in this area.

Baffes (2004) gave an excellent description of the world cotton market before the year 2001, which is of considerable importance to this thesis, for in this year China acceded to the WTO, and marked the successive tremendous growth in its import of cotton. Within the four decades from 1960 to 2001, the global cotton production doubled from 10 to 20 million tons as a result of the progress in the quality of seeds and technologies of fertilizers and irrigation, complemented by the increasingly wide application of genetic modification technology in cotton. With the total growth area barely changed, the colossal increase in cotton production attributed almost entirely to the doubling in yields per hectare. Except for traditional producer countries of cotton such as the U.S.A., China, India, Central Asian countries and Francophone African countries, Australia emerged as a new significant producer whose cotton production was 325 times higher in the late 90s than it was four decades ago. The direct impact on cotton market of the boost in production was that the cotton price decreased considerably in the second half of the 20th century, with the real price in 2001 having decreased around 80% from 1950. This price decline was further aided by the ascending production and application of chemical fibers that almost tripled during the same two-score period. Such price plummet could be devastating to developing countries whose cotton sector plays a considerable role in their economies such as the West African countries, more notably in rural areas. Minot and Daniels (2005) concluded that the 40% decrease in world cotton prices in 2002 compared to those in 2001 led to an 8 percent higher short run rural area poverty in the West African country Benin, with the long run effect leveling at 6 to 7 percent. However, agricultural labor employment did not appear to be strongly affected by the world cotton prices in Benin, as the cotton growth will be transferred to the growth of other agriculture products, which had comparable labor intensity to that in cotton sector.

The price of cotton has demonstrated yet another pattern that its volatility varied in four sub-periods, namely before 1973, from 1973 to 1984, 1985, and afterwards. The price saw more uncertainty in the second period than in the first, which decreased in 1985, and increased after that year once again to twice the level of that before 1973. According to Hudson and Coble (1999), the time-to-maturity alone had little explanatory power in volatility of the cotton trade prices. Meanwhile, weather was also insignificant as cotton growth is widely dispersed, which may have made the influence of weather "indifference" with a global point of view. Thus, to explain the pattern of volatility in cotton, one may need to focus more on the demand and supply changes taking place in the international market, which, unfortunately, has been observed to be rather different from year to year, leaving it difficult to decide the best model of explaining and predicting price volatility in cotton trade within a long term framework.

With such importance of the cotton market, relative policies should not be overlooked. The United States, China and the European Union are the three producers with the biggest economy, and all were supporting their cotton sectors with a variety of measures. Such policies of exporting cotton producers led to the domestic price of the U.S.A. in 2001 91% higher than the world price and that of Greece and Spain, the two main producers in the EU, 144% and 184% higher, respectively. (Baffes, 2004) Such supporting policies of the big producers in the cotton market spelled devastating influence on those less developed with cotton production being a main source of income, especially African cotton producers such as Benin, 40% of whose total export and 7% of GDP was contributed by its cotton sector. Studies concluded that if all the supporting policies were to be removed, the world cotton price would have risen by 12.7% within a decade after 2001, and the production in all producers would have increased with the exception of the U.S.A. and EU, and the less developed cotton producing countries actually had been coping with them by different means as introducing an offsetting support and requiring for their abolition through WTO. Despite this, these supporting were not likely to be completely removed. The United States Department of Agriculture (USDA) introduced a Farm Bill in 2002 that would not expire until 2007 ensuring the cotton growers a minimum price that was more than fifty per cent higher than the world price by then. As for the EU, cotton supporting policy was perceived as countermeasures to poverty with most cotton growers in Southern Europe where the income was relatively low. The inertia of the supports given to EU cotton sector was maintained also by the absence of potential budge expansion in subsidy because no potential new entrant to the EU was cotton producer. Fortunately, to some extent, the negative impact on less developed cotton producing countries of the supporting policies by their more developed counterparts were compensated by the elimination of Multi-Fiber Arrangement and the international cooperation programs, aside to the reform in policies within these countries leaning to the cotton sector.

Concerning the protective measures that main players in the world cotton market are taking involves almost the all ranges of trade distorting policies. The two biggest producer and trader of cotton, the U.S.A. and China, have both been heavily engaging in protecting their cotton sectors with the U.S.A. providing subsidies to cotton producers on the export side and China introducing a TRQ system on the import side.

Among the supporting policies on cotton sector, the Step 2 Program introduced by the U.S.A was one of the most enthusiastically studied. In 2003 it was challenged by Brazil to WTO, seconded by African cotton producers and Australia, which almost two years later was supported by the WTO appellate body in 2005 nearly completely. The USDA responded with a policy adjustment that called for the abandon of the Step 2 Program. Pan et al. (2006) predicted the potential influence on the international cotton market of removing the U.S. cotton subsidy with a partial equilibrium model[1]. Results demonstrated that the effect on cotton production and export of such liberalization of trade distortions from the U.S.A. would not be evenly distributed among all other producers of cotton, among which Brazil would see a 2% increase of cotton export, Australia around 1% and African cotton producing countries would hardly benefit from it. In addition to its uneven distribution, the estimated increase of world cotton price of the scenario was relatively small in comparison with former researches, a mere 2.39% in the second year, and would not last long for the average of price increase was to be only around 1% over the five years to follow. Thus, the long term results were likely to be a slightly reduced world cotton production and trade with practically little change in the world price.

Though it was the U.S. cotton support program that had been petitioned by Brazil and other exporting countries against within the WTO, Pan et al. (2005a) claimed that more serious suppression of world cotton trade was caused by China's TRQ system. In comparison to the scenario introduced above where the U.S.A. removes its cotton subsidies, the assumption that China abolished its TRQ would result in the price to increase by 5.17% one year after the

[1] This model developed by Pan et at (2004) allows analysis of the international fiber market.

liberalization, and the five-year average would be 2.74%, both more than twice higher than the estimation of eliminating the U.S. subsidies. Regarding the cotton production and trade, the repercussion of removing the Chinese TRQ system would contradict that of the elimination of the U.S. subsidies, for the former would result in an expansion of both cotton production and trade. Brazil again would be the biggest winner in this scenario with an export increase of 3.24%, followed by the African cotton producing countries, and even the U.S.A would enjoy a slight export increase.

Pan et al. (2007) took one step further to analyze the situation of cotton trade in an absolutely free-trade market with the elimination of all trade distorting policies including domestic support for the cotton sector and border barriers in any form. Except for the common, economic-theory proving result that the removal of all trade distortions would lead to an increase in world cotton price of 10.50% and a 2.69% growth in total cotton trade within five years, a more noteworthy contribution of this study was that it provided diversifying conclusions on countries with different current policy settings. On the export side, elimination of all trade distortions would lead to an expansion of export in countries with a relatively low level of support for cotton sector prior to the occurrence of trade free-up, which was the case for most cotton exporters except for the U.S.A.; with no surprise, the opposite would take place for the United States that was currently holding a large support for its cotton production. On the import side, the situation would be reversed with textile industries, the main sink of cotton import, of countries holding low duties being worse off, yet those with comparatively high original domestic support benefiting from a free trade cotton market as the overall cost for raw cotton to produce textiles would be lower.

As stated above, the price of cotton has been more volatile since the mid 1980s, and naturally studies have also been following this trend. Fadiga and Misra (2007) decomposed the prices of cotton along with other fibers into two dimensions, trend and cyclical. The price of cotton appeared with a stochastic behavior that was transitory and permanent, and if the former characteristic prevailed, shocks would last, if opposite, shocks would be temporary. Another interesting conclusion was that though at the first sight the production and price of cotton would be heavily dependent on that of the polyester, yet such relation was not backed by the study, leading to a potential method in which cotton demand could be enhanced by reducing the price of cotton relative to that of polyester. Aside from studies concerning cotton prices from a market perspective, Mutuc et al. (2012) took an unusual viewpoint to analyze the relation between the climate change and cotton prices. It was recovered that if the global temperature rises by 1°C, a 6% increase in cotton price would occur, and if the scenario was changed into a more extreme one with 5°C rise in global temperature, the cotton price would witness a dramatic 135% rocket.

2.3 Cotton trade of China

Cotton is a vital agricultural product to China because it is both one of the major output of China's agriculture and the main input of its textile industry, which partly explains that fact that before China acceded to the WTO in December, 2001, its cotton trade, and actually most other agricultural trade, had always been government-administrated through STEs. Yet after that, China has committed itself to transform its cotton trade management by phasing into a TRQ system so as to limit the level of control power owned by the national government over the trade flows. Just one year later, Lohmar and Skully (2003) argued that despite the admitted potential possibility, this newly introduced system could not be proved to be significantly impeding the overall agricultural trade. Ge et al (2010) also indicated that the relaxation of policies restrictions on cotton trade from the Chinese Government, together with China's exchange regime recently reformed to be more flexible led to the close connection between the cotton future prices on Chinese and U.S. exchange markets represented by the price transmission and similar volatilities shared by the two markets.

However, even the current TRQ system still lays rather restrictive effects on China's cotton market. Vlontzos and Duquenne (2007) provided evidence to the competitiveness of the domestically produced cotton on China's cotton market, as a result of the internal cotton policies held by the Chinese government that kept the price of domestic cotton lower with a sliding duty tariff on imported cotton. As such competitiveness was due to the governmental policies instead of market behaviors, this conclusion is very important for this study as it justifies the assumption that the Chinese Government tends to ensure the domestic cotton production and deems the cotton import as a complement to the former in order to meet the total demand.

Naturally, the domestic cotton production of China can then also influence the cotton import demand of the country. What has been enhancing the competitiveness of Chinese production of cotton in recent years is a genetically modified new breed of cotton named Bacillus thuringiensis (Bt) cotton. Genetic technology is up till now under fierce debate as some experts were concerned that it may lead to potential harms to human beings when it was applied to food product. However, this is not considered a problem in cotton as it is not used in foodstuffs. Pray et al. (2001) studied 283 cotton farms located in Northern China, and concluded that the Bt cotton benefits those farms where it was grown, especially small ones, as it reduced production costs by 20% to 23% mainly with less pesticide usage. Though the surplus profit was not enjoyed by the consumers for the price for Bt cotton and that of other cotton categories were practically the same controlled price held by the government, it may still improve the competitiveness of the Chinese domestic cotton for the extra profit may lead to more production and squeeze out the demand for imported cotton under the protective policies introduced by Chinese Government before its accession to the WTO. This was verified by Fang and Babcock (2003) who claimed that without the policy adjustment after China's accession to the WTO, the Bt cotton adoption would have decreased the cotton import of the country. Nevertheless, this squeeze effect was to be overwhelmed by the huge growth of cotton demand after policy changes succeeding the WTO accession, and with the two affairs combined, the quantity of cotton imported by China will further increase even with the adoption of Bt cotton.

In addition to the domestic cotton policies and genetic engineering, international affairs also influenced China's cotton trade. With the elimination of the Multi-Fiber Arrangement as an agreement achieved by the Uruguay Round negotiation since 2005, import of textiles and apparels into developed countries such as the U.S.A. and Canada will be less restricted for developing countries including China. With the tight connection between textile industry and cotton, this international agreement was almost sure to lay great impact on cotton market, and as China was, and still is, the biggest textile producer, such impact on Chinese cotton market was extraordinarily worth mentioning. McDonald et al. (2010) obtained an estimated 1% growth in cotton import of China within a decade as the elimination of the Multi-Fiber Arrangement was estimated to increase China's textile production by 6%, consistent with the results of other works such as Yang et al. (1997).

2.4 Former works on demand structure in cotton trade

After the introduction of the two-stage Armington model, it was applied to agricultural trade for its merit in differentiating products by their origins, which fits agricultural products inherently. Concerning cotton, Babula (1987) first applied the Armington procedure to the demand of U.S.

exported cotton produced in various regions, through which he coped with criticisms raised upon researches on agricultural international trade that economic theories had been neglected. Additionally, he dealt with the claim that the estimate ranges of parameters in the Armington model were too wide, and that ordinary least square (OLS) is inappropriate to estimate the model. In this study the Armington model was estimated with both OLS and seemingly unrelated regression (SUR), and it turned out that both estimates provided fine estimations, and the OLS even outperformed SUR at predicting the demand for exported U.S. cotton not included in the data.

With other demand system models available, economists also developed studies with them on cotton. Chang and Nguyen (2002) evaluated the competitiveness of Australian produced cotton in Japan market. With the AIDS model, they paid special attentions to the two biggest exporter of cotton to Japan, namely the U.S.A. and Australia. The results indicated that the total quantity of cotton imported by Japan influenced the market shares of these two countries, yet the behavior of the cotton from them did differ from each other with the U.S. cotton demonstrated higher income elasticity and that from Australia greater price elasticity. Besides, there emerged, as reported, a potential trend that if the relative price of the U.S. cotton decreased with respect to the Australian one, the demand for the former would increase at a larger scale than that of the latter shall the situation reverse, leading to a conclusion that the quality highly influenced the market share of cotton from the two countries, and Australia could improve its cotton export to Japan if it was able to better its cotton quality.

From the view of the final consumable form of cotton, which mostly is the textile, McDonald et al. (2011) investigated the effect on China's cotton demand of a raise in the minimum wage in the country by estimating the demand system of textile of China taking a Nonlinear Quadratic AIDS functional form. They estimated an income elasticity of around 0.6 for the domestic textile consumption. It was also predicted that the domestic demand growth for textile would cause a decrease in the textile export of China, but it would be make up with more textiles produced within other countries. The overall Chinese cotton import would be enhanced slightly by the raised minimum income implying that the bigger domestic demand for textile would outstrip the decreased export.

Similarly, Lopez and Malaga (2004) also explore the cotton final "consumption" demand of the

European Union (EU) that was at that time the largest importer of cotton, but they took a more radical approach by basing their study on the AIDS demand system with home uses data instead of the normally used mill consumption in order to capture the demand for fibers including cotton at the consumers' end. They avoided aggregating the by then 15 members of the EU to explicate the different relations between cotton and wool, viewed as a competing commodity of cotton. The Hicksian cross price elasticities revealed whether cotton and wool appeared to be complements or substitutes to each other, and the results seemed to be divided among different EU member countries, as the two commodities complement each other in some countries and substitute in other members. The non-aggregated data also furnished the expenditure elasticities of cotton that had never been published by former literature, which, similar to the cross price elasticities, varied among the EU countries, for in some of them cotton was a normal luxury commodity while a normal necessary one in the others.

However, as cotton is mostly used as an intermediate material in textile industry but not a final consumption commodity, it could be valuable to construct a demand system that allows analysis of trade in intermediate agricultural products. During studying the Japanese textile industry, Pick and Park (1989) integrated the demand for inputs such as cotton and labor, as well as the supply for final products that were textiles into one system based on production theory through a cost minimizing or profit maximizing procedure. With a profit function taking the normalized biquadratic form being maximized, the authors derived the demand functions of imported cotton and required labor in the section, companied by the export supply functions of textiles. This procedure opened up a more specific route to estimate the demand for agricultural products with intermediate features rather than to somewhat unreasonably equalize them to final goods, because the industry in which the intermediate agricultural products would serve as inputs should also be taken into consideration to more accurately uncover the demand structure of them.

2.5 Conclusion

In this chapter, the literature concerning the cotton import demand has been reviewed. Within the first section, the Armington Model was introduced and its deficiencies pointed out, which can mostly be remedied by the introduction of the CDE functional form. In the second section, the literature on world cotton market demonstrated that the cotton trade was rather highly distorted by major players, including China, with their governments' policies mostly supporting the domestic production of cotton. The third section summarized former studies on China's cotton import structure, where the domestic cotton was still heavily protected by the government and thus justifying the introduction of the assumption that the domestic cotton was preferred over imported cotton by the Chinese Government that has, at least to some extent, the power to determine the cotton import of the country. The fourth section briefed the former works on cotton import demand, with an interesting perspective in which cotton is viewed as intermediate product instead of a final consumption one.

CHAPTER 3 – THEORETICAL AND EMPIRICAL MODELS

In this chapter, the theoretical model will first be derived based on the research hypotheses stated in Section 1.4. The assumption has been made that cotton serve as the input to produce textiles, so the model will be based on producer theory instead of the more common import demand models concerning directly consumable products. Then the specification of the empirical model will be determined taking affairs in international cotton market into account.

3.1 Theoretical model of cotton import of China

As described in Section 2.1, the Armington procedure provided a powerful method for modeling the trade in products that can be differentiated by their regions of production in a two-stage procedure. This study employs a theoretical model, the nature of which is similar to the Armington.

The Chinese textile industry is of interest in this thesis, for as stated in Section 1.4, both the domestically produced and imported cotton in China is assumed to be inputs of the textile industry. The textile industry of China is then modeled as a producer who minimizes its cost by adjusting the combination of inputs such as cotton, labor and capital to produce the demanded quantity of textiles for the domestic and international markets. Suppose that the production function of China's textile industry takes the following form:

$$Y = f\left(K, L, TD, TI\right) = f\left(K, L, TD, TI\left(q_1, q_2, \cdots, q_m\right)\right) \qquad (3.1)$$

In Equation 3.1, Y is the quantity of production in textiles; K is the amount of input in capital, L that of labor; TD the amount of domestically produced cotton, TI that of the imported cotton; q_m is the quantity of cotton imported from the source m. It has been assumed that the Chinese Government prefers domestically produced cotton over imported cotton, which was justified by that the policies currently in practice such as the sliding duty tariff insure that the price of domestic cotton is lower than that of the imported (Vlontzos and Duquenne, 2007). In this sense, the cotton import is used to close the gap between domestic cotton and the actual demand, and thus when cotton goes into the production function as a material input, the domestic and imported cotton is separated and weak separability is assumed between the cotton imported from the m sources and the other inputs in the textile industry. With the economics theory, it is reasonable to assume the cost function of textile production is homogeneous of degree 1 with the prices of all the inputs. Accordingly, the cost function of the Chinese textile industry can be written as:

$$C\left(w_K, w_L, w_D, w_I\left(p_1, p_2, \cdots p_m\right), Y\right)$$

$$= \min\{w_K K + w_L L + w_D TD + w_I TI\} \quad s.t. \quad Y = f\left(K, L, TD, TI\right) \qquad (3.2)$$

In Equation 3.2, C is the cost function of textiles production; w s are the price of the inputs; p_i is the price of cotton imported from the source of import i. It is assumed that the cost function is second order differentiable, so that the minimum can be decided.

In the second stage, with the costs on each types of input decided, the total expenditure of cotton will be further allocated among different sub-categories of cotton from various source of production. Similarly, it is also a cost minimizing process, and it is also reasonable to assume the cost function of cotton import is homogeneous of degree 1 with the prices of cotton from each and every individual source of import.

$$CI\left(p_1, p_2, \ldots, p_m, TI\right) = \min\{p_1 q_1 + p_2 q_2, \cdots, p_m q_m\}$$

$$s.t. \quad TI = TI\left(q_1, q_2, \cdots, q_m\right) \qquad (3.3)$$

In Equation 3.3, CI is the total cost on imported cotton; p_i and q_i are the price and quantity of cotton from the ith import source. This minimization subjects to that TI, the total import quantity of cotton is satisfied with a function of the quantities of cotton imported from all the sources. This leads to an expression of the optimal quantity of import from different sources according to Hotelling's Lemma: $q_i\left(p_i, CI\right) = \partial CI / \partial p_i$ for $i = 1, 2, \cdots, m$. Clearly the expenditure on each sub-category of imported cotton is dependent on the individual price and the total expenditure on imported cotton.

Succeeding to the determination of total cotton import and its cost, the unit cost of cotton import could be derived by taking another equivalent form of Equation 3.3.

$$CI\left(p_1, p_2, \cdots, p_m, TI\right) = c\left(p_1, p_2, \cdots, p_m\right) \cdot TI \qquad (3.4)$$

In Equation 3.4, c is the unit cost of cotton import that is dependent on the individual prices of cotton imported from the main sources of import. Under competitive settings, the unit cost of cotton import equals to the aggregated imported cotton price function p. In the case of cotton import, as it has been assumed that the cost function is homogeneous of degree 1 with the prices of cotton. Thus, there is the following relation between the unity cost and the aggregated cotton import price:

$$p = c(p_1, p_2, \cdots, p_m) \Rightarrow c\left(\frac{p_1}{p}, \frac{p_2}{p}, \cdots, \frac{p_m}{p}\right) \equiv 1 \qquad (3.5)$$

3.2 The CDE functional form

The CDE functional form is selected in this research for the unit cost function because of its advantages of allowing non-homothetic separable structures, as well as its less numbers of coefficients than other flexible functional forms. As stated before, the cost function is homogeneous of degree 1, hence in this study the homogeneous indirectly implicitly additive CDE function introduced by Hanoch (1975) is taken:

$$\sum_{i=1}^{m} G_i(w_i, c) = \sum_{i=1}^{m} B_i w_i^{b_i} = \sum_{i=1}^{m} B_i \left(\frac{p_i}{p}\right)^{(1-\alpha_i)} \equiv 1 \qquad (3.6)$$

In Equation 3.6, B_i is the distribution parameter; $\alpha_i = 1 - b_i$ is the substitution parameter; p_i is the price of the cotton from the i^th source of import; p is the aggregated price index of all imported cotton; w_i is then the price of the cotton from the i^th source of import normalized by the aggregated price of imported cotton. Obviously, the homogeneous CDE functional form has two parameters for each sub-category of cotton, and thus the total number of parameters for m different cotton is $2m$.

With the homogeneous CDE functional form, the global validity of the cost function can be tested with the following restrictions as proved by Hanoch (1975):

$$B_i > 0 \quad and \quad b_i < 0 \quad for \quad all \quad i = 1,2,\cdots,m$$

$$or \quad B_i > 0 \quad and \quad 0 < b_i < 1 \quad for \quad all \quad i = 1,2,\cdots,m \qquad (3.7)$$

The CDE cost function can be then linearized with the Roy's Identity (Roy, 1947).

$$S_i = \frac{w_i \dfrac{\partial G_i}{\partial w_i}}{\sum_{j=1}^{m} w_j \dfrac{\partial G_j}{\partial w_j}} = \frac{b_i B_i w_i^{b_i}}{\sum_{j=1}^{m} b_j B_j w_j^{b_j}} \qquad (3.8)$$

S_i is the expenditure share of the cotton imported from the i[th] source of import. Taking S_m as the numeraire, the logarithm linear CDE cost function could be obtained:

$$\log(S_i) = \log\left|b_i B_i w_i^{\ b_i}\right| - \log\left|\sum_{j=1}^{m} b_j B_j w_j^{\ b_j}\right|$$

$$\log\left(\frac{S_i}{S_m}\right) = A_i + b_i \log\left(\frac{p_i}{p}\right) - b_m \log\left(\frac{p_m}{p}\right)$$

$$where \quad A_i = \log\left(\frac{B_i b_i}{B_m b_m}\right) \qquad (3.9)$$

Worth noticing is that if $b_i = b_2 = \cdots = b_m$, then the CDE functional form will be reduced to the CES form and the procedure taken in this thesis will be the same as the Armington Model. Thus, the procedure taken in this thesis is by its nature a generalized Armington Model.

In order to explicate the substitution effects, the Allen elasticities of substitution (AES) could be derived with the parameters in the CDE functional form according to Hanoch (1975), which is the ratio between the percentage change in the demand for the cotton imported from one source and the percentage change in the total expenditure caused by the percentage price change of the cotton imported from another source:

$$\sigma_{ij} = \frac{\partial \log q_i}{\partial \log c} = \frac{\partial \log q_i / \partial \log p_j}{\partial \log c / \partial \log p_j} = \frac{1}{S_j}\frac{\partial \log q_i}{\partial \log p_j} = \alpha_i + \alpha_j - \sum_{l=1}^{m} \alpha_l S_l - \delta_{ij}\frac{\alpha_i}{S_i}$$

$$\delta_{ij} = 1 \;\; if \quad i = j; \;\; \delta_{ij} = 0 \;\; if \quad i \neq j \qquad (3.10)$$

In Equation 3.10, σ_{ij} is the Allen partial elasticity of substitution between cotton imported from the i[th] source and that from the j[th] source (Hanoch 1975). The expenditure elasticities could also be calculated, but as we are taking a CDE functional form that is homogeneous of degree 1 here, it is restricted to be 1 for all sub-categories of cotton import.

3.3 Weak separability

Weakly separability is commonly discussed in demand systems. Within the cost functions (or utility functions for consumers), weak separability could be intuitively demonstrated in the following form:

$$c = c\left(c_1\left(p_{11},\cdots,p_{1n_1}\right),\cdots,c_k\left(p_{k1},\cdots,p_{kn_k}\right)\right) \qquad (3.11)$$

In Equation 3.11, c is the unit cost function; c_i, $i = 1,2,\cdots,k$ is the unit cost function for the i^th^ subset and the p_{ij} is the price of the j^th^ product in the i^th^ subset. The CDE functional form also allows the separable structures among different sources of import to be assumed and tested with the model. If the m products $x_1, x_2, \cdots, x_m$ are separated into k subsets $S_1, S_2, \cdots, S_k$, as stated in Moschini et al. (1994), separability could be tested with the restriction:

$$\sigma_{lm} =, \sigma_{sn}\, x_l, x_s \in S_i, \quad x_m, x_n \in S_j, \quad i \neq j, \quad for \quad all \quad l,s,m,n \qquad (3.12)$$

In Equation 3.12, σ is the Allen elasticities of substitution. Keeping the definition of Allen substitution elasticities in mind, claiming two products x_i and x_j in the same subset thus is equivalent to setting $b_i = b_j$, where b s are the same in the CDE functional form defined in Equation 3.6

3.4 Empirical model

3.4.1 Model specification

The empirical model specification in this thesis is designed to capture the features of cotton imports of China during the period of 1992 to 2011, which not only has to take the policy regime into consideration, but also the institutional affairs that occurred during the period of interest in the international cotton market. The preference of the Chinese Government to domestically produced cotton over the imported has been reflected in the first stage of the procedure as domestic and imported cotton was treated differently, and cotton imports were used to fulfill the gap between domestically produced cotton and the total cotton demand.

The following affairs are to be taken into consideration in the specification of the model. Firstly, there was a major shortage of supply of cotton in year 1993; secondly, China acceded to the WTO in December, 2001; thirdly, the Multi-Fiber Arrangement was eliminated in the end of year 2004. Accordingly, three dummy variables will be introduced in the model for each and every one of the three major affairs that took place during the two-decade period: one for the year 1993, one for the year 2002 and afterwards and yet another for the year 2005 and afterwards.

Another important hypothesis to take into consideration is that the cotton imported is used as an input in textile industry, and in this procedure, linear homogeneity is assumed with respect to the cotton input. Because cotton in the most basic material used to produce textile, it transfers into textile with certain proportion, so under the given technology and the composition of a textile output, it is hard to imagine that a ratio change in the quantity of cotton input will lead to a different ratio change in the quantity of textile output. A time trend will be included to reveal the relation between the current and lagged expenditure share of cotton from different sources of import, as well as to fix the potential omission of variables, and the products of the time trend and the dummy variables for China's WTO accession and the abolition of Multi-Fiber Arrangement will also be comprised in the model.

These assumptions and requirements then lead to the specification of the unit cost function:

$$\log\left(\frac{S_i}{S_7}\right) = \alpha_i + \beta_{1i}\cdot D93 + \beta_{2i}\cdot DWTO + \beta_{3i}\cdot DMFA + \beta_{4i}\cdot DWTOT + \beta_{5i}\cdot DMFAT$$
$$+ \beta_{6i}\cdot T + b_i \log\left(\frac{p_i}{p}\right) - b_7 \log\left(\frac{p_7}{p}\right), \quad for \quad i = 1,2,\cdots,6 \qquad (3.13)$$

It has been mentioned in Section 1.2 that there are seven major sources of cotton import for China, and in the demand system that consists of six equations represented by Equation 3.13, $i = 1$ stands for West Africa, $i = 2$ for Egypt and Sudan, $i = 3$ for Central Asia, $i = 4$ for Indo Sub-Continent, $i = 5$ for Australia, $i = 6$ for the U.S.A. and $i = 7$ for the rest of the world (ROW). As for some countries such as Benin, the quantity of cotton imported by China is 0 for some years, and thus an aggregation was practiced to overcome this problem, and the aggregation pattern was by geographic location of the countries, which seems plausible with agricultural products as cotton. In this equation system, α_i is the intercept; $D93$ is the dummy variable for the supply shortage in world cotton market that takes the value 1 for year 1993 and 0 for the rest years; $DWTO$ is the dummy variable for China's accession to the WTO in the end of 2001 that takes the value 1 from year 2002 to 2011 and 0 from 1992 to 2001; $DMFA$ is the dummy variable for the elimination of the Multi-Fiber Arrangement in the end of 2004 that takes the value 0 from year 2005 to 2011 and 1 from 1992 to 2004; $DWTOT$ and $DMFAT$ are the product of $DWTO$ and $DMFA$ with the time trend T, respectively. $\log(p_i/p)$ and $\log(p_7/p)$ are the prices of cotton imported from various sources designated above that are normalized by the aggregated price, which takes the form of the Stone price index.

3.4.2 Weak separability

To explore the separability in China's cotton import demand, three separable structures will be introduced to the demand system, and these structures will be tested. The performance and the influence on the model of the separable structures will be reported and discussed in the following chapters of the thesis.

The first structure separates the cotton from different sources of import into three subsets. The cotton from West Africa and Egypt and Sudan will be put in the same subset, which stands for the cotton imported from Africa; the cotton from Central Asia and Indo Sub-Continent will be placed in the same subset, thus the cotton from Asia; the cotton from Australia, the U.S.A. and the ROW will be set together in one subset, which is the cotton from other cotton import source. Hence, the cost function of this separable structure is:

$$c = c\left(c_1\left(p_1, p_2\right), c_2\left(p_3, p_4\right), c_3\left(p_5, p_6, p_7\right)\right) \qquad (3.14)$$

The restrictions for this separable structure then are $b_1 = b_2, b_3 = b_4, b_5 = b_6 = b_7$.

The second structure separates in the following manner: the cotton from West Africa and Egypt and Sudan in a subset Africa, the cotton from Central Asia, Indo Sub-Continent and the U.S.A. in a subset Asia and the U.S.A., the cotton from Australia and the ROW in a subset other sources. Accordingly, the cost function of this separable structure is:

$$c = c\left(c_1\left(p_1, p_2\right), c_2\left(p_3, p_4, p_6\right), c_3\left(p_5, p_7\right)\right) \qquad (3.15)$$

The restrictions for this structure are $b_1 = b_2, b_3 = b_4 = b_6, b_5 = b_7$

The third structure has the following three subsets: the cotton from West Africa, Egypt and Sudan and the U.S.A., thus Africa and the U.S.A., the cotton from Central Asia and Indo Sub-Continent in a subset as Asia, the cotton from Australia and the ROW in a subset as other sources. Thus, the following cost function holds with this separable structure:

$$c = c\left(c_1\left(p_1, p_2, p_6\right), c_2\left(p_3, p_4\right), c_3\left(p_5, p_7\right)\right) \qquad (3.16)$$

The restrictions for this separable structure are $b_1 = b_2 = b_6, b_3 = b_4, b_5 = b_7$.

CHAPTER 4 – ECONOMETRIC APPROACH

In this chapter, the methodology in this thesis is stated. Firstly, the basic concepts of Bayesian econometrics will be introduced; secondly, the BBMR algorithm will be presented; finally, the estimation methodology will be described in the context of China's import demand system for cotton.

4.1 A brief introduction to Bayesian econometrics

In this section, a brief outline of Bayesian econometrics will be provided with respect to the development and application of the method, as well as its difference with the traditional frequentist econometrics.

4.1.1 Bayes Theorem

The foundation of Bayesian econometrics as a recently developed econometric branch could be traced back to much earlier to the famous Bayes Theorem. The theorem was named after the English mathematician Thomas Bayes, who formulated a specific case of what was to become one of the most widely used theorem in mathematical statistics, the Bayes Theorem. Though Bayes himself never published the study, his work was edited by Richard Price, whose paper was published posthumously. Finally, the current form of the theorem was further consummated and published in 1812 by the French mathematician Pierre-Simon marquis de Laplace in his *Théorie analytique des probabilités*. The modern form of the Bayes Theorem is as follows:

$$\Pr(A \mid B) = \frac{\Pr(B \mid A)\Pr(A)}{\Pr(B)} \qquad (4.1)$$

In Equation 4.1, $\Pr(A \mid B)$ is the probability of event A taking place conditional on event B, and similarly is $\Pr(B \mid A)$ defined. $\Pr(A)$ and $\Pr(B)$ are respectively the unconditional probabilities with which event A and B occur. In the theorem, $\Pr(A)$ is called the prior probability, or prior, and $\Pr(A \mid B)$ is referred to as the posterior probability, or posterior. This theorem is the foundation of Bayesian econometrics.

4.1.2 The Bayesian econometrics in comparison to frequentist econometrics

Bayesian econometrics is relatively new in econometric analysis and is rapidly becoming popular in economic research. Prior to the 1970s, Bayesian methods were not very widely applied in economics studies mainly because of the restriction in computing complexity with the approach.

However, with the significant growth in computer capabilities, economists have attached increasing attention to Bayesian methods. Zellner (1971) authored the first comprehensive book introducing Bayesian methods, and the textbook of Koop (2003) provided a more modern view on Bayesian econometrics.

The most fundamental feature that distinguishes Bayesian econometrics to frequentist econometrics is that in the latter, parameters are deemed fixed values and the estimators of them are random, whilst in the former, parameters themselves are considered to be random. Thus, with Bayesian methods, the estimation is not on the value of the parameters, but rather their posterior distribution, combining the prior information with the information contained in the data in the form of the likelihood function. In Bayesian econometrics, Bayesian Theorem takes another form (Koop, 2003)

$$\Pr(\theta \mid y) = \frac{\Pr(y \mid \theta)\Pr(\theta)}{\Pr(y)} \qquad (4.2)$$

In Equation 4.2, θ is the matrix of parameters and y is the vector of data that is to be explicated by the parameters. Thus, $\Pr(\theta \mid y)$, the posterior distribution of the parameters is then the probability that they take certain values conditional on the data that is observed. $\Pr(y \mid \theta)$, known as the likelihood function, depicts how the data observed is "generated". The prior information, $\Pr(\theta)$, is what is already known or believed by the researchers before the data is obtained. As $\Pr(y)$ is constant once the data is given, Equation 4.2 could be abbreviated as indicating that the posterior distribution is proportional to the product of the likelihood and prior.

$$\Pr(\theta \mid y) \propto \Pr(y \mid \theta)\Pr(\theta) \qquad (4.3)$$

Here $\propto$ stands for "proportional to".

With the posterior distribution of the parameters, $E(\theta_i \mid y)$, the posterior mean and $\operatorname{var}(\theta_i \mid y)$, the posterior variance of θ_i, a parameter in θ could be derived with the following formulation:

$$E(\theta_i \mid y) = \int \theta_i \Pr(\theta_i \mid y) d\theta \qquad (4.4)$$

$$\operatorname{var}(\theta_i \mid y) = E(\theta_i^2 \mid y) - E^2(\theta_i \mid y) = \int \theta_i^2 \Pr(\theta_i \mid y) d\theta - \left(\int \theta_i \Pr(\theta_i \mid y) d\theta\right)^2 \qquad (4.5)$$

The advantages of Bayesian methods are multifold. The one that is the most significant for this study is that with frequentist econometrics, only the information contained by data is explored and explicated; on the contrary with Bayesian methods, the believes held by the researchers out of experiences or economic theories could be integrated into the estimation of the parameters' posterior distribution by the inclusion of prior information. Chalfant et al. (1991) imposed concavity and monotonicity restrictions on the expenditure functions of consumers taking an inequality form with prior information to estimate the Canadian meat demand system with the AIDS model. Montgomery and Rossi (1999) estimated price elasticities in a demand system with multiple brands and stores applying the prior information derived from the additive utility functions by hierarchical Bayesian methods, the results from simulation and real datasets revealing that the performance with this approach outstripped that of other Bayesian and non-Bayesian estimation. This advantage will feature as an important one in this study, the reason of which is to be further explained in the upcoming section.

4.2 Bayesian bootstrap multivariate regression (BBMR)

The specific technique that will be used in this thesis is Bayesian bootstrap multivariate regression (BBMR) introduced by Heckelei and Mittelhammer (2003). This section is devoted to introduce this algorithm.

4.2.1 The development of BBMR

Bootstrap is a technique to generate sampling distribution of parameters, which was first introduced by Efron (1979). It was natural that the Bayesian analogue was then developed, known as the Bayesian bootstrap, which applies bootstrap technique to the former Monte Carlo integration (MCI) that is also widely used in researches with Bayesian methods. Kloek and Dijk (1978) used Monte Carlo to draw the posterior distributions of parameters, aiming at solving the Bayesian methods' unpleasant characters of in medium sample size. Zellner et al. (1988) developed the MCI algorithm for models with potential endogeneity and consequently identification problems to obtain the posterior distribution of reduced form and structural parameters.

Bayesian bootstrap (BB) was introduced by Rubin (1981). BB could serve to overcome the difficulties that Bayesian methods encounter when applied to a relatively small sample with a complex or unfamiliar population distribution as the original sample is bootstrapped to generate a bootstrap sample, and posterior distributions are allocated to bootstrap sample.

However, as pointed out by Heckelei and Mittelhammer (2003), the kernel of the posterior allocation procedure was generated by ordered random values from a uniform distribution from 0 to 1. Accordingly, it is the inherent feature of the BB method that its posterior distribution is tightly connected with the Dirichlet distribution, impeding its application to parameterized equation systems. In the contrast, BBMR method bootstraps the likelihood function without the necessity to determine the form and specification of the likelihood function itself; it fits a wider range of choices in prior information, which could be derived from experience or theories and provides a more general approach to estimate highly parameterized multi-equation systems with Bayesian methods that is robust regarding the likelihood function.

4.2.2 The BBMR algorithm

As the equation system in this thesis is going to encounter endogeneity, the algorithm developed by Heckelei et al. (1997) and Heckelei and Mittelhammer (2003) will be introduced here in this section. Suppose that the equation system to be regressed is the following:

$$Y_{n\times m} = \iota_{n\times 1}\alpha_{1\times m} + X_{n\times l}\beta_{l\times m} + Z_{n\times k}\gamma_{k\times m} + U_{n\times m} \qquad (4.6)$$

In Equation 4.6, Y is the matrix of n observations on each of the dependent variables in the equation system; ι is a vector of n ones; X is the matrix of n observations on l exogenous explanatory variables; Z is the matrix of n observations on l endogenous explanatory variables; α, β and γ are the matrices of coefficients corresponding to the explanatory variables; U is matrix of error terms in the structural form.

The reduced form on the endogenous variables in Equation 4.6 is like the following:

$$Z_{n\times k} = T_{n\times p}\delta_{p\times k} + V_{n\times k} \qquad (4.7)$$

In Equation 4.7, T is a matrix of exogenous variables and δ is the matrix of corresponding reduced form coefficients. V is the reduced form error term, and its rows are independently distributed with mean vectors of zeroes, and a covariance matrix Σ that is positive definite. Let the posterior distribution of δ be $\Pr(\delta \mid Z)$ and then it will be mapped to the posterior of α, β and γ with the following algorithm:

1. Regress the reduced form with OLS to obtain $\hat{\delta}$, the estimator of δ and the estimated reduced form residual matrix $\hat{V}$ with the following:

$$\hat{\delta} = (T'T)^{-1} T'Z, \quad \hat{V} = Z - T\hat{\delta} \qquad (4.8)$$

And then define:

$$S = \hat{V}'\hat{V} \qquad (4.9)$$

2. Generate N bootstrap samples of the rows in the matrix of estimated reduced for residuals: $\hat{V}_1, \hat{V}_2, \cdots, \hat{V}_n$ to obtain N matrices $V_i^*, \ i = 1,2,\cdots,N$. Afterwards, these matrices are corrected with the following adjustment:

$$V_i^{**} = V_i^* S^{-1/2} \left(S S_i^{*-1} S \right)^{1/2}, \ \ i = 1,2,\cdots,N$$

$$With \ \ S_i^* = V_i^{*}{}' M V_i^* \ \ and \ \ M = I - T(T'T)^{-1} T' \qquad (4.10)$$

I in Equation 4.10 is identical matrix with the appropriate order and the exponent 1/2 is the symmetric square root of matrices defined as $S^{1/2} S^{1/2} = S$

3. Obtain N bootstrap samples $\delta_i^*, \ i = 1,2,\cdots,N$ by combining the regression structure likelihood $L(\delta, \Sigma \mid \hat{\delta}, S)$ and an ignorance prior for Σ:

$$\delta_i^* = \hat{\delta} - (T'T)^{-1} T' V_i^{**}, \ \ i = 1,2,\cdots,N \qquad (4.11)$$

4. With the N bootstrap samples, $\delta_i^*, \ i = 1,2,\cdots,N$, N bootstrap samples $Z_i^*, \ i = 1,2,\cdots,N$ could be obtained for Z, the matrix of endogenous variables in the structural form:

$$Z_i^* = T\delta_i^*, \ \ i = 1,2,\cdots,N \qquad (4.12)$$

5. Insert $Z_i^*, \ i = 1,2,\cdots,N$ into Equation 4.6, and estimating the structural form with two Stage Least Square (2SLS) or three Stage Least Square (3SLS) will lead to N samples from the posterior distribution of α, β and γ corresponding to the estimation strategy.

4.2.3 Posterior expectations and variance of the coefficients

Designate the posterior distribution of α, β and γ obtained with the algorithm above $\Pr(\alpha \mid Y)$, $\Pr(\beta \mid Y)$ and $\Pr(\gamma \mid Y)$, respectively. These posteriors are based on ignorance priors for the coefficients that are proportional to a constant. However, in most demand systems, the priors are based on inequalities regarding the coefficients to satisfy the restrictions such as the concavity of the cost function. With this type of priors, the samples from the posteriors that satisfy the restrictions will be assigned a prior probability of 1, and those not will be assigned to a prior probability of 0. Hence, the posterior mean and variance are simply the sample mean and variance of the samples of the coefficients that satisfy the restrictions.

4.3 BBMR applied to China's cotton import demand system

4.3.1 Estimation of the model

Concerning the cotton import demand system specified in Section 3.3, the equation system consists of six equations, whose structural form is the following:

$$\log\left(\frac{S_i}{S_7}\right) = \alpha_i + \beta_{1i}\cdot D93 + \beta_{2i}\cdot DWTO + \beta_{3i}\cdot DMFA + \beta_{4i}\cdot DWTOT + \beta_{5i}\cdot DMFAT$$
$$+\beta_{6i}\cdot T + b_i \log\left(\frac{p_i}{p}\right) - b_7\log\left(\frac{p_7}{p}\right), \quad for \quad i = 1,2,\cdots,6 \qquad (3.13)$$

Projecting to the designation in Equation 4.6, $\log(S_i/S_7)$, $for \quad i = 1,2,\cdots,6$ are the dependent variables; $D93$, $DWTO$, $DMFA$, $DWTOT$, $DMFAT$, T and $\log(p_i)$, $for \quad i = 1,2,\cdots,7$ are the exogenous variables in X; $\log(p)$ is the endogenous variable in Z. The reduced form of the equation system in Equation 3.13 takes $\log(p)$ as dependent variables, and the T in Equation 4.7 includes the constant in ι and all the exogenous variables in X. Thus there are 14 variables in T.

Similar to Heckelei et al. (1997) who studied the Japanese meat demand, the estimation strategy adopted in this thesis is to carry out the step 5 in algorithm introduced in Section 4.2.2 is the iterative version of the 3SLS introduced by Zellner and Theil (1962), which estimates all the equations in a system with endogeneity simultaneously, instead of separately as the mechanism of the 2SLS. As in this demand system the ROW was taken as the numeraire, to ensure that the estimators of the parameters are independent on the choice of numeraire, the variance-covariance matrix of the regression residuals of the 3SLS will be iterated until it is identical.

The BBMR algorithm for China's demand for cotton import and relative statistical analysis are programmed in the TSP software, and the code of the program is available in Appendix D.

4.3.2 Testing separable structures with Bayesian methods

Similar to frequentist econometrics, Bayesian methods also allows hypotheses to be tested. However, as stated before, Bayesian econometrics view the parameters themselves as random variables instead of a fixed value, and thus the hypotheses taking the form as functions of the parameters can be directly tested with their posterior distributions. An increasingly interested and applied approach in hypothesis testing in Bayesian methods is the Highest Posterior Density (HPD) Intervals (HPDI). The HPDI (Koop, 2003, pp44) appears similar to the confidence interval in the frequentist econometrics, but the similarity is only in the outlook, and these two definitions have very different inherent thoughts behind the appearance, most obviously because the HPDI uses the parameters, or functions of the parameters themselves to test the hypotheses.

To define the HPDI, one must first define the credible sets. Let $\theta \in \Re^n$ be a vector of parameters, and $\varphi = f(\theta)$ a vector of functions of θ defined on a region Ψ with a dimension of s with $s \leq n$. If $\Xi \subseteq \Psi$ is a region, and it is a α ($\alpha \leq 1$) credible set if:

$$\Pr(\varphi \in \Xi \mid y) = \int_{\Xi} \Pr(\varphi \mid y) d\varphi = \alpha \qquad (4.13)$$

Then the α HPDI is simply the shortest α credible set. If the values of the hypotheses functions are within the interval, then the hypotheses are maintained.

Within the context of this thesis, the test is carried out on the separable structures. All the three separable structures have a 4-dimensional hypotheses to be tested, among which three are common cross the structures, which take the form of $b_1 - b_2 = 0$, $b_3 - b_4 = 0$ and $b_5 - b_7 = 0$, and the particular ones with the three structures are: $b_6 - b_7 = 0$ for the first separable structure, $b_3 - b_6 = 0$ for the second separable structure and $b_1 - b_6 = 0$ for the third separable structure. Thus, the HPDI for each separable structure are presented by two 4 by 1 vectors with the lower and higher bound of the HPDI for each hypothesis listed above, respectively.

It is worth mentioning that the test can be imposed with another direction. As Heckelei et al. (1997) pointed out, the smallest HPD Probability is more consistent with the Bayesian idea to test hypotheses based on the posterior distribution of parameters and functions on them, taking a full collection of information into account, instead on only reporting the interval that the hypotheses are held with a preset significant level. Hence, this approach will report the smallest mass probabilities that the function values in the hypotheses being tested are still included in the HPD region. This approach resembles the P-value in frequentist econometrics, and the smaller the smallest HPD probability, the more confirmative the data are to the hypotheses with the ignorance prior indicated by the BBMR algorithm. To be more specific in the context of testing the separable structures, it involves calculating the probabilities that zero are contained in the HPD of the six hypotheses functions above to be tested.

CHAPTER 5 – DATA

In this chapter, the data used in this thesis will be introduced. Necessary processing has been applied to the data to satisfy this study and they will be described in this chapter. In the meanwhile, preliminary statistical analyses are performed and the results of it will be reported in this chapter. The statistics are referred to Appendix B including the mean, standard error, maximum, minimum, skewness and kurtosis of the values, quantities, prices and expenditure shares of all the sources of import.

5.1 The source and content of the data

The data used in this thesis are provided by Food and Agriculture Organization of the United Nations (FAO), which is one of the most authorized data sources in agricultural sector. This dataset includes data in the quantity and value of China's cotton imports from the entire world and six specified regions, namely West Africa, Egypt and Sudan, Central Asia, Indo Sub-Continent, Australia and the U.S.A, covering a time period from 1992 to 2011. The quantity in the dataset is presented in tons, and the value of import in thousand dollars. This dataset is balanced and includes no missing data

5.2 Processing of the data

The first step taken is to calculate the value and quantity of cotton imported by China from the regions of origin except for the six main regions listed in Section 5.1. Combined, it is designated the ROW for $i = 7$, and the calculation is simply:

$$V_7 = V_T - \sum_{i=1}^{6} V_i, \quad Q_7 = Q_T - \sum_{i=1}^{6} Q_i \qquad (5.1)$$

In Equation 5.1, V_7 and Q_7 are respectively the value and quantity of cotton imported from the ROW; V_T and Q_T are respectively the total value and quantity of China's cotton import; V_i and Q_i for $i = 1,2,\cdots,6$ are respectively the value and quantity of cotton imported from the six main sources of import.

As stated in Section 3.3, the price of the cotton produced in each and every region in dollar per ton is included in the equations, and they are obtained with the following equation:

$$ap_i = V_i \times 1000 / Q_i, \quad for \quad i = 1,2,\cdots,7 \qquad (5.2)$$

In Equation 5.2, ap_i are the absolute prices of the import cotton, and then they are normalized to $p_i(t)$, the relative prices with respect to those in 2000, i.e. $p_i(2000) = 1$.

$$p_i(t) = ap_i(t)/ap_i(2000), \quad for \quad i = 1,2,\cdots,7; \quad t = 1992 \quad to \quad 2011 \qquad (5.3)$$

Finally, with $\log(S_i/S_7)$ for $i = 1,2,\cdots,6$ being the dependent variables in the equation system, S_i for $i = 1,2,\cdots,7$, the expenditure share of cotton import from the seven sources, also needs to be gained with the following formula:

$$S_i = V_i/V_T, \quad for \quad i = 1,2,\cdots,7 \qquad (5.4)$$

5.3 Preliminary statistical analysis of the data

A glimpse at the data reveals that both the values and quantities imported from different sources vary drastically throughout the time period. The prices and expenditure shares of the cotton import derived from the available data also fluctuated within an extraordinarily wide range. The statistical analyses carried out on the data are presented in the following sections

5.3.1 West Africa

The value and quantity of cotton import from West Africa was very variable. Regarding the values of import, the maximum is more than 535 times more than the minimum, with the standard error of the import values even larger than the mean. Similar phenomena were also observed for the quantities. The changes in value were mainly attributed to that in the quantities of import, as the changes in the prices of cotton imported from West Africa was not as fluctuating as the others', whose maximum was only 2.5 times of the minimum. The expenditure share of West African cotton varied from 0.7% to more than 16%. Its share was generally small from 1994 to 2001, and the minimum was observed in 2000; the share increased afterwards, reaching the maximum in 2002, but afterwards the share decreased again till 2011.

5.3.2 Egypt and Sudan

The cotton imported from Egypt and Sudan witnessed a value difference of more than 470 times between the maximum and minimum; the maximum quantity was more than 580 times higher than the minimum. In the meantime, the price of cotton from Egypt and Sudan also changed in a rather large range, with the highest price reaching more than six times higher to the lowest. The expenditure share of the cotton imported from this source was relatively small through the whole time period with a minimum of less than 0.3% and even the maximum share was lower than 6%.

5.3.3 Central Asia

The more than 530 times difference in values of cotton imported from Central Asia was mainly contributed by the changes in prices. The flux in quantities of import from this region was relatively small compared to the other sources of import, with the maximum 157 times more than the minimum. In contrast, the prices changed dramatically during the 20 years of interest, as the maximum price was more than 9.6 times higher than the minimum. As for the expenditure share of Central Asian cotton, the maximum was around 18%, whilst the minimum was a little more than 0.7%; the share increased through the 90s till the millennium, and then it decreased in trend till 2011.

5.3.4 Indo Sub-Continent

The values of cotton import from Indo Sub-Continent fluctuated the most dramatically during the two decades in this thesis, with the maximum value more than 6300 times higher than the minimum. The quantities of import from this region also varied tremendously, as the peak quantity almost 780 times as large as the lowest one. Both the highest value and quantity of import took place in 2011. Indian cotton's price saw a difference of more than 8 times during the two decades. The cotton imported from this region accounted for a highly varied share of China's total cotton import expenditure. Its share was relatively low before 2005 with the minimum just above 0.2% while the share grew greatly since 2006 and saw the highest of more than 31%. This increase is partly related to the introduction of Bt cotton in cotton sectors in Indo Sub-Continent.

5.3.5 Australia

Australia exports more than 90% of its cotton output. China importing values of cotton from Australia have undergone a 640 times difference between the maximum and minimum from 1992 to 2011. The maximum quantity of cotton imported from this source was almost 300 times greater than the minimum. The prices were less variable than the others', as the highest price was less than 2.5 times higher than the lowest. The share of Australian cotton started with a minimum of less than 1.5% in 1992, and increased in trend during the 90s till 2001 with the maximum of 24% in 1999; then it went through a decrease in recent years with a share of around 5% while it increased again to more than 16% in 2011.

5.3.6 The U.S.A.

The United States has long been the biggest cotton exporter to China. The import value of U.S. cotton was the second most fluctuating in the period only after Indo Sub-Continent with the maximum more than 1490 times more than the minimum. The import quantities from the U.S.A. also experienced great difference with the largest quantity more than 450 times greater than the minimum. Regarding the price, U.S. cotton had a highest price more than 5.5 times the lowest. As the biggest cotton import source of China, the U.S.A. accounted for up to more than 64% of the total cotton import expenditure of China, while the lowest share of just below 8% took place in 1993, the year that saw a major supply shortage. Except for 1993, the U.S. cotton never took a smaller share than 25%, with a mean of more than 45%. However, there was a trend in recent years as in 2011 the U.S. cotton had a share of 30% in China's cotton import.

5.3.7 The rest of world (ROW)

As the combination of all the cotton import sources other than the six major ones introduced above, the ROW had a maximum value of cotton imported by China 140 times higher than the minimum, which is the smallest change in value among all the sources. The quantities of the cotton import from the ROW were also the least variable among the sources, which differed 17 times between the largest and smallest. On the contrary to the values and quantities of cotton import from the ROW, its prices was the most variable with the highest price more than 13 times higher than the lowest one. The expenditure share of cotton from the ROW was the lowest in 2008, which was a little more than 6%, while the highest share was in 1993 with the shortage of supply in the six major import sources, which was above 46%. Except for the extreme share in 1993, the expenditure shares of the ROW were relatively stable, which were divided into two periods: before 2000, it was between 10% and 22%, and afterwards, it reduced to between 6% and 10% with the exception for 2011 when the share was more than 13%. The ROW was chosen in the empirical model as the numeraire, though the choice of it should not influence the result as the iterative 3SLS was used to estimate the demand system with the Bayesian bootstrapped endogenous variables, which has been explicated in Section 4.3.

5.4 Conclusion

From the preliminary statistical analyses on the original and derivative data, it can be concluded that the values, quantities, prices and expenditure shares of all the sources varied significantly throughout the whole time period. All sources of import witnessed a variant of more than 400 times in the values of import with the exception of the ROW; and the import quantities of them also experienced a dramatic fluctuation in the quantities of import. The overall cotton import of China increased with a great scale after its accession to the WTO, and accorded the international economic situation as stated in Section 1.2. The prices of China’s cotton import from different sources also witnessed a tremendous flux, which had a similar trend in which the prices first decreased gradually before around year 2000, and then increased rapidly in recent years. After the processing performed on the data, they can serve to analyze the demand system of China’s cotton import.

CHAPTER 6 – RESULTS AND DISCUSSION

In this chapter, the results of the study will be presented and discussed. One unrestricted model will first be estimated for the sake of comparison. Then three separable structures will be introduced to the model with the first separable structure assuming weak separability between "Africa", "Asia" and "Australia, the U.S.A. and the ROW"; the second between "Africa", "Asia and the U.S.A." and "Australia and the ROW"; the third between "Africa and the U.S.A.", "Asia" and "Australia and the ROW". All the separable structures will be tested with both frequentist and Bayesian approach, and the results will be discussed.

6.1 Unrestricted model

The results of the model presented in Equation 3.16 are first reported with both frequentist and Bayesian approaches as the basis of comparison with the models with separable structures assumed.

6.1.1 Results with iterative 3SLS

The regression results concerning the b coefficients are given in Table 6.1. The complete results table can be found in Appendix C.

Parameter	Estimate	Std. Error	t-statistic	P-value
b_1	2.22015	.321581	6.90385	[.000]
b_2	-1.33122	.155221	-8.57626	[.000]
b_3	.054441	.150468	.361813	[.717]
b_4	3.98300	.342614	11.6253	[.000]
b_5	-4.99523	.743205	-6.72120	[.000]
b_6	3.70171	.302450	12.2391	[.000]
b_7	2.03181	.163662	12.4147	[.000]

Table 6.1 Results of the unrestricted model with 3SLS

In Table 6.1, it can be observed that the restrictions of validity laid by the CDE functional form stated in Equation 3.7 are not satisfied. b_1, b_4, b_6 and b_7 are greater than 1; b_3 is between 0 and 1 while b_2 and b_5 are negative. Thus, thought the level of significance seems rather attractive as all except b_3 are highly significant, the model failed to stay consistent with the information contained in the data. Thus, it is of some interest to look at how the model will behave with BBMR.

6.1.2 Results with BBMR

BBMR is applied to the unrestricted model with 1000 bootstraps, and it provides a success rate at which the restrictions as satisfied, i.e. the number of bootstraps in which the restrictions in Equation 3.7 are satisfied divided by the total number of bootstraps, thus 1000 in this case. With the unrestricted model BBMR yields a success rate of practically zero with 1000 bootstraps, indicating that the CDE form is still somewhat too demanding and inconsistent with the data even though it is a generalization to the CES functional form in the Armington model.

In the following part of the chapter, three separable structures described in Section 3.4.2 will be added to the model to explore their influence on the model performance without changing the fundamental CDE cost functional form.

6.2 The 1st separable structure

This structure supposes the weak separability between "Africa", "Asia" and "Australia, the U.S.A. and the ROW", and the hypotheses laid on the model are $b_1 = b_2$, $b_3 = b_4$ and $b_5 = b_6 = b_7$.

6.2.1 Results and test with iterative 3SLS

The results concerning the b s with this separable structure are provided in Table 6.2. Consequent to the separability, there are now only three different b s in the model, one for each subset.

Parameter	Estimate	Std. Error	t-statistic	P-value
b_1	-.828551	.221555	-3.73971	[.000]
b_3	-.636689	.219576	-2.89963	[.004]
b_7	1.34382	.237033	5.66932	[.000]

Table 6.2 3SLS results with separability between "Africa", "Asia" and "Australia, the U.S.A. and the ROW"

The estimates in Table 6.2 demonstrate that they are all significant in 1% level, but still not meeting the restrictions of validity with b_1 and b_3 negative and b_7 greater than one.

Test for the separable hypotheses can be carried out with the Quasi Likelihood Ratio (Gallant and Jorgenson, 1979), and the statistic is $T = n \cdot (Q_0 - Q_1)$, with Q_0 and Q_1 being the values of the minimum distance criterion for the unrestricted and restricted model, respectively. The statistic T follows a χ^2 distribution with the degrees of freedom of the number of restrictions, thus in this case a χ^2 distribution with four degrees of freedom. The result of the test is in Table 6.3

$n \cdot Q_0$	$n \cdot Q_1$	T	P-value (χ_4^2)
67.8713	56.7148	11.1565	.0248603

Table 6.3 QLR test for the separability between “Africa”, “Asia” and “Australia, the U.S.A. and the ROW”

As shown in Table 6.3, the statistic has a P-value of 0.025. This separable structure does not seem very plausible with frequentist econometric test, as the hypothesis of the hypotheses laid on the model according to the separable structure can be rejected in the 5% level of significance.

6.2.2 Results and test with BBMR

The BBMR with this separable structure leads to a success rate, i.e. the probability of the restrictions being satisfied of 22.4%, indicating an improvement regarding the consistency of the model with the data compared with the unrestricted model without any weak separability among the cotton import sources assumed. The results of the BBMR are reported below in Table 6.4 including the posterior means and standard errors of the b s, as well as the minimum and maximum value within the bootstraps where the restrictions are satisfied.

Parameter	Posterior Mean	Posterior S.D.	Min	Max
b_1	0.24216	0.15092	0.00067083	0.65765
b_3	0.53014	0.25587	0.012523	0.99099
b_7	0.45514	0.24910	0.012216	0.99669
Success Rate		22.4%		

Table 6.4 BBMR results with separability between “Africa”, “Asia” and “Australia, the U.S.A. and the ROW”

The posterior distribution of the own-price Allen elasticities of substitution (AES) can then be calculated with Equation 3.12, and they are reported below in Table 6.5.

Own-price AES	Posterior Mean	Posterior S.D.	Min	Max
σ_{11}	-8.56949	1.52519	-11.03462	-4.11650
σ_{22}	-33.24628	6.43713	-43.45481	-15.26419
σ_{33}	-3.98569	1.79418	-7.71165	-0.73031
σ_{44}	-3.89582	1.74530	-7.52283	-0.72859
σ_{55}	-5.27118	2.27470	-9.32428	-0.29843

σ_{66}	-0.65289	0.16529	-0.95668	-0.21627
σ_{77}	-3.63215	1.52545	-6.35287	-0.28848

Table 6.5 Own-price AES with separability between “Africa”, “Asia” and “Australia, the U.S.A. and the ROW”

The own-price AES reveals the ratio of the percent changes in demand of cotton import from a certain source to the percentage change in the total expenditure of China’s cotton import, should the price of this source change with this separable structure. With the average term, the AES with this separable structure are all negative, which is not surprising regarding that the restrictions are satisfied by all the samples. The cotton produced by Egypt and Sudan are the most sensitive to the change in its own price, as if the price of cotton produced in this region increases, the relative decrease in the quantity of cotton imported from there will be more than 33 times higher than the increase in the total compensated expenditure on cotton import. The AES of West Africa is also rather large at 8.5, followed by Australian cotton imported by China, which had an AES of more than 5. The AES of Central Asian cotton and that from the ROW have close AES a little lower than 4, indicating that cotton imported by China from these regions are not as sensible to its own prices as the former ones. What worth noticing is the U.S.A., whose own-price AES was extraordinarily low, which was the only one lower than 1 among the seven sources of import, but this seems to be no surprise as it has long been the dominant cotton exporter to China.

Regarding the posterior standard deviation, the own-price AES of cotton imported from West Africa, Egypt and Sudan and the U.S.A have relatively small standard deviations in comparison to their posterior means as the former are around 25% or below in absolute value compared to that of the latter for these three sources, revealing that the own-price AES of these sources are more ‘tightly’ distributed. On the contrary, the standard deviations are larger relative to the posterior means in the sense of absolute value with the other cotton import sources of China, for the former are around 40% to 45% as large as the latter in absolute value.

The cross AES posterior distribution are reported below in Table 6.6. Notice that according to the separable structure, some cross Allen elasticities are the same with each other.

Cross AES[2]	Posterior Mean	Posterior S.D.	Min	Max
σ_{12}	0.96546	0.38774	0.035253	1.71509

[2] In this separable structure, the following cross AES are equal to each other: $\sigma_{13}=\sigma_{14}=\sigma_{23}=\sigma_{24}$; $\sigma_{13}=\sigma_{16}=\sigma_{17}=\sigma_{25}=\sigma_{26}=\sigma_{27}$; $\sigma_{15}=\sigma_{16}=\sigma_{17}=\sigma_{25}=\sigma_{26}=\sigma_{27}$; $\sigma_{35}=\sigma_{36}=\sigma_{37}=\sigma_{45}=\sigma_{46}=\sigma_{47}$; $\sigma_{56}=\sigma_{57}=\sigma_{67}$. Only one in each group will be listed in the table.

σ_{13}	0.67747	0.41924	-0.24943	1.64659
σ_{15}	0.75248	0.14306	0.20779	1.01028
σ_{34}	0.38949	0.59734	-0.64639	1.63474
σ_{35}	0.46449	0.14718	0.14402	0.85260
σ_{56}	0.53950	0.38284	-0.26878	1.22312

Table 6.6 Cross AES with separability between “Africa”, “Asia” and “Australia, the U.S.A. and the ROW”

In comparison to the own-price AES, the cross AES are all positive and below 1, indicating that the influence on a certain cotton exporter to China of the price change in a different source of import of China is smaller than the change in its own-price price. Regarding the mean of the posterior distribution of the cross AES, the cotton produced in West Africa and Egypt and Sudan seems to be most influential to each other, as the price rise in one region will lead to a percentage increase in China’s cotton import demand for the other that is 97% as big as the increase in the total cost of Chinese cotton import. The cross AES is also relatively high with respect to the cotton exported to China by Africa and Australia, the U.S.A. and the ROW, as well as African and Asian cotton. The AES between Australia, the U.S.A. and the ROW are restricted to be the same by separable structure, and it is around 0.54. The influence of cross price change on the ratio of relative change in demand and expenditure between Asian cotton exporters to China and Australia, the U.S.A. and the ROW is relatively small, at around 0.46. The AES is the smallest between the cotton import sources of China in Asia, namely Central Asia and Indo Sub-Continent, which is only 0.39, indicating that a one percent rise in the total cotton import expenditure China caused by the increase of price in either of the two regions will be companied by only 0.39 percent growth in the demand for cotton exported by the other region.

The posterior standard deviations of the cross AES are larger in a relative term to the posterior mean than those of the own-price AES. The largest ration of posterior standard deviation to mean is observed with the cross AES between the cotton imported from Central Asia and Indo Sub-Continent, which is more than 150%. The more “loose” distribution of the cross AES is not that unexpected as the uncertainty in prices and demands from both sources in a cross AES are included, as well as that in the total expenditure on cotton import of China. However, the generally larger posterior standard deviations relative to means are not without exception. For instance, the cross AES between sources in the subsets “Africa” and “Australia, the U.S.A. and the ROW” has a standard deviation that is only 19% as large as the posterior mean, indicating that the substitution effect between sources in these two subsets are relatively “stable”.

As introduced in Section 4.3.2, the hypotheses for the separable structures can also be tested with a Bayesian approach. The test results are reported in Table 6.7 below.

Shared Hypothesis	95% HPDI	Smallest HPD Probability
$b_1 - b_2 = 0$	[-0.10854, 7.41145]	0.940
$b_3 - b_4 = 0$	[-6.03060, 0.053560]	0.948
$b_5 - b_7 = 0$	[-6.48984, -0.94374]	0.976
Structure – Particular Hypothesis	95% HPDI	Smallest HPD Probability
$b_6 - b_7 = 0$	[-2.55294, 4.20667]	0.536

Table 6.7 HPD test for the separability between “Africa”, “Asia” and “Australia, the U.S.A. and the ROW”

Table 6.7 demonstrates the HPDI and smallest HPD probabilities for the three hypotheses shared by all three separable structures tested in this thesis and the one hypothesis particular in this structure. In the following sections on the other two separable structures, the HPDI and smallest HPD probabilities will not be reported again as they are identical to the results in Table 6.7.

It can be seen that in the three common hypotheses, the first two, $b_1 - b_2 = 0$ and $b_3 - b_4 = 0$, the 95% HPDI contain the value 0, and expectedly, the smallest HPD probabilities are smaller than 0.95 with these two hypotheses, and thus they are not rejected with a 5% significance level.

Unfortunately, the third common hypothesis, $b_5 - b_7 = 0$ has an HPDI left to zero, indicating that zero lied in the right hand tail of the distribution of $b_5 - b_7$. Confirmatively, the smallest HPD probability of this hypothesis is 0.976, greater than 0.95. Thus, the hypothesis is rejected, and the inclusion of Australia and the ROW in the same subset does not seem very sound statistically. However, as the comparison with separable structures other than the three that are discussed in detail in this thesis confirmed that these three separable structures lead to the highest consistency between the model and data without any modification to the theoretical model and cost functional form, it may as well be the case that one has to balance between statistical significance and economic plausibility, and it is the choice in this thesis to prefer the consistency between the model and data over more statistically sound, yet less economically reasonable separable structures. In addition, it is more or less expected that it might cause some turmoil in statistical aspects when it is included in a subset within a separable structure because the ROW is the combination of the cotton import sources except the major six.

Concerning the hypothesis that is particular to this separable structure, $b_6 - b_7 = 0$, the 95% HPDI comfortably contains the value zero, and the smallest HPD probability is also well below 0.95 naturally, so the inclusion of the U.S.A. in the same subset with the ROW seems less problematic than the inclusion of Australia and the ROW, and this is partly due to the huge import expenditure share held by the cotton imported from the U.S.A.

Conclusively, the assumption of the weak separability between “Africa”, “Asia” and “Australia, the U.S.A. and the ROW” has improved the performance of the BBMR estimate of the model with respect to the consistency between the model and data, though the hypotheses seem to have been rejected in 5% level with frequentist QLR test, and one out of the four hypotheses has also been rejected with the Bayesian HPD approach.

6.3 The 2nd separable structure

This structure assumes the weak separability between “Africa”, “Asia and the U.S.A.” and “Australia and the ROW”, and the hypotheses laid on the model are $b_1 = b_2$, $b_3 = b_4 = b_6$ and $b_5 = b_7$.

6.3.1 Results and test with iterative 3SLS

The results concerning the b s with this separable structure are provided in Table 6.8. There are also three different b s in the model, same as the number of subsets.

Parameter	Estimate	Std. Error	t-statistic	P-value
b_1	.535125	.369226	1.44932	[.147]
b_3	.901489	.246060	3.66370	[.000]
b_7	-.297731	.245210	-1.21419	[.225]

Table 6.8 3SLS results with separability between “Africa”, “Asia and the U.S.A.” and “Australia and the ROW”

Table 6.8 reveals that the estimate is significant in 1% level for the subset “Asia and the U.S.A.”, but not significant for the others with iterative 3SLS. Still, the coefficients with classical econometrics are not meeting the restrictions of validity.

Test for separability with the Quasi Likelihood Ratio is reported in Table 6.9.

$n \cdot Q_0$	$n \cdot Q_1$	T	P-value (χ_4^2)
67.8713	58.8731	8.9982	. 0611445

Table 6.9 QLR test for the separability between “Africa”, “Asia and the U.S.A.” and “Australia and the ROW”

This separable structure appears to be more plausible than the first one, as the hypothesis of the restriction can not be rejected in the 5% level of significance, but rejected in 10% significance level. Thus the plausibility of this separable structure is somewhat ambiguous with the frequentist econometrics approach.

6.3.2 Results and test with BBMR

The BBMR with this separable structure leads to a success rate of 39.4%. The results taking the form of posterior means and standard errors, as well as the minimum and maximum value within the bootstraps where the restrictions are satisfied are reported here in Table 6.10.

Parameter	Posterior Mean	Posterior S.D.	Min	Max
b_1	0.29476	0.17688	0.00016773	0.85024
b_3	0.74349	0.13224	0.16912	0.99614
b_7	0.29781	0.16870	0.0044466	0.93932
Success Rate		39.4%		

Table 6.10 BBMR results for the separability between “Africa”, “Asia and the U.S.A.” and “Australia and the ROW”

The performance of BBMR with this separable structure has improved considerably in comparison to that of the first one with respect to the success rate. It seems that the aggregation of this structure is more consistent to the information contained in the data.

With the bootstrap outcome above, the own-price Allen elasticities of substitution (AES) are reported below in Table 6.11

Own-price AES	Posterior Mean	Posterior S.D.	Min	Max
σ_{11}	-7.86476	1.86576	-11.03292	-1.90113
σ_{22}	-30.82870	7.62410	-43.58931	-6.77768
σ_{33}	-2.27765	1.04378	-6.76458	-0.28019

σ_{44}	-2.22859	1.01849	-6.60565	-0.27945
σ_{55}	-6.48624	1.45176	-9.04898	-0.99892
σ_{66}	-0.45045	0.10337	-0.88257	-0.21304
σ_{77}	-4.37393	0.94541	-6.08577	-0.81640

Table 6.11 Own-price AES with the separability between “Africa”, “Asia and the U.S.A.” and “Australia and ROW”

The outline of own-price AES in this separable structure is similar to the one with the first separable structure. The most elasticities of substitution in this structure have a smaller posterior mean in absolute value with the exception of the own-price AES of the cotton imported from Australia and the ROW. The largest own-price AES is that of the cotton imported from Egypt and Sudan with a value of -30.8 indicating that the price rise of the cotton imported by China from this region leading to a expenditure rise of one percent will cause a decrease of more than 30% in the cotton import demand from this region. This result is consistent with the last separable structure. A likely reason for this phenomenon is that the cotton imported from this region accounted for a relatively small share in the Chinese cotton demand, as stated in Section 5.3.2; accompanied by the drastically fluctuating price of the it, it is understandable that the cotton from Egypt and Sudan has an extremely high AES.

Just as the situation of the first separable structure, the smallest own-price AES is also observed with the U.S.A., the increase in the price of the U.S. cotton will lead to only 0.45 times as large a decrease in China’s cotton demand for it as an increase in the total compensated expenditure on cotton import of China. Consistent with the first separable structure, this could be explicated with the huge share of the U.S. cotton in China’s cotton import. As Vlontzos and Duquenne (2007) claimed, even without an official agreement between China and the U.S.A., the Chinese cotton import market is somehow dominated by the U.S. cotton for a long period. As stated in Section 5.3.6, the U.S. cotton witnessed peak share of more than 60% in the total value of cotton import of China, and its share remained remarkably high even though its price has been fluctuating in a rather large range. This led to the result that the price changes will lead to a great change in China’s cotton import expenditure as the U.S. cotton accounted for such a large percentage in it, yet the demand for the U.S. cotton is not that sensitive to price regarding the data.

The own-price AES of the other sources of import are also close to those with the first separable structure. They are all negative and above one in absolute value, suggesting that if the prices of these sources change, the relative change of total Chinese cotton import expenditure will be in a smaller scale than that of the demand for the cotton originated from the corresponding sources.

The posterior standard deviations are smaller than those in the first separable structure in comparison to the posterior means of the own-price AES. Only the cotton import from Central Asia and Indo Sub-Continent sees standard deviations more than 45% as large as its posterior means, whilst the ratios for all the other sources are below 25%. This separable structure seems to have led to a less variable posterior distribution of the own-price AES.

Cross AES are reported below. Notice that according to the separable structure in Table 6.12.

Cross AES[3]	Posterior Mean	Posterior S.D.	Min	Max
σ_{12}	1.00836	0.36982	-0.18128	1.78818
σ_{13}	0.55963	0.20518	-0.033744	1.04522
σ_{15}	1.00531	0.13555	0.28349	1.26980
σ_{34}	0.11090	0.18876	-0.25817	0.97235
σ_{35}	0.55658	0.13853	0.12082	0.88492
σ_{57}	1.00227	0.35807	-0.35184	1.65707

Table 6.12 Cross AES with the separability between "Africa", "Asia and the U.S.A." and "Australia and the ROW"

According to Table 6.12 with this separable structure, the cross AES are somewhat different to those in the first separable structure. At a glimpse, it is clear that the cross AES are all positive and can be divided into three main subgroups in the posterior mean, with σ_{12}, $\sigma_{15,17} = \sigma_{25,27}$ and σ_{57} greater than 1; $\sigma_{13,14,16} = \sigma_{23,24,26}$ and $\sigma_{35,37} = \sigma_{45,47} = \sigma_{56} = \sigma_{67}$ around 0.55; $\sigma_{34,36} = \sigma_{46}$ around 0.11. The influence of the change in the price of cotton produced in one source on another seems to be more separately distributed among different sources than the situation of the first separable structure.

It can be found that the cotton produced by West Africa and Egypt and Sudan has the highest posterior mean cross AES, the same as in the last separable structure. This indicates that the price change in African cotton tends to relatively strongly influence the demand for cotton from different African producers. This is partly due to the comparatively small and very fluctuating

[3] In this separable structure, the following cross AES are equal to each other: $\sigma_{13}=\sigma_{14}=\sigma_{16}=\sigma_{23}=\sigma_{24}=\sigma_{26}$; $\sigma_{15}=\sigma_{17}=\sigma_{25}=\sigma_{27}$; $\sigma_{34}=\sigma_{36}=\sigma_{46}$; $\sigma_{35}=\sigma_{37}=\sigma_{45}=\sigma_{47}=\sigma_{56}=\sigma_{67}$. Only one in each group will be listed in the table.

share in expenditure of cotton from this region, as well as fairly strong substitution effect between the cotton produced by African exporters, leading to the fact that the changes in price of one African import source will cause somewhat strong influence on the demand for cotton from another African country, and impact the total expenditure on cotton import of China with the same direction but slightly smaller in relative scale. Similar conclusions could be drawn on the subset “Africa” and “Australia and the ROW” with the second highest cross AES, as well as Australia and the ROW with a cross AES above 1 under this separability assumption, where the situation resembles the former case.

The posterior mean of cross AES between the subset “Africa” and “Asia and the U.S.A.”, along with that between subsets “Asia and the U.S.A.” and “Australia and the ROW” are both around 0.55. This implies that the substitution effect between these two pairs are not as strong as the three discussed in the last paragraph. The potential reason for the phenomena could be two-fold. On the one hand, the price change in one subset in the two pairs has relatively small influence on the demand for cotton imported from the other in the same pairs. On the other hand, the impact laid by the price change on one another in either of the two pairs is further diluted by the prevailing expenditure share held by the subset “Asia and the U.S.A.” leading to great percentage variance in total cotton import expenditure should the price change.

Within the subset “Asia and the U.S.A.”, the lowest posterior mean of cross AES is observed with this separable structure. At 0.11, it is lower than the posterior mean of the AES within the subset “Asia” in the first separable structure, which was also the lowest in that separable structure. This could be explained in the same manner with the case of cross AES between “Africa” and “Asia and the U.S.A.” and that between “Asia and the U.S.A.” and “Australia and the ROW”. The inclusion of the U.S.A. seems to have laid similar impact on the AES.

Similar to the situation of own-price AES, the posterior standard deviations in comparison to the posterior means of the cross AES also is smaller than in the first separable structure. One noteworthy point is the ratio between posterior standard deviation and mean still well higher than 150% in the cross AES between Central Asia, Indo Sub-Continent and the U.S.A., which are in the same subset in this separable structure. It seems that the substitution effect between these sources has become even more variable with the inclusion of the U.S.A. in the subset.

Similarly, the separability between “Africa”, “Asia and the U.S.A.” and “Australia and the ROW” is tested with the Bayesian approach. Only the results of the constraints particular in this separable structure are reported in Table 6.13.

Structure – Particular Hypothesis	95% HPDI	Smallest HPD Probability
$b_3 - b_6 = 0$	[-7.09208, 1.54325]	0.878

Table 6.13 HPD test for the separability between “Africa”, “Asia and the U.S.A.” and “Australia and the ROW”

From Table 6.13, it can be seen that the 95% HPDI for this particular hypothesis contains the value 0, and accordingly, smallest HPD probability is below 0.95. Thus, the hypothesis that $b_3 - b_6 = 0$ is not rejected, and it seems plausible to include the U.S. cotton in the same subset as the Asian cotton.

To conclude, the second separable structure, which is the weak separability between “Africa”, “Asia and the U.S.A.” and “Australia and the ROW” is more plausible than the first separable structure discussed in Section 6.2, for it is not rejected in 5% level (still rejected in 10% level), and the particular hypothesis in the structure is also maintained with Bayesian methods. Besides, it provides a considerably higher success rate, implying an improvement in consistency with compared to the first separable structure.

6.4 The 3rd separable structure

This structure assumes the weak separability between “Africa and the U.S.A.”, “Asia” and “Australia and the ROW”, and the hypotheses laid on the model are $b_1 = b_2 = b_6$, $b_3 = b_4$ and $b_5 = b_7$.

6.4.1 Results and test with iterative 3SLS

The results concerning the b s are reported in Table 6.14. Again, only three b s are different from each other.

Parameter	Estimate	Std. Error	t-statistic	P-value
b_1	.961036	.400071	2.40216	[.016]
b_3	.695808	.264895	2.62673	[.009]
b_7	-.451963	-.451963	-1.75765	[.079]

Table 6.14 3SLS results with separability between “Africa and the U.S.A.”, “Asia” and “Australia and the ROW”

As shown in Table 6.14, the estimate is significant in 1% level for the subset “Asia”, in 5% level for the subset and in 10% level for the subset “Africa and the U.S.A.” with iterative 3SLS. Still, the coefficients with classical econometrics are not meeting the restrictions of validity.

Test for separability with the Quasi Likelihood Ratio for the separable structure is reported below in Table 6.15.

$n \cdot Q_0$	$n \cdot Q_1$	T	P-value (χ_4^2)
67.8713	60.5882	7.2831	.121663

Table 6.15 QLR test for separability between “Africa and the U.S.A.”, “Asia” and “Australia and the ROW”

As Table 6.15 reflects, this separable structure can not be rejected in 10% significant level, indicating that it is more plausible than the first two separable structures with frequentist econometrics test.

6.4.2 Results and test with BBMR

The BBMR with this separable structure leads to a success rate of 41.4%. The posterior means, standard errors with the minimum and maximum successful bootstrap values of b s are reported here in Table 6.16.

Parameter	Posterior Mean	Posterior S.D.	Min	Max
b_1	0.52855	0.23922	0.0068842	0.99885
b_3	0.49099	0.24856	0.0047872	0.99441
b_7	0.23340	0.19133	0.00062770	0.95420
Success Rate		41.4%		

Table 6.16 BBMR results with separability between “Africa and the U.S.A.”, “Asia” and “Australia and the ROW”

The performance of BBMR with this separable structure has improved slightly in comparison to that of the second with respect to the success rate. It seems that the model gives higher consistency to the data information.

With the bootstrap outcome above, the own-price Allen elasticities of substitution (AES) are reported below in Table 6.17.

Own-price AES	Posterior Mean	Posterior S.D.	Min	Max

σ_{11}	-5.53458	2.61693	-11.23669	-0.39045
σ_{22}	-20.88591	10.40643	-43.57438	-0.42778
σ_{33}	-4.26759	1.81406	-7.89002	-0.59855
σ_{44}	-4.17023	1.76658	-7.70072	-0.59748
σ_{55}	-7.18799	1.58631	-9.15679	-1.08003
σ_{66}	-0.63466	0.13318	-0.94817	-0.26430
σ_{77}	-4.88194	1.01126	-6.15053	-0.94226

Table 6.17 Own-price AES with the separability between "Africa and the U.S.A.", "Asia" and "Australia and ROW"

Concerning the own-price AES in this separable structure, it remains similar to those in the first two, with all the posterior means negative and the absolute value between 4 to 10 with the exception of Egypt and Sudan, and the U.S.A. However, in this separable structure, the posterior mean of cotton imported from Egypt and Sudan is notably smaller in absolute value that the cased in the first two structures. This could be the result of the fact that this region is now allocated to the same subset with the U.S.A. unlike in the first two separable structures. On the contrary, the own-price AES of the U.S.A. is not that much influenced with its dominant expenditure share.

Regarding the deviation, this separable structure results in ratios of the posterior standard deviation relative to the means in absolute value that are overall higher than those produced by the second separable structure. The own-price AES of Australia, the U.S.A. and the ROW have posterior standard deviations less than 25% as large as posterior means, and for the other resources the ratios are above 40%. What is interesting here is that the standard deviation of the own-price AES of Egyptian and Sudanese cotton has increase considerably relative to its posterior mean compared to the first two separable structures. The own-price AES of cotton from this region seems to have become more variable with the inclusion of the U.S.A. in the same subset. Keeping in mind that the posterior mean of the AES of the same source has also greatly decreased as the U.S.A. was put in the same subset, it appears that the U.S. cotton has a great impact on the AES posterior distribution of Egypt and Sudan, which is consistent with the conclusion of Pan et al. (2005b).However, the influence is not observed in the opposite direction, as the U.S. cotton own-price AES still appears with a low ratio between the posterior standard deviation and posterior mean, not different from the situations in the first two separable structures.

Cross AES with this separable structure are reported below in Table 6.18.

Cross AES[4]	Posterior Mean	Posterior S.D.	Min	Max
σ_{12}	0.39707	0.39396	-0.39255	1.30183
σ_{13}	0.43464	0.22381	-0.14231	1.07775
σ_{15}	0.69222	0.15286	0.27742	1.08631
σ_{34}	0.47220	0.51055	-0.64299	1.55849
σ_{35}	0.72978	0.31886	-0.13160	1.43864
σ_{57}	0.98737	0.45801	-0.59162	1.71293

Table 6.18 Cross AES with the separability between "Africa and the U.S.A.", "Asia" and "Australia and ROW"

The posterior means of the cross AES with this separable structure is more evenly distributed without clear clusters, and they are all positive and smaller than 1, indicating the changes in prices of the cotton imported from any source will always lead to a percentage change in the demand for cotton from another source that is smaller than the percentage change in the total expenditure of China on cotton import in the same direction.

With this separable structure, the largest posterior mean of the cross AES is observed between Australia and the ROW, which is close to one, indicating that the changes in prices of either one of the two sources will result in almost the same percentage change in the demand for the cotton from the other source and as in the total expenditure of China's cotton import.

The lowest posterior mean of AES is between African exporters and the U.S.A., which is followed by that between the subset "Africa and the U.S.A." and "Asia", and then the one between Central Asia and Indo Sub-Continent. These three cross AES are smaller than 0.5, suggesting that the substitution effect is relatively weak between one source and another within any of the three pairs.

The AES have posterior means around 0.7 between the subset "Africa and the U.S.A." and "Australia and the ROW", and also that between the subset "Asia" and "Australia and ROW", meaning that the price change of cotton produced in one source within either subset of one pair will change the demand for the cotton from a source within the other subset of the same pair with a percentage about 0.7 time as large as the percentage change in the total expenditure of Chinese cotton import.

[4] In this separable structure, the following cross AES are equal to each other: $\sigma_{12}=\sigma_{16}=\sigma_{26}$; $\sigma_{13}=\sigma_{14}=\sigma_{23}=\sigma_{24}=\sigma_{36}=\sigma_{46}$; $\sigma_{15}=\sigma_{17}=\sigma_{25}=\sigma_{27}=\sigma_{56}=\sigma_{67}$; $\sigma_{35}=\sigma_{37}=\sigma_{45}=\sigma_{47}$. Only one in each group will be listed in the table.

The cross AES posterior standard deviation has similar behavior with that in the first separable structure. The posterior standard deviations of the cross AES are larger in the relative sense to the posterior means compared to the case in own-price AES. Once again, the ratio of the cross AES posterior standard deviation to posterior mean between the cotton imported from Central Asia and Indo Sub-Continent is the largest and higher than one, further confirming the conclusion with the first two separable structures.

Test results for the particular constraint in this separable structure are presented in Table 6.19.

Structure – Particular Hypothesis	95% HPDI	Smallest HPD Probability
$b_1 - b_6 = 0$	[-2.80300, 2.58693]	0.082

Table 6.19 HPD test for the separability between “Africa and the U.S.A.”, “Asia” and “Australia and the ROW”

Table 6.19 demonstrates that the particular hypothesis in this separable structure has a 95% HPDI containing zero and the smallest HPD probability is the lowest among the six constraints in total at 0.082. Thus, this constraint is not rejected, and the separable structure seems more plausible than the first two with Bayesian HPD test, similar to the conclusion drawn from the frequentist econometrics test.

6.5 Conclusion

As the iterative 3SLS estimates of the substitution coefficients fail to satisfy the restrictions, BBMR and three separable structures are deployed to estimate the posterior distribution of the coefficients, leading to the posterior of own-price and cross AES. The posterior distributions are somewhat similar among the own-price AES posterior mean, and the behavior of Egypt and Sudan, and the U.S.A. are especially worth noticing, as the former has the largest posterior mean in absolute value; the latter is the smallest, and the only own-price AES posterior mean smaller than 1 in absolute value with all three separable structures. Yet the posterior standard deviations seem to be more impacted by different separable structures. This is especially remarkable with whether to include the U.S.A. in the same subset with Egypt and Sudan. The U.S.A. appears to be very influential concerning the own-price AES posterior standard deviation in a relative sense to the own-price AES posterior mean of the cotton from this source of import.

Concerning the cross AES, the posterior distributions are more dependent on different separable structures. With the first and third separable structures, all the posterior means of AES are between 0 and 1, whilst with the second, they appear in three clusters, one slightly above 1, one around 0.55 and the other about 0.11. The behavior of posterior standard deviations of the cross AES also varies among the three separable structures analyzed in this chapter. With the first and the third separable structures, the posterior standard deviations of the cross AES appear to be rather large in comparison to the posterior means, yet it was relatively small in the second separable structure. However, there is an obvious shared feature with the cross AES posterior standard deviation, namely that the cross AES between Central Asia and Indo Sub-Continent appear to be very variable as its posterior standard deviations are larger than its posterior means in all three separable structures.

The three separable structures have different plausibility. The first structure can be rejected in 5% level; the second can be rejected in 10% level but not in 5%; the third one cannot be rejected in 10% level and appears to be the most plausible one. Tests have also been carried out on the three separable structures with Bayesian HPD as well. It seems that the inclusion of Australia and the ROW in the same subset is not accepted, yet this might be a price one must pay to set the model in a more economically plausible manner. Other hypotheses laid on the model by the separable structures are accepted by the Bayesian HPD test. The extent to which the model is consistent to the data is reflected by the success rate in Bayesian bootstrap. The first separable structure leads to a success rate of 22.4%; the second structure results in a success rate of 39.4%, which is much better than the first one; the third structure obtained a success rate of 41.4%, slightly improved compared with the second one. In comparison, the Armington Model with the CES functional form results in a success rate of almost 100%, yet this is in the cost of sacrificing the possibility to test any separability among different sources of import, and is simply one more compromise one must make.

CHAPTER 7 – CONCLUSION

China is the biggest producer of cotton and the biggest importer as well because of the huge textile production and exporting industry. In the year 2011 China imported more than 3.5 million tons of cotton from seven main sources of import around the world, namely West Africa, Egypt and Sudan, Central Asia, Indo Sub-Continent, Australia, the U.S.A. and the Rest of the World. With such a large market, it is worth investigating China's cotton import demand system, especially the substitution effects between different sources of import.

The Armington Model is often used in trade of agricultural products by differentiating the products by the geographic regions of production, but the limits of the Armington Model are many, among which is the same constant substitution between commodities from all regions caused by the CES functional form it used in underlying the cost (or utility) function. Another major problem of the Armington Model is the exclusion of the possibility to test separability among different products. These can be remedied by introducing a Constant Difference of Elasticity functional form in the cost (or utility) functions, leading to a generalization of the Armington Model.

To study the cotton import structure of China, a two-stage procedure similar to the Armington Model was set and the CDE functional form was employed to generalize the Armington Model. As cotton is mostly used as intermediate product to produce textiles, it is a two-stage cost minimization procedure. In the first stage, the textile industry of China is considered to be minimizing its total cost by deciding the quantities of different inputs. Then in the second stage, the Chinese Government, which has been controlling the cotton import of the country, closes the gap between domestic cotton production and the total cotton demand by imported cotton, and in the meantime, minimizes the total import cost on cotton by allocating the total expenditure on the cotton imported from various sources with linear homogeneity.

As the iterative 3SLS estimators failed to satisfy the restrictions laid by the CDE functional form, the BBMR is hired to estimate the model in a Bayesian approach, investigating the posterior distribution of the coefficients and Allen elasticities of substitution among different sources of import, with the restrictions of the CDE functional form as the prior information. A success rate, in other words, the probability of the restrictions being satisfied in bootstraps was reported as a sign of consistency between the model and data.

As the success rate of bootstraps with the unrestricted model was practically zero, the hint was that the CDE functional form may still be too restrictive with its implicit additivity, and a more flexible functional form may be more consistent with the data. However, to test the goodness of fit of the model to the data information without changing the fundamental CDE functional form, three weak separable structures were introduced to the model, and were tested with both frequentist and Bayesian approaches. With the frequentist QLR test, the separability among “Africa”, “Asia” and “Australia, the U.S.A. and the ROW” was rejected in a 5% significance level; the separability among “Africa”, “Asia and the U.S.A.” and “Australia and the ROW” was not rejected in a 5% significance level, but was rejected in a 10% level; the separability among “Africa and the U.S.A.”, “Asia” and “Australia and the ROW” was not rejected even in a 10% level. With the Bayesian HPD test, all the hypotheses laid by the three separable structures were not rejected except for the inclusion of Australia and the ROW in one subset, which unfortunately, was present in all three separable structures. Nevertheless, this may be a compromise one must make with statistical soundness for the sake of economic plausibility, as these three separable structures were the ones with the highest success rates in bootstrap thus the consistency between the model and the data, which were 22.4%, 39.4% and 41.4% in order.

With the posterior means of the own-price AES, it can be concluded that the cotton from the U.S.A was the least sensitive to the changes in its own price, while that from Egypt and Sudan was the most sensitive, and this conclusion held mutually with all three separable structures. The posterior standard deviations were more impacted by different separable structures, especially remarkable with whether to include the U.S.A. in the same subset with Egypt and Sudan. The U.S.A. appeared to be very influential concerning the own-price AES posterior standard deviation in a relative sense to the own-price AES posterior mean of the cotton from this source of import, while the conclusion in a reversed direction did not hold.

For the cross AES, all the posterior means of AES are between 0 and 1 with the first and third separable structures, whilst with the second, they appear in three clusters, yet the conclusion could be drawn that the overall substitution effects between the cotton from different sources were relatively small. The posterior standard deviations of the own-price AES were quite dependent on the specification of the separable structures as they were relatively small in the second whilst rather large with the other two. Despite of this, one may still conclude that the cross AES between Central Asia and Indo Sub-Continent appeared to be very variable as its posterior standard deviations were larger than its posterior means in all three separable structures.

REFERENCE

Articles:

1. Yearbook, C. S. (2012). National Bureau of statistics of China. *China Statistical Yearbook*.
2. U.S. International Trade Commission, 2011, China's Agricultural Trade: Competitive Conditions and Effects on U.S. Exports.
3. Hongxing, N. (2013). Agricultural Domestic Support and Sustainable Development in China. Issue Paper No. 47. *International Centre for Trade and Sustainable Development*, Geneva.
4. Wakelyn, P.J. & Chaudhry, M.R. (2010). Cotton: Technology for the 21st Century. *International Cotton Advisory Committee*, Washington, ISBN 9780979390357.
5. Hanoch, G. (1975). Production and demand models with direct or indirect implicit additivity. *Econometrica*, 43(3): 395-419.
6. Heckelei, T. & Mittelhammer R. (2003). Bayesian bootstrap multivariate regression. *Journal of Econometrics*, 112: 241-264.
7. Theil, T. (1965). The Information Approach to Demand Analysis. *Econometrica*, 33(1): 67-87.
8. Barten, A.P. (1966). Evidence on the Slutsky Conditions for Demand Functions. *Review of Economics and Statistics*, 49: 77-84.
9. Deaton, A. & Muellbauer, J. (1980). An Almost Ideal Demand System. *American Economic Review*, 70: 312-326.
10. Alston, J.M. & Chalfant, J.A. (1993). The Silence of the Lambdas: A Test of the Almost Ideal and Rotterdam Models. *American Journal of Agricultural Economics*, 75(2): 304-313.
11. Sarker, R. & Surry, Y. (2006). Product differentiation and trade in agri-food products: taking stock and looking forward. *Journal of International Agricultural Trade and Development*, 2(1): 39-79.
12. Armington, P.S. (1969). A theory of demand for products distinguished by place of production. *IMF Staff Papers*, 16: 159-178.
13. Alston, J., Carter, C., Green, R. & Pick, D. (1990). Whither Armington trade models? *American Journal of Agricultural Economics*, 72: 455-467.
14. Ito, S., Chen, D.T. & Peterson, E.W.F. (1990). Modeling international trade flows and market shares for agricultural commodities: a modified Armington procedure for rice. *Agricultural Economics*, 4: 315-333.
15. Yang, S.R. & Koo, W.W. (1993). A generalized Armington trade model: respecification.

Agricultural Economics, 9: 347-356.

16. Goldman, S. M., & Uzawa, H. (1964). A note on separability in demand analysis. *Econometrica*, 32(3), 387-398.
17. Gorman, W. M. (1959). Separable utility and aggregation. *Econometrica*, 27(3), 469-481.
18. Strotz, R. H. (1959). The Utility Tree--A Correction and Further Appraisal. *Econometrica*, 27(3), 482-488.
19. Strotz, R. H. (1957). The empirical implications of a utility tree. *Econometrica*, 25(2), 269-280.
20. Pearce, I. F. (1961). An exact method of consumer demand analysis. *Econometrica*, 29(4), 499-516.
21. Edgerton, D. L. (1997). Weak separability and the estimation of elasticities in multistage demand systems. *American Journal of Agricultural Economics*, 79(1), 62-79.
22. Christensen, L.R., Jorgenson, D.W. & Lau, L.J. (1973). Transcendental logarithmic production frontiers. *Review of Economics and Statistics*, 55: 28-45.
23. Dar, A. & Dasgupta, S. (1985). The estimation of production functions: the CRES and CDE approaches applied to US manufacturing data – a comparative study. *Applied Economics*, 17: 437-449.
24. Mukerji, V. (1963). Generalized SMAC Function with Constant Ratios of Elasticities of Substitution. *Review of Economic Studies*, 30: 233-236.
25. Hanoch, G. (1971). CRESH production functions. *Econometrica*, 39(5): 695-712.
26. Surry, Y. (1993). The 'Constant Difference of Elasticities' function with applications to the EC animal feed sector. *Journal of Agricultural Economics*, 44(1): 110-125.
27. Surry, Y., Herrard, N. & Le Roux, Y. (2002). Modeling trade in processed food products: an econometric investigation for France. *European Review of Agricultural Economics*, 29(1): 1-27.
28. Baffes, J. (2004). Cotton market settings, trade policies, and issues. *World Bank Policy Research Working Paper* No. WPS 3218.
29. Minot, N., & Daniels, L. (2005). Impact of global cotton markets on rural poverty in Benin. *Agricultural Economics*, 33(3), 453-466.
30. Hudson, D., & Coble, K. (1999). Harvest contract price volatility for cotton. *Journal of Futures Markets*, 19(6), 717-733.

31. Pan, S., Mohanty, S., Ethridge, D. & Fadiga, F. (2006). The Impacts of U.S. Cotton Programs on the World Market: An Analysis of Brazilian WTO Petition. *Journal of Cotton Science*, 10: 180-192.
32. Pan, S., Mohanty, S., Fadiga, M., & Ethridge, D. (2004). Structural models of the United States and the rest-of-the-world natural fiber market. *Cotton Economics Research Institute Working Paper*, 04-03.
33. Pan, S., Welch, M., Mohanty, S., Fadiga, M., & Ethridge, D. (2005a). Assessing the Impacts of the Chinese TRQ System and the US Subsidies on the World Cotton Market. *The Estey Centre Journal of International Law and Trade Policy*, 6(2): 251-273.
34. Pan, S., Fadiga, M., Mohanty, S., & Welch, M. (2007). Cotton in a free trade world. *Economic Inquiry*, 45(1), 188-197.
35. Fadiga, M. L., & Misra, S. K. (2007). Common trends, common cycles, and price relationships in the international fiber market. *Journal of Agricultural and Resource Economics*, 32(1), 154-168.
36. Mutuc, M. E. M., Hudson, D., & Reeves, J. M. (2012). The Effects of Uniform Climate Change on International Cotton Prices and Production. In *2012 Conference, August 18-24, 2012, Foz do Iguacu, Brazil* (No. 126362). International Association of Agricultural Economists.
37. Lohmar, B., & Skully, D. (2003, June). China’s TRQ administration after one year: Crossing the river by feeling for stones. In *Annual Meeting of the International Agricultural Trade Research Consortium* (pp. 17-19).
38. Ge, Y., Wang, H. H., & Ahn, S. K. (2010). Cotton market integration and the impact of China's new exchange rate regime. *Agricultural Economics*, 41(5), 443-451.
39. Vlontzos, G., & Duquenne, M. N. (2007, July). Evolution of trade flows for Chinese cotton. In *2007 Summer Symposium of the International Agricultural Trade Research Consortium (IATRC)*.
40. Pray, C., Ma, D., Huang, J., & Qiao, F. (2001). Impact of Bt cotton in China. *World Development*, 29(5), 813-825.
41. Fang, C., & Babcock, B. A. (2003). *China's cotton policy and the impact of China's WTO accession and Bt cotton adoption on the Chinese and US cotton sectors*. Center for Agricultural and Rural Development, Iowa State University.

42. MacDonald, S., Pan, S., Somwaru, A., & Tuan, F. (2010). China's role in world cotton and textile markets: a joint computable general equilibrium/partial equilibrium approach. *Applied Economics*, 42(7), 875-885.
43. Yang, Y., Martin, W., & Yanagishima, K. (1997). Evaluating the benefits of abolishing the MFA in the Uruguay Round package. *Global Trade Analysis: modeling and applications*, 253-79.
44. Babula, R. (1987). An Armington model of US cotton exports. *Journal of Agricultural Economics Research*, 39(4), 12-22.
45. Chang, H. S. C., & Nguyen, C. (2002). Elasticity of demand for Australian cotton in Japan. *Australian Journal of Agricultural and Resource Economics*, 46(1), 99-113.
46. MacDonald, S., Pan, S., Hudson, D., & Tuan, F. C. (2011). Toward a Consumer Economy in China: Implications of Changing Wage Policies for US Cotton Exports. In *2011 Annual Meeting, July 24-26, 2011, Pittsburgh, Pennsylvania* (No. 103615). Agricultural and Applied Economics Association.
47. Lopez, J. A., & Malaga, J. E. (2004). European Union Cotton Demand: An Application Of Demand Systems And Panel Data. *In 2004 Annual Meeting, February 14-18, 2004, Tulsa, Oklahoma* (No. 34660). Southern Agricultural Economics Association.
48. Pick, D. H., & Park, T. (1989). *Export Supply and Import Demand Elasticities in the Japanese Textile Industry: A Production Theory Approach* (No. 51255). International Agricultural Trade Research Consortium.
49. Roy, R. (1947). La distribution du revenu entre les divers biens. *Econometrica*, 15(3), 205-225.
50. Zellner, A. (1971). An Introduction to Bayesian Inference in Econometrics. New York: John Wiley & Sons.
51. Moschini, G., Moro, D., & Green, R. D. (1994). Maintaining and testing separability in demand systems. *American Journal of Agricultural Economics*, 76(1), 61-73.
52. Koop, G. (2003). *Bayesian Econometrics*. New York: John Wiley & Sons.
53. Chalfant, J. A., Gray, R. S., & White, K. J. (1991). Evaluating prior beliefs in a demand system: the case of meat demand in Canada. *American Journal of Agricultural Economics*, 73(2), 476-490.
54. Montgomery, A. L., & Rossi, P. E. (1999). Estimating price elasticities with theory-based

priors. *Journal of Marketing Research*, 36(4), 413-423.

55. Efron, B. (1979). Bootstrap methods: another look at the jackknife. *The annals of Statistics*, 7(1), 1-26.
56. Kloek, T., & Van Dijk, H. K. (1978). Bayesian estimates of equation system parameters: an application of integration by Monte Carlo. *Econometrica*, 46(1), 1-19.
57. Zellner, A., Bauwens, L., & Van Dijk, H. K. (1988). Bayesian specification analysis and estimation of simultaneous equation models using Monte Carlo methods. *Journal of Econometrics*, 38(1), 39-72.
58. Rubin, D. B. (1981). The Bayesian bootstrap. *The annals of statistics*, 9(1), 130-134.
59. Heckelei, T., Mittelhammer, R. C., & Wahl, T. I. (1997). *Bayesian Analysis of a Japanese Meat Demand System: A Robust Likelihood Approach* (No. 18783).
60. Zellner, A., & Theil, H. (1962). Three-stage least squares: simultaneous estimation of simultaneous equations. *Econometrica*, 30(1), 54-78.
61. Gallant, A. R., & Jorgenson, D. W. (1979). Statistical inference for a system of simultaneous, non-linear, implicit equations in the context of instrumental variable estimation. *Journal of Econometrics*, 11(2), 275-302.
62. Pan, S., Mohanty, S., & Fadiga, M. L. (2005b). *The impacts of US cotton programs on the west and central African countries cotton export earnings*.

Websites:

1. WTO Trade Policy Review Body. (2012). WTO Trade Policy Review: China, Secretariat Report. http://www.wto.org/english/tratop_e/tpr_e/tp364_e.htm
2. WTO Trade Policy Review Body. (2012). WTO Government Report China. http://www.wto.org/english/tratop_e/tpr_e/tp364_e.htm
3. Food and Agriculture Organization of the United Nations. http://www.fao.org/index_en.htm

APPENDIX A – FIGURES IN THE THESIS

Figure 1.1: Domestic cotton production of China from 1992 to 2011

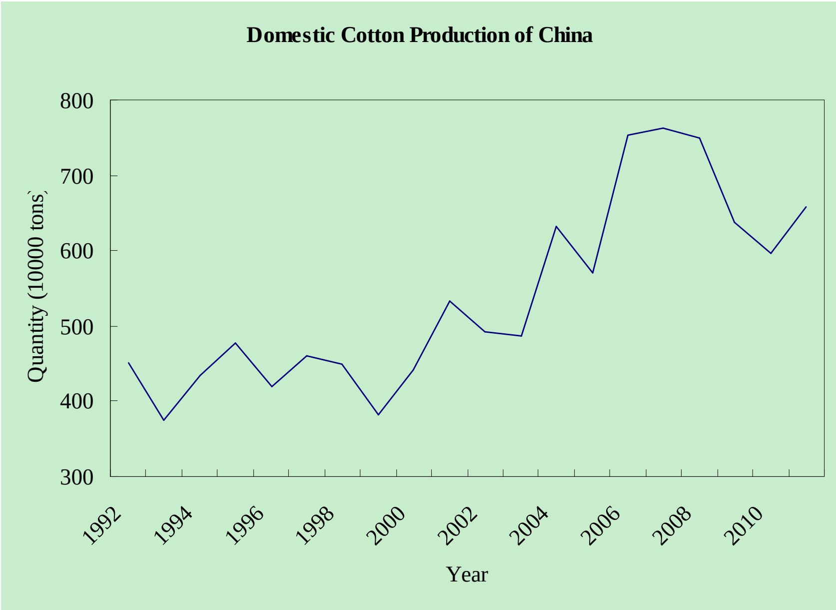


Figure 1.2: China's cotton import quantities from different sources

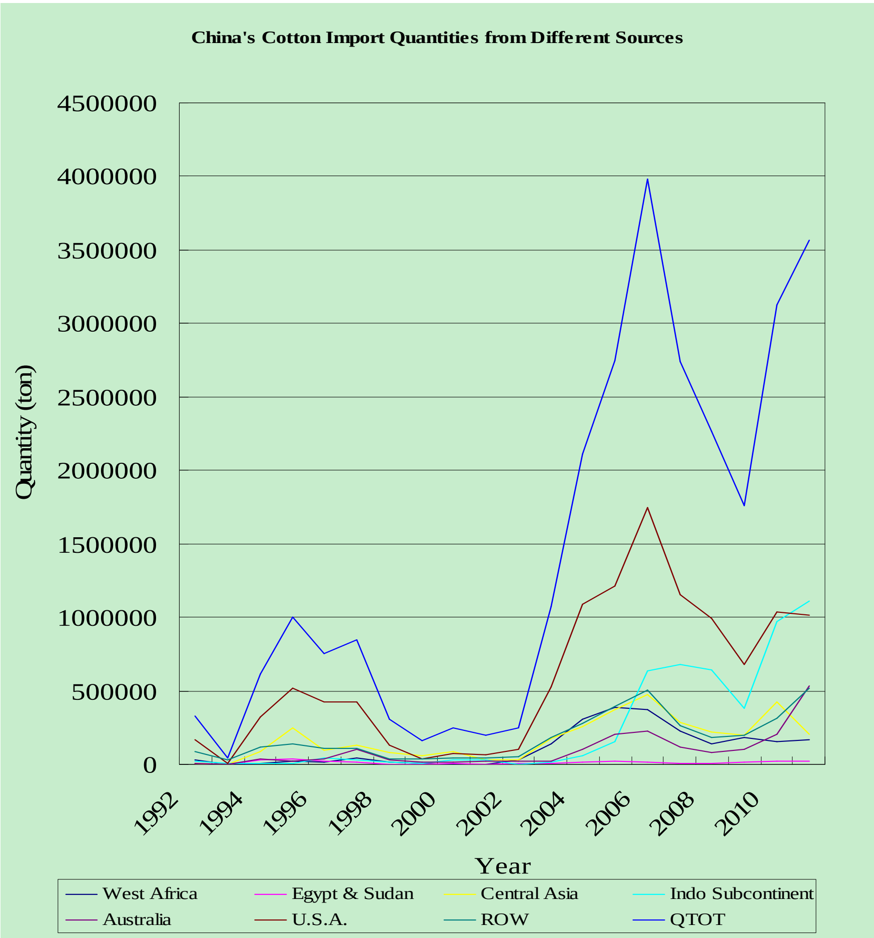


Figure 1.3: China's total value of cotton import

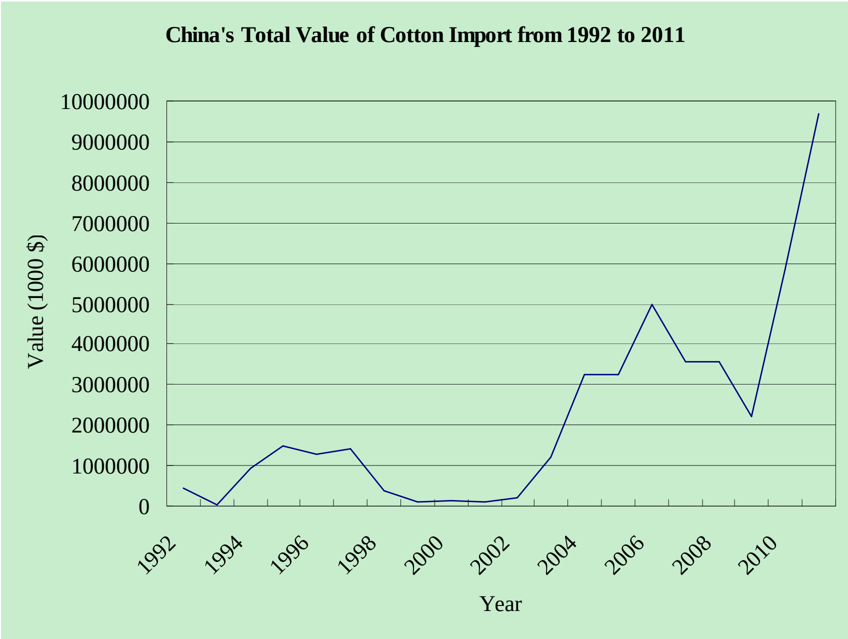
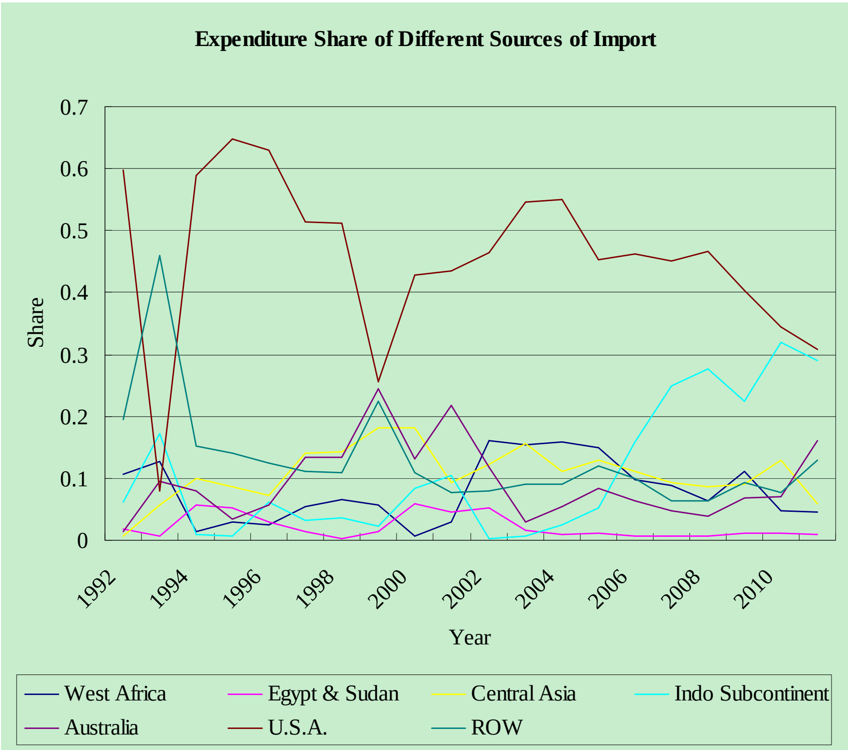


Figure 1.4: Expenditrue share of different sources of import



APPENDIX B – PRELIMINARY STTISTICS OF THE DATA

B. 1 West Africa

West Africa	Mean	Std. Dev	Minimum	Maximum
Value (1000 $)	172689.86489	186628.37726	957.08099	512497.93750
Quantity (ton)	112606.77587	127902.20361	747.42902	390779.53125
Price (2000=1)	1.24485	0.26182	0.79834	1.99644
Share	0.079481	0.050782	0.0069759	0.16029

Table B.1 Preliminary statistics of the data of West Africa

B. 2 Egypt and Sudan

Egypt and Sudan	Mean	Std. Dev	Minimum	Maximum
Value (1000 $)	29052.79498	26224.83118	192.54100	92233.65625
Quantity (ton)	13092.11666	10541.11182	65.00700	37829.53906
Price (2000=1)	1.08464	0.36627	0.36419	2.19724
Share	0.022152	0.019427	0.0026425	0.059556

Table B.2 Preliminary statistics of the data of Egypt and Sudan

B. 3 Central Asia

Central Asia	Mean	Std. Dev	Minimum	Maximum
Value (1000 $)	216594.10484	220147.97615	1410.28699	757460.68750
Quantity (ton)	173720.88396	138680.81904	3014.02490	475324.93750
Price (2000=1)	3.60345	2.09545	1.00000	9.66899
Share	0.10739	0.042852	0.0071425	0.18117

Table B.3 Preliminary statistics of the data of Central Asia

B. 4 Indo Sub-Continent

Indo Sub-Continent	Mean	Std. Dev	Minimum	Maximum
Value (1000 $)	414642.77924	745487.33078	444.91400	2805763.50000
Quantity (ton)	242552.66621	359683.41328	1408.48096	1110873.75000
Price (2000=1)	2.86592	1.42186	0.78238	6.27569
Share	0.10964	0.10745	0.0022300	0.31837

Table B.4 Preliminary statistics of the data of Indo Sub-Continent

B. 5 Australia

Australia	Mean	Std. Dev	Minimum	Maximum
Value (1000 $)	188188.67684	340040.51381	2419.94800	1549105.62500
Quantity (ton)	95090.24604	124043.04253	1777.18701	529687.25000
Price (2000=1)	1.19513	0.28840	0.85527	2.11660
Share	0.093769	0.061561	0.014096	0.24506

Table B.5 Preliminary statistics of the data of Central Asia

B. 6 U.S.A.

U.S.A.	Mean	Std. Dev	Minimum	Maximum
Value (1000 $)	956823.38704	871720.85747	1998.43604	2979460.00000
Quantity (ton)	586470.17124	502868.80280	3803.28809	1747803.75000
Price (2000=1)	1.77670	0.67390	0.64917	3.62963
Share	0.45695	0.13562	0.079305	0.64863

Table B.6 Preliminary statistics of the data of the U.S.A.

B. 7 ROW

ROW	Mean	Std. Dev	Minimum	Maximum
Value (1000 $)	226708.37051	283520.20325	8886.54004	1259432.75000
Quantity (ton)	182957.23066	152008.36821	29154.55859	516330.12500
Price (2000=1)	2.95455	1.54396	0.54975	7.15700
Share	0.13061	0.088007	0.062780	0.46064

Table B.7 Preliminary statistics of the data of the ROW

APPENDIX C – COMPLETE TABLE OF RESULTS

In this chapter, the full estimation results with both iterative 3SLS and BBMR of the models involved in the thesis are presented. For the tables presenting the iterative 3SLS results, the relationships between the parameters in the table to those in Equation 3.13 are: Ci is the α_i; $Ci93$ is the β_{1i}; $CiWTO$ is the β_{2i}; $Ci2005$ is the β_{3i}; $CTiWTO$ is the β_{4i}; $CTi2005$ is the β_{5i}; CTi is the β_{6i}; Bi is the b_i. For the tables presenting the BBMR results, the relationships are: $SCBOOTi$ is the α_i; $SCBOOTi93$ is the β_{1i}; $SCBOOTiWTO$ is the β_{2i}; $SCBOOTi2005$ is the β_{3i}; $SCTBOOTiWTO$ is the β_{4i}; $SCTBOOTi2005$ is the β_{5i}; $SCTBOOTi$ is the β_{6i}; $BBOOTi$ is the b_i.

C. 1 The unrestricted model

Parameter	Estimate	Standard Error	t-statistic	P-value
C1	1.99143	.658590	3.02377	[.002]
C193	-2.73777	.935734	-2.92580	[.003]
C1WTO	-9.29732	6.79943	-1.36737	[.172]
C12005	11.4605	7.24026	1.58289	[.113]
CT1WTO	1.09599	.572177	1.91548	[.055]
CT12005	-.866851	.582134	-1.48909	[.136]
CT1	-.348071	.097820	-3.55829	[.000]
B1	2.22015	.321581	6.90385	[.000]
B7	2.03181	.163662	12.4147	[.000]
C2	-2.45081	.556826	-4.40139	[.000]
C293	-1.40041	.795758	-1.75985	[.078]
C2WTO	11.4630	5.76784	1.98740	[.047]
C22005	-14.3250	6.13479	-2.33504	[.020]
CT2WTO	-.986809	.485036	-2.03451	[.042]
CT22005	1.13630	.493560	2.30225	[.021]
CT2	.057970	.082228	.704992	[.481]
B2	-1.33122	.155221	-8.57626	[.000]
C3	-.684183	.551658	-1.24023	[.215]
C393	-1.70273	.794442	-2.14331	[.032]
C3WTO	-3.58980	5.87389	-.611144	[.541]
C32005	4.64803	6.24339	.744473	[.457]
CT3WTO	.242759	.493460	.491952	[.623]
CT32005	-.342621	.502082	-.682401	[.495]
CT3	.145824	.083343	1.74968	[.080]

B3	.054441	.150468	.361813	[.717]
C4	-3.15701	.476070	-6.63141	[.000]
C493	-.935867	.593972	-1.57561	[.115]
C4WTO	-2.38915	4.75629	-.502313	[.615]
C42005	2.51739	4.87499	.516388	[.606]
CT4WTO	-.013501	.401341	-.033640	[.973]
CT42005	-.131253	.389479	-.336996	[.736]
CT4	.293350	.067721	4.33177	[.000]
B4	3.98300	.342614	11.6253	[.000]
C5	-4.97076	.793891	-6.26127	[.000]
C593	1.61081	.822173	1.95921	[.050]
C5WTO	13.8005	5.71906	2.41306	[.016]
C52005	-17.6899	6.12866	-2.88642	[.004]
CT5WTO	-1.48349	.491485	-3.01839	[.003]
CT52005	1.38120	.489332	2.82262	[.005]
CT5	.527411	.092014	5.73183	[.000]
B5	-4.99523	.743205	-6.72120	[.000]
C6	3.22522	.445803	7.23463	[.000]
C693	-2.50142	.662666	-3.77479	[.000]
C6WTO	-10.7966	4.71899	-2.28791	[.022]
C62005	12.7225	5.02020	2.53426	[.011]
CT6WTO	.979523	.396592	2.46985	[.014]
CT62005	-.954656	.403457	-2.36619	[.018]
CT6	-.167451	.067262	-2.48952	[.013]
B6	3.70171	.302450	12.2391	[.000]

Table C.1 Results of the unrestricted model with iterative 3SLS

C. 2 The 1st separable structure

C. 2. 1 Results with iterative 3SLS

Parameter	Estimate	Standard Error	t-statistic	P-value
C1	-.847760	.514582	-1.64747	[.099]
C193	-.207216	.705890	-.293553	[.769]
C1WTO	-8.45848	5.91953	-1.42891	[.153]
C12005	11.2897	6.25841	1.80393	[.071]
CT1WTO	.865470	.498145	1.73739	[.082]
CT12005	-.899779	.504362	-1.78400	[.074]
CT1	-.070430	.076005	-.926649	[.354]

B1	-.828551	.221555	-3.73971	[.000]
B7	1.34382	.237033	5.66932	[.000]
C2	-2.29763	.620814	-3.70099	[.000]
C293	-1.69596	.832140	-2.03807	[.042]
C2WTO	14.8927	6.74431	2.20819	[.027]
C22005	-16.8409	7.13093	-2.36168	[.018]
CT2WTO	-1.26782	.568548	-2.22993	[.026]
CT22005	1.34274	.575215	2.33432	[.020]
CT2	.061095	.087138	.701125	[.483]
C3	-1.07122	.561680	-1.90717	[.056]
C393	-1.17128	.773105	-1.51504	[.130]
C3WTO	1.60467	6.55290	.244880	[.807]
C32005	-.696885	6.94662	-.100320	[.920]
CT3WTO	-.159100	.551160	-.288664	[.773]
CT32005	.055957	.559857	.099950	[.920]
CT3	.194548	.083392	2.33295	[.020]
B3	-.636689	.219576	-2.89963	[.004]
C4	-1.02138	.598645	-1.70616	[.088]
C493	.411641	.778928	.528471	[.597]
C4WTO	-24.0524	6.90577	-3.48295	[.000]
C42005	20.1734	7.18561	2.80747	[.005]
CT4WTO	1.85166	.581909	3.18205	[.001]
CT42005	-1.48164	.578180	-2.56260	[.010]
CT4	.031490	.087503	.359867	[.719]
C5	-.317491	.588468	-.539521	[.590]
C593	-1.30934	.695646	-1.88220	[.060]
C5WTO	-3.72526	5.79219	-.643152	[.520]
C52005	3.66418	6.04728	.605921	[.545]
CT5WTO	.212307	.491287	.432145	[.666]
CT52005	-.265500	.486582	-.545643	[.585]
CT5	.143748	.077845	1.84659	[.065]
C6	2.59652	.370996	6.99879	[.000]
C693	-3.30811	.443281	-7.46278	[.000]
C6WTO	-7.87778	4.02311	-1.95813	[.050]
C62005	7.93384	4.21340	1.88300	[.060]
CT6WTO	.730809	.339440	2.15299	[.031]
CT62005	-.622745	.338439	-1.84005	[.066]
CT6	-.129083	.051373	-2.51265	[.012]

Table C.2 Results of the 1st separable structure with iterative 3SLS

C. 2. 2 Results with BBMR

Parameter	Mean	Std. Dev.	Minimum	Maximum
SCBOOT1	-0.72478	0.15782	-0.99961	-0.17807
SCBOOT193	-0.42243	0.12843	-0.92071	-0.20586
SCBOOT1WTO	0.62760	0.86773	-2.53296	2.20852
SCBOOT12005	3.02219	0.62783	0.94971	5.51455
SCTBOOT1WTO	0.14432	0.074462	0.011654	0.40990
SCTBOOT12005	-0.22496	0.048815	-0.41828	-0.049343
SCTBOOT1	-0.076447	0.016581	-0.13792	-0.047847
SCBOOT2	-1.31126	0.19582	-1.65846	-0.55122
SCBOOT293	-2.81021	0.18959	-3.53748	-2.47338
SCBOOT2WTO	8.37600	0.90748	4.96493	10.63429
SCBOOT22005	-9.76219	0.78781	-12.39556	-6.60424
SCTBOOT2WTO	-0.68560	0.080377	-0.87387	-0.39118
SCTBOOT22005	0.74574	0.063275	0.51034	0.96905
SCTBOOT2	-0.015084	0.018349	-0.082138	0.022928
SCBOOT3	-1.90331	0.20185	-2.30406	-1.40504
SCBOOT393	-0.91365	0.10852	-1.23816	-0.67152
SCBOOT3WTO	1.16774	0.71533	-1.55956	3.37439
SCBOOT32005	1.98065	0.60705	-0.56363	3.98026
SCTBOOT3WTO	-0.20343	0.066543	-0.42589	0.030527
SCTBOOT32005	-0.13932	0.047448	-0.29949	0.070339
SCTBOOT3	0.26124	0.017007	0.20532	0.30237
SCBOOT4	-2.49578	0.31372	-3.12120	-1.76993
SCBOOT493	0.77865	0.11588	0.45810	1.03230
SCBOOT4WTO	-12.79998	2.07278	-17.90339	-7.36050
SCBOOT42005	12.17527	1.59434	7.35001	17.08019
SCTBOOT4WTO	0.86983	0.17952	0.39438	1.29446
SCTBOOT42005	-0.84670	0.12025	-1.19551	-0.47123
SCTBOOT4	0.20297	0.034215	0.11009	0.27595
SCBOOT5	-1.70701	0.39340	-2.40651	-0.85173
SCBOOT593	-0.32944	0.27726	-0.93221	0.16355
SCBOOT5WTO	4.58212	1.62340	1.05274	7.46869
SCBOOT52005	-4.22624	1.40302	-6.72095	-1.17599
SCTBOOT5WTO	-0.52861	0.14926	-0.79401	-0.20412
SCTBOOT52005	0.34836	0.10712	0.11548	0.53883

SCTBOOT5	0.27297	0.036885	0.19277	0.33855
SCBOOT6	1.72231	0.21275	1.34402	2.18484
SCBOOT693	-3.13783	0.026405	-3.19524	-3.09088
SCBOOT6WTO	-1.80087	1.16979	-4.34406	0.27913
SCBOOT62005	3.00037	1.06019	1.11524	5.30529
SCTBOOT6WTO	0.19796	0.10210	0.016408	0.41993
SCTBOOT62005	-0.22664	0.079761	-0.40005	-0.084820
SCTBOOT6	-0.038190	0.019994	-0.081658	-0.0026391
SBBOOT1	0.24216	0.15092	0.00067083	0.65765
SBBOOT2	0.24216	0.15092	0.00067083	0.65765
SBBOOT3	0.53014	0.25587	0.012523	0.99099
SBBOOT4	0.53014	0.25587	0.012523	0.99099
SBBOOT5	0.45514	0.24910	0.012216	0.99669
SBBOOT6	0.45514	0.24910	0.012216	0.99669
SBBOOT7	0.45514	0.24910	0.012216	0.99669

Table C.3 Results of the 1st separable structure with BBMR

C. 3 The 2nd separable structure

C. 3. 1 Results with iterative 3SLS

Parameter	Estimate	Standard Error	t-statistic	P-value
C1	-1.07960	.555731	-1.94266	[.052]
C193	-.181724	.724153	-.250948	[.802]
C1WTO	-3.57624	5.86317	-.609950	[.542]
C12005	8.98916	6.19397	1.45128	[.147]
CT1WTO	.495765	.495351	1.00084	[.317]
CT12005	-.713248	.498950	-1.42950	[.153]
CT1	-.038032	.078109	-.486902	[.626]
B1	.535125	.369226	1.44932	[.147]
B7	-.297731	.245210	-1.21419	[.225]
C2	-1.52160	.777501	-1.95704	[.050]
C293	-2.75491	.965711	-2.85272	[.004]
C2WTO	13.2631	7.29713	1.81758	[.069]
C22005	-13.5555	7.64465	-1.77320	[.076]
CT2WTO	-1.09881	.618619	-1.77623	[.076]
CT22005	1.05580	.617426	1.71000	[.087]
CT2	.019716	.097959	.201269	[.840]
C3	-2.44732	.430427	-5.68581	[.000]

C393	-.606865	.578924	-1.04826	[.295]
C3WTO	5.66540	4.91295	1.15316	[.249]
C32005	-2.14654	5.14573	-.417150	[.677]
CT3WTO	-.605100	.412223	-1.46790	[.142]
CT32005	.184168	.414236	.444597	[.657]
CT3	.305841	.062873	4.86444	[.000]
B3	.901489	.246060	3.66370	[.000]
C4	-3.21260	.559510	-5.74181	[.000]
C493	1.09938	.747620	1.47051	[.141]
C4WTO	-5.90007	6.51573	-.905512	[.365]
C42005	5.84256	6.80738	.858269	[.391]
CT4WTO	.282362	.548755	.514549	[.607]
CT42005	-.360640	.547795	-.658348	[.510]
CT4	.275559	.082365	3.34556	[.001]
C5	-3.01006	.487924	-6.16912	[.000]
C593	.583851	.489869	1.19185	[.233]
C5WTO	10.3052	3.98819	2.58393	[.010]
C52005	-8.43025	4.04602	-2.08359	[.037]
CT5WTO	-1.05763	.342363	-3.08921	[.002]
CT52005	.687192	.324696	2.11641	[.034]
CT5	.403814	.057682	7.00071	[.000]
C6	1.24493	.369676	3.36763	[.001]
C693	-2.51623	.491985	-5.11445	[.000]
C6WTO	.907131	4.04561	.224226	[.823]
C62005	1.17340	4.21968	.278079	[.781]
CT6WTO	-.035130	.341114	-.102987	[.918]
CT62005	-.090599	.339610	-.266772	[.790]
CT6	.011225	.052606	.213383	[.831]

Table C.4 Results of the 2nd separable structure with iterative 3SLS

C. 3. 2 Results with BBMR

Parameter	Estimate	Std. Dev	Minimum	Maximum
SCBOOT1	-0.80463	0.059626	-0.94052	-0.43288
SCBOOT193	-0.36859	0.065800	-0.75151	-0.22411
SCBOOT1WTO	1.12400	0.42452	-1.62815	2.50053
SCBOOT12005	2.74472	0.31052	1.56100	4.61362
SCTBOOT1WTO	0.10280	0.033065	0.0030159	0.31137

SCTBOOT12005	-0.20348	0.024968	-0.34861	-0.11219
SCTBOOT1	-0.068044	0.0066222	-0.11729	-0.050866
SCBOOT2	-1.35325	0.15400	-1.65365	-0.62328
SCBOOT293	-2.79753	0.18326	-3.56987	-2.43122
SCBOOT2WTO	8.67905	0.57043	6.17294	10.13795
SCBOOT22005	-9.87955	0.65020	-11.82465	-7.68297
SCTBOOT2WTO	-0.71125	0.052070	-0.83704	-0.47714
SCTBOOT22005	0.75361	0.054641	0.56897	0.90964
SCTBOOT2	-0.0093550	0.011749	-0.083897	0.018227
SCBOOT3	-2.03641	0.13705	-2.35951	-1.60609
SCBOOT393	-0.88346	0.10125	-1.16255	-0.64267
SCBOOT3WTO	1.23506	0.72036	-1.07944	3.61305
SCBOOT32005	2.13748	0.59393	0.057397	3.95937
SCTBOOT3WTO	-0.22238	0.062241	-0.43404	-0.024465
SCTBOOT32005	-0.15079	0.046621	-0.28950	0.031564
SCTBOOT3	0.27013	0.013883	0.23364	0.30975
SCBOOT4	-2.73451	0.17363	-3.07703	-2.03865
SCBOOT493	0.82105	0.10146	0.55253	1.06050
SCBOOT4WTO	-11.21270	1.13923	-16.00641	-7.81802
SCBOOT42005	10.96311	0.88554	7.98742	14.19405
SCTBOOT4WTO	0.73194	0.098426	0.44246	1.13636
SCTBOOT42005	-0.75550	0.068140	-0.99683	-0.50599
SCTBOOT4	0.22902	0.018980	0.15864	0.27289
SCBOOT5	-1.95548	0.26643	-2.41878	-0.94233
SCBOOT593	-0.15432	0.18777	-0.86836	0.17220
SCBOOT5WTO	5.60745	1.09945	1.42660	7.51932
SCBOOT52005	-5.11238	0.95019	-6.76471	-1.49910
SCTBOOT5WTO	-0.62288	0.10108	-0.79866	-0.23849
SCTBOOT52005	0.41602	0.072546	0.14015	0.54217
SCTBOOT5	0.29626	0.024981	0.20127	0.33970
SCBOOT6	1.62608	0.13097	1.30806	2.01845
SCBOOT693	-2.90867	0.14266	-3.48919	-2.57363
SCBOOT6WTO	-1.49822	0.73039	-4.08878	1.08181
SCBOOT62005	3.15267	0.57433	0.97503	4.83535
SCTBOOT6WTO	0.17023	0.063315	-0.051281	0.38768
SCTBOOT62005	-0.23721	0.045224	-0.36488	-0.047115
SCTBOOT6	-0.025738	0.014453	-0.065495	0.013713
SBBOOT1	0.29476	0.17688	0.00016773	0.85024

SBBOOT2	0.29476	0.17688	0.00016773	0.85024
SBBOOT3	0.74349	0.13224	0.16912	0.99614
SBBOOT4	0.74349	0.13224	0.16912	0.99614
SBBOOT5	0.29781	0.16870	0.0044466	0.93932
SBBOOT6	0.74349	0.13224	0.16912	0.99614

Table C.5 Results of the 2nd separable structure with BBMR

C. 4 The 3rd separable structure

C. 4. 1 Results with iterative 3SLS

Parameter	Estimate	Standard Error	t-statistic	P-value
C1	-.865502	.606609	-1.42679	[.154]
C193	-.393425	.767351	-.512706	[.608]
C1WTO	-3.86654	6.12595	-.631175	[.528]
C12005	9.55720	6.45363	1.48090	[.139]
CT1WTO	.538832	.518900	1.03841	[.299]
CT12005	-.757090	.519721	-1.45672	[.145]
CT1	-.058462	.083226	-.702455	[.482]
B1	.961036	.400071	2.40216	[.016]
B7	-.451963	.257141	-1.75765	[.079]
C2	-.992723	.840204	-1.18153	[.237]
C293	-3.30531	1.00643	-3.28418	[.001]
C2WTO	10.9390	7.42914	1.47245	[.141]
C22005	-11.2428	7.71316	-1.45761	[.145]
CT2WTO	-.887492	.631655	-1.40502	[.160]
CT22005	.864085	.623171	1.38659	[.166]
CT2	-.023757	.101776	-.233425	[.815]
C3	-2.56202	.433456	-5.91068	[.000]
C393	-.453318	.578126	-.784116	[.433]
C3WTO	7.01488	4.90625	1.42978	[.153]
C32005	-3.29405	5.13167	-.641907	[.521]
CT3WTO	-.710751	.411649	-1.72660	[.084]
CT32005	.273473	.413048	.662086	[.508]
CT3	.322810	.062906	5.13165	[.000]
B3	.695808	.264895	2.62673	[.009]
C4	-3.21830	.592610	-5.43072	[.000]
C493	1.23644	.787911	1.56926	[.117]
C4WTO	-6.43489	6.89186	-.933694	[.350]

C42005	6.41748	7.19219	.892285	[.372]
CT4WTO	.326915	.580510	.563152	[.573]
CT42005	-.404088	.578695	-.698275	[.485]
CT4	.274773	.087094	3.15491	[.002]
C5	-3.26304	.503778	-6.47714	[.000]
C593	.761726	.497092	1.53237	[.125]
C5WTO	11.6234	4.03519	2.88051	[.004]
C52005	-9.56659	4.07756	-2.34615	[.019]
CT5WTO	-1.17695	.346945	-3.39231	[.001]
CT52005	.776702	.327105	2.37448	[.018]
CT5	.428249	.058890	7.27200	[.000]
C6	1.12699	.384624	2.93012	[.003]
C693	-2.39291	.534497	-4.47694	[.000]
C6WTO	1.62448	4.20566	.386260	[.699]
C62005	.736821	4.41108	.167039	[.867]
CT6WTO	-.097964	.354623	-.276249	[.782]
CT62005	-.055365	.354572	-.156146	[.876]
CT6	.024314	.054630	.445062	[.656]

Table C.6 Results of the 3rd separable structure with iterative 3SLS

C. 4. 2 Results with BBMR

Parameter	Estimate	Std. Dev	Minimum	Maximum
SCBOOT1	-0.67324	0.13498	-1.13042	-0.24571
SCBOOT193	-0.49251	0.12582	-0.89692	-0.097373
SCBOOT1WTO	0.86322	0.62198	-1.57167	2.38915
SCBOOT12005	3.14046	0.55463	1.59768	4.83522
SCTBOOT1WTO	0.13501	0.054405	-0.016802	0.33205
SCTBOOT12005	-0.23407	0.043044	-0.36309	-0.11124
SCTBOOT1	-0.080452	0.013861	-0.13540	-0.036864
SCBOOT2	-1.05358	0.27469	-1.86205	-0.29636
SCBOOT293	-3.10440	0.28902	-3.87682	-2.32737
SCBOOT2WTO	7.55891	1.05365	4.55386	10.87877
SCBOOT22005	-8.77223	1.06717	-11.80045	-5.85908
SCTBOOT2WTO	-0.60849	0.095851	-0.90757	-0.33793
SCTBOOT22005	0.66251	0.087429	0.42743	0.90663
SCTBOOT2	-0.033646	0.022588	-0.11188	0.034748
SCBOOT3	-2.06980	0.15450	-2.34715	-1.52421
SCBOOT393	-0.77109	0.11720	-1.17898	-0.56915

SCBOOT3WTO	2.07373	0.83498	-0.33842	3.65881
SCBOOT32005	1.34059	0.74286	-0.15794	3.92403
SCTBOOT3WTO	-0.28077	0.068228	-0.39923	-0.056418
SCTBOOT32005	-0.090715	0.056952	-0.27944	0.023682
SCTBOOT3	0.27906	0.015388	0.22321	0.30972
SCBOOT4	-2.64288	0.23323	-3.15854	-1.91929
SCBOOT493	0.91898	0.11426	0.49939	1.11716
SCBOOT4WTO	-12.17296	1.61534	-17.41137	-8.34684
SCBOOT42005	11.78646	1.27209	8.79576	15.99187
SCTBOOT4WTO	0.81432	0.13970	0.48284	1.26902
SCTBOOT42005	-0.81694	0.095815	-1.13820	-0.58058
SCTBOOT4	0.21764	0.025821	0.13494	0.27646
SCBOOT5	-2.05719	0.30216	-2.42481	-0.91883
SCBOOT593	-0.082638	0.21296	-0.88492	0.17645
SCBOOT5WTO	6.02719	1.24690	1.32964	7.54421
SCBOOT52005	-5.47514	1.07763	-6.78622	-1.41530
SCTBOOT5WTO	-0.66147	0.11464	-0.80095	-0.22958
SCTBOOT52005	0.44372	0.082276	0.13375	0.54382
SCTBOOT5	0.30580	0.028331	0.19907	0.34027
SCBOOT6	1.56070	0.13550	1.30126	2.04973
SCBOOT693	-2.97100	0.21583	-3.71737	-2.50545
SCBOOT6WTO	-1.05499	0.68454	-3.90351	0.56583
SCBOOT62005	2.59145	0.52163	1.04646	4.40921
SCTBOOT6WTO	0.13206	0.059882	-0.0052918	0.38186
SCTBOOT62005	-0.19564	0.040434	-0.33848	-0.066747
SCTBOOT6	-0.020770	0.015879	-0.080449	0.022186
SBBOOT1	0.52855	0.23922	0.0068842	0.99885
SBBOOT2	0.52855	0.23922	0.0068842	0.99885
SBBOOT3	0.49099	0.24856	0.0047872	0.99441
SBBOOT4	0.49099	0.24856	0.0047872	0.99441
SBBOOT5	0.23340	0.19133	0.00062770	0.95420
SBBOOT6	0.52855	0.23922	0.0068842	0.99885
SBBOOT7	0.23340	0.19133	0.00062770	0.95420

Table C.7 Results of the 3rd separable structure with BBMR

APPENDIX D – TSP CODING

D. 1 The TSP coding with the 3rd separable structure

```
OPTIONS MEMORY=2000;
FREQ A;
SMPL 1992 2011;
CONST NOBS 20;
?
TITLE 'VARIABLE DEFINITIONS';

?1= WEST AFRICA
?2= EGYPT AND SUDAN
?3= CENTRAL ASIA
?4= INDO SUB CONTINENT
?5= AUSTRALIA
?6= USA
?7= REST OF WORLD
?
?
LOAD V1 Q1;
  49220.676      31222.721
   3203.665       1999.812
  12441.52    6825.653
  43984.03   22083.1
  31943.134      16815.44
  76006.262      43907.784
  24990.415      14528.373
   5834.673       3801.686
    957.081        747.429
   3538.164       2584.793
  31980.018      31283.227
187098.571      135729.887
512497.925      308234.758
486232.866      390779.538
485175.149      369038.853
316374.088      229903.395
230105.856      136975.939
244927.036      180569.386
274397.898      155770.84
432888.218      169332.924
;
TREND TIME;
GENR P1=V1*1000/Q1;
PRINT V1 Q1 P1;
?
?
LOAD V2 Q2;
  8134.414  5715.152
   192.541  65.007
53805.348  31430.991
77705.481  37829.54
37069.812  23564.476
20698.362  12720.21
  1007.702  420.468
  1521.454  2079.827
  8170.971  4067.883
```

```
  5208.626  2064.818
10536.189  5075.735
17966.101  9946.279
32148.306  15728.383
38931.879  21138.3
35574.274  14796.958
24329.122  10248.425
21509.433  8921.349
27260.42    11694.539
67051.801  23435.872
92233.659  20898.123
  ;
GENR P2=V2*1000/Q2;
PRINT V2 Q2 P2;
?
LOAD V3 Q3;
    3268.297              7115.957
    1410.287              3014.025
  92551.97    91064.938
128624.626          248387.476
  92050.176            91746.716
198616.431          128578.079
  54477.466            79122.662
  18991.074            60397.398
  24749.272            87675.716
  10872.437            31181.393
  24532.992            29111.368
191569.283          176805.807
358854.985          255980.876
417297.918          375245.709
556985.604          475324.941
332242.865          288243.834
305289.57  217317.578
202324.872          200611.577
757460.69  422422.593
559711.239          205069.017
;
GENR P3=V3*1000/Q3;
PRINT V3 Q3 P3;
?
?
LOAD V4 Q4;
    27542.032       18979.892
      4366.697         4961.42
      9500.356       10069.236
    11164.696         7827.255
    77929.04        46801.642
    43866.273       30371.373
    13820.935       14733.498
      2467.94          7837.772
    11619.379         28870.74
    12221.04           28911.601
        444.914          1408.481
      8680.425         15178.48
    82179.08           60227.151
  169950.406       150651.244
  784144.229       637658.544
  888925.674       680155.12
```

```
  983404.277       643818.166
  493507.073       383274.98
1861357.617       968442.931
2805763.442        1110873.788
;
GENR P4=V4*1000/Q4;
PRINT V4 Q4 P4;
?
LOAD V5 Q5;

    6450.296            4289.597
    2419.948            1777.187
  73786.576          40050.016
  50570.192          23782.936
  73611.056          39434.064
187835.648         101203.232
  50900.728          30459.252
  25688.45             17524.581
  18021.072          13042.439
  25245.626          21129.198
  23575.571          19949.644
  36335.257          24257.634
176852.555        102983.74
274992.503        202638.804
318402.552        227948.617
171702.084        117199.88
133691.173          77037.218
148794.408        102491.544
415792.229        204918.1
1549105.63        529687.275
;
GENR P5=V5*1000/Q5;
PRINT V5 Q5 P5;
?
LOAD V6 Q6;
  273468.736        170574.464
      1998.436            3803.288
  551302.912        317836.896
  964342.144        521284.768
  803832.128        423381.504
  725273.152        420764.544
  195003.6            134663.088
    26733.786          33246.815
    58683.336          72500.555
    50636.182          63796.205
    92672.655        105175.531
  666387.525        529455.53
1782180.804      1091630.801
1471545.67        1213250.332
2302777.003      1747803.744
1615187.655      1154368.382
1666913.921        994313.98
  891642.286        681812.344
2016425.988      1035592.043
2979460.099      1014148.542
;
GENR P6=V6*1000/Q6;
PRINT V6 Q6 P6;
```

```
?
LOAD VWORLD QWORLD;
   457584.96        326955.296
   25199.434         44775.296
  936139.776        615757.056
1486725.76        1003366.592
1276438.016        751459.648
1410343.168        848835.264
  381343.84         310285.728
  104825.974        163871.814
  137197.321        250906.032
  116608.617        197097.699
  199511.78         245061.35
1218245.977       1074961.058
3242122.824       2114129.012
3246197.095       2745287.768
4974642.693       3980021.554
3579753.596       2740434.396
3564706.744       2263696.391
2211367.939       1758926.167
5846449.51        3127633.895
9678595.164       3566339.643
;
GENR PWORLD=VWORLD*1000/QWORLD;
PRINT VWORLD QWORLD PWORLD;
?
GENR V7=VWORLD-V1-V2-V3-V4-V5-V6;
GENR Q7=QWORLD-Q1-Q2-Q3-Q4-Q5-Q6;
GENR P7=V7*1000/Q7;
PRINT V7 Q7 P7;
?
GENR VTOT=V1+V2+V3+V4+V5+V6+V7;
DOT 1-7;
NORMAL P.,2000,1;
ENDDOT;
PRINT P1-P7;


DOT 1-7;
GENR S.=V./VTOT;
MSD S.;
SET SM.=@MEAN(1);
ENDDOT;
PRINT P1-P7;
GENR TOTALS=S1+S2+S3+S4+S5+S6+S7;
PRINT S1-S7 TOTALS;
?
LOAD DUM1993;
0 1 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0;

LOAD DUMWTO;
0 0 0 0 0 0 0 0 0
1 1 1 1 1 1 1 1 1
1 1;
LOAD DUMWTO1;
0 0 0 0 0 0 0 0 0
0 1 1 1 1 1 1 1 1
```

```
1 1;
LOAD DUM2005;
0 0 0 0 0 0 0 0 0 0 0 0 0
1 1 1 1 1 1 1;
PRINT DUM1993 DUMWTO DUMWTO1 DUM2005;
?

SMPL 1992 2011;
DOT 1-6;
Y.=LOG(S.)-LOG(S7);
ENDDOT;
PRINT Y1-Y6;

?
TITLE 'STONE PRICE INDEX WITH CURRENT ''BUDGET SHARES';

GENR
PSTONE_CUR=EXP(S1*LOG(P1)+S2*LOG(P2)+S3*LOG(P3)+S3*LOG(P4)+S5*LOG(P5)+S6*LOG(P6)+S7*
LOG(P7));
PRINT PSTONE_CUR;

DOT 1-7;
GENR LP.=LOG(P.);
ENDDOT;
PRINT LP1-LP7;

GENR LP=LOG(PSTONE_CUR);
PRINT LP;

GENR DUMWTO_TIME=DUMWTO1*TIME;

GENR DUM2005_TIME=DUM2005*TIME;
?

TITLE 'CDEH MODEL FOR CHINESE IMPORTS';
?
DOT 1-6;
FRML EQ. Y.=C.+C.93*DUM1993+(C.WTO*DUMWTO1+C.2005*DUM2005)+
                 +(CT.WTO*DUMWTO1+CT.2005*DUM2005)*TIME+CT.*TIME
                 +B.*(LP.-LP)-B7*(LP7-LP);

GENR DUMWTO_TIME=DUMWTO1*TIME;
GENR DUM2005_TIME=DUM2005*TIME;
PRINT EQ.;
ENDDOT;
PARAM C193-C693;
PARAM CT1-CT6;
PARAM CT1WTO-CT6WTO;
PARAM CT12005 CT22005 CT32005 CT42005 CT52005 CT62005;
PARAM B1-B7;
PARAM C1-C6;
PARAM C1WTO-C6WTO;
PARAM C12005 C22005 C32005 C42005 C52005 C62005;
?
SMPL 1992 2011;
PRINT Y1-Y6;
DOT 1-6;
LSQ EQ.;
```

```
ENDDOT;
?

LSQ(MAXIT=1000,MAXITW=200)EQ1-EQ6;
LSQ(MAXIT=1000,MAXITW=200,INST=(C,LP1-LP7,DUM1993,DUMWTO1,DUM2005,TIME,DUMWTO_TI
ME,DUM2005_TIME))EQ1-EQ6;
?CONST    C12005 0 C22005 0 C32005 0 C42005 0 C52005 0 C62005 0;
?LSQ(MAXIT=200)EQ1-EQ6;
?

?
TITLE 'SEPARABILITY BETWEEN "AFRICA, US", "ASIA" AND "AUSTRAILA, RESTOF"';

FRML EQSEP2 B2=B1;
FRML EQSEP4 B4=B3;
FRML EQSEP5 B5=B7;
FRML EQSEP6 B6=B1;
EQSUB(PRINT)EQ2 EQSEP2;
EQSUB(PRINT)EQ4 EQSEP4;
EQSUB(PRINT)EQ5 EQSEP5;
EQSUB(PRINT)EQ6 EQSEP6;
PRINT EQ1-EQ6;
LSQ(MAXIT=1000,MAXITW=200,INST=(C,LP1-LP7,DUM1993,DUMWTO1,DUM2005,TIME))EQ1-EQ6;
?


LOAD CONST;
1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1;

?All EXOGENOUS VARIABLES
MMAKE X CONST DUM1993 DUMWTO1 DUM2005 DUMWTO_TIME DUM2005_TIME TIME LP1
        LP2 LP3 LP4 LP5 LP6 LP7;
MAT INVX=(X'X)"X';
MAT XINVX=X*INVX;

?ENDOGENOUS VARIABLES
MMAKE Z LP;
MAT MEANPI=INVX*Z;
MAT EHAT=Z-X*MEANPI;
PRINT EHAT;
MAT S=EHAT'EHAT;
PRINT S;

?SQUARE ROOT OF S
MAT EIGVAS=EIGVAL(S);
PRINT EIGVAS;
MAT EIGVES=EIGVEC(S);
PRINT EIGVES;
MAT SQS=EIGVES*SQRT(DIAG(EIGVAS))*EIGVES';
PRINT SQS;
?
MAT M=IDENT(NOBS)-XINVX;
PRINT M;

?BOOTSTRAP AND 3SLS MAPPING
?
SET FLAG=0;
```

```
CONST NBOOT 1000;
CONST NCOEFF 45;
MFORM(TYPE=GENERAL,NROW=NBOOT,NCOL=NCOEFF) MCOEFF;
DO I=1 TO NBOOT BY 1;
   SMPL 1 NOBS;
   RANDOM (UNIFORM) BOOTS;
   GENR U=NOBS*BOOTS+1;
   GENR INTU=INT(U);
   GENR ESAMPB=0;
   DO J=1 TO NOBS BY 1;
      SET ORD=INTU(J);
      SET ESAMPB(J)=EHAT(ORD);
   ENDDO;
   MMAKE ESAMPX ESAMPB;

   SMPL 1992 2011;
   MAT ESAMPXX=M*ESAMPX;
   MAT OMBOOT=ESAMPXX'ESAMPXX;
   MAT SIGSTA=S*OMBOOT"S;
   MAT EIGVASIGSTA=EIGVAL(SIGSTA);
   MAT EIGVESIGSTA=EIGVEC(SIGSTA);
   MAT SQSIGSTA=EIGVESIGSTA*SQRT(DIAG(EIGVASIGSTA))*EIGVESIGSTA';
   MAT ESAMP=ESAMPX*SQS"SQSIGSTA;
   MAT PIBOOT=MEANPI-INVX*ESAMP;
   MAT ZBOOT=X*PIBOOT;
   UNMAKE ZBOOT LPBOOT;

   DOT 1-6;
   FRML EQBOOT. Y.=CBOOT.+CBOOT.93*DUM1993+(CBOOT.WTO*DUMWTO1
                      +CBOOT.2005*DUM2005)+(CTBOOT.WTO*DUMWTO1+
                      CTBOOT.2005*DUM2005)*TIME+CTBOOT.*TIME+
                      BBOOT.*(LP.-LPBOOT)-BBOOT7*(LP7-LPBOOT);
   ENDDOT;

   PARAM CBOOT193-CBOOT693;
   PARAM CTBOOT1-CTBOOT6;
   PARAM CTBOOT1WTO-CTBOOT6WTO;
   PARAM CTBOOT12005 CTBOOT22005 CTBOOT32005 CTBOOT42005 CTBOOT52005
            CTBOOT62005;
   PARAM BBOOT1-BBOOT7;
   PARAM CBOOT1-CBOOT6;
   PARAM CBOOT1WTO-CBOOT6WTO;
   PARAM CBOOT12005 CBOOT22005 CBOOT32005 CBOOT42005 CBOOT52005 CBOOT62005;

   ?
   SMPL 1992 2011;
   DOT 1-6;
   LSQ (NOPRINT,SILENT)EQBOOT.;;
   ENDDOT;
   ?
   FRML EQSEPBOOT2 BBOOT2=BBOOT1;
   FRML EQSEPBOOT4 BBOOT4=BBOOT3;
   FRML EQSEPBOOT5 BBOOT5=BBOOT7;
   FRML EQSEPBOOT6 BBOOT6=BBOOT1;
   EQSUB(PRINT)EQBOOT2 EQSEPBOOT2;
   EQSUB(PRINT)EQBOOT4 EQSEPBOOT4;
   EQSUB(PRINT)EQBOOT5 EQSEPBOOT5;
   EQSUB(PRINT)EQBOOT6 EQSEPBOOT6;
```

```
    LSQ(NOPRINT,MAXITW=50,MAXIT=1000,SILENT)EQBOOT1-EQBOOT6;
    ?

MCOEFF[I,1]=CBOOT1;
MCOEFF[I,2]=CBOOT2;
MCOEFF[I,3]=CBOOT3;
MCOEFF[I,4]=CBOOT4;
MCOEFF[I,5]=CBOOT5;
MCOEFF[I,6]=CBOOT6;
MCOEFF[I,7]=CBOOT193;
MCOEFF[I,8]=CBOOT293;
MCOEFF[I,9]=CBOOT393;
MCOEFF[I,10]=CBOOT493;
MCOEFF[I,11]=CBOOT593;
MCOEFF[I,12]=CBOOT693;
MCOEFF[I,13]=CBOOT1WTO;
MCOEFF[I,14]=CBOOT2WTO;
MCOEFF[I,15]=CBOOT3WTO;
MCOEFF[I,16]=CBOOT4WTO;
MCOEFF[I,17]=CBOOT5WTO;
MCOEFF[I,18]=CBOOT6WTO;
MCOEFF[I,19]=CBOOT12005;
MCOEFF[I,20]=CBOOT22005;
MCOEFF[I,21]=CBOOT32005;
MCOEFF[I,22]=CBOOT42005;
MCOEFF[I,23]=CBOOT52005;
MCOEFF[I,24]=CBOOT62005;
MCOEFF[I,25]=CTBOOT1WTO;
MCOEFF[I,26]=CTBOOT2WTO;
MCOEFF[I,27]=CTBOOT3WTO;
MCOEFF[I,28]=CTBOOT4WTO;
MCOEFF[I,29]=CTBOOT5WTO;
MCOEFF[I,30]=CTBOOT6WTO;
MCOEFF[I,31]=CTBOOT12005;
MCOEFF[I,32]=CTBOOT22005;
MCOEFF[I,33]=CTBOOT32005;
MCOEFF[I,34]=CTBOOT42005;
MCOEFF[I,35]=CTBOOT52005;
MCOEFF[I,36]=CTBOOT62005;
MCOEFF[I,37]=CTBOOT1;
MCOEFF[I,38]=CTBOOT2;
MCOEFF[I,39]=CTBOOT3;
MCOEFF[I,40]=CTBOOT4;
MCOEFF[I,41]=CTBOOT5;
MCOEFF[I,42]=CTBOOT6;
MCOEFF[I,43]=BBOOT1;
MCOEFF[I,44]=BBOOT3;
MCOEFF[I,45]=BBOOT7;

IF ((BBOOT1<0&BBOOT3<0&BBOOT7<0)
    |(BBOOT1>0&BBOOT3>0&BBOOT7>0&BBOOT1<1&BBOOT3<1&BBOOT7<1));
    THEN; SET FLAG=FLAG+1;
ENDDO;
PRINT FLAG;

MFORM(TYPE=GENERAL,NROW=FLAG,NCOL=NCOEFF) MVALCOEFF;
SET RC=1;
DO CK=1 TO NBOOT BY 1;
```

```
    IF ((MCOEFF[CK,43]<0&MCOEFF[CK,44]<0&MCOEFF[CK,45]<0)|
        (MCOEFF[CK,43]>0&MCOEFF[CK,44]>0&MCOEFF[CK,45]>0
        &MCOEFF[CK,43]<1&MCOEFF[CK,44]<1&MCOEFF[CK,45]<1));
       THEN; DO;
          DO CC=1 TO NCOEFF BY 1;
          MVALCOEFF[RC,CC]=MCOEFF[CK,CC];
          ENDDO;
       SET RC=RC+1;
    ENDDO;
ENDDO;

FREQ NONE;
SMPL 1 FLAG;
UNMAKE MVALCOEFF SCBOOT1-SCBOOT6 SCBOOT193 SCBOOT293 SCBOOT393
SCBOOT493 SCBOOT593 SCBOOT693 SCBOOT1WTO-SCBOOT6WTO SCBOOT12005
SCBOOT22005 SCBOOT32005 SCBOOT42005 SCBOOT52005 SCBOOT62005
SCTBOOT1WTO-SCTBOOT6WTO SCTBOOT12005 SCTBOOT22005 SCTBOOT32005 SCTBOOT42005
SCTBOOT52005 SCTBOOT62005 SCTBOOT1-SCTBOOT6 SBBOOT1 SBBOOT3 SBBOOT7;

GENR SBBOOT2=SBBOOT1;
GENR SBBOOT4=SBBOOT3;
GENR SBBOOT5=SBBOOT7;
GENR SBBOOT6=SBBOOT1;

? POSTERIOR MEAN AND VARIANCE FOR ALL COEFFICIENTS
DOT 1-6;
MSD SCBOOT.;
MSD SCBOOT.93;
MSD SCBOOT.WTO;
MSD SCBOOT.2005;
MSD SCTBOOT.WTO;
MSD SCTBOOT.2005;
MSD SCTBOOT.;
ENDDOT;
?
DOT 1-7;
MSD SBBOOT.;
ENDDOT;

DOT 1-7;
GENR ALPHABOOT.=1-SBBOOT.;
MSD ALPHABOOT.;
ENDDOT;

?
GENR ROTBOOT=ALPHABOOT1*SM1+ALPHABOOT2*SM2+ALPHABOOT3*SM3+ALPHABOOT4*SM4
           +ALPHABOOT5*SM5+ALPHABOOT6*SM6+ALPHABOOT7*SM7;
MSD ROTBOOT;
?

TITLE 'ALLEN ELASTICITIES OF SUBSTITUTION';
TITLE 'SHORT RUN';
?
TITLE 'OWN PRICE ELASTICITIES OF SUBSTITUTION';
TITLE 'SHORT RUN';
?
GENR ALLENBOOT11=ALPHABOOT1+ALPHABOOT1-ROTBOOT-ALPHABOOT1/SM1;
MSD ALLENBOOT11;
```

```
?
GENR ALLENBOOT22=ALPHABOOT2+ALPHABOOT2-ROTBOOT-ALPHABOOT2/SM2;
MSD ALLENBOOT22;
?
GENR ALLENBOOT33=ALPHABOOT3+ALPHABOOT3-ROTBOOT-ALPHABOOT3/SM3;
MSD ALLENBOOT33;
?
GENR ALLENBOOT44=ALPHABOOT4+ALPHABOOT4-ROTBOOT-ALPHABOOT4/SM4;
MSD ALLENBOOT44;
?
GENR ALLENBOOT55=ALPHABOOT5+ALPHABOOT5-ROTBOOT-ALPHABOOT5/SM5;
MSD ALLENBOOT55;
?
GENR ALLENBOOT66=ALPHABOOT6+ALPHABOOT6-ROTBOOT-ALPHABOOT6/SM6;
MSD ALLENBOOT66;
?
GENR ALLENBOOT77=ALPHABOOT7+ALPHABOOT7-ROTBOOT-ALPHABOOT7/SM7;
MSD ALLENBOOT77;
?
DOT 2-7;
GENR ALLENBOOT1.=ALPHABOOT1+ALPHABOOT.-ROTBOOT;
MSD ALLENBOOT1.;
ENDDOT;
?
DOT 3-7;
GENR ALLENBOOT2.=ALPHABOOT2+ALPHABOOT.-ROTBOOT;
MSD ALLENBOOT2.;
ENDDOT;
?
DOT 4-7;
GENR ALLENBOOT3.=ALPHABOOT3+ALPHABOOT.-ROTBOOT;
MSD ALLENBOOT3.;
ENDDOT;
?
DOT 5-7;
GENR ALLENBOOT4.=ALPHABOOT4+ALPHABOOT.-ROTBOOT;
MSD ALLENBOOT4.;
ENDDOT;
?
DOT 6-7;
GENR ALLENBOOT5.=ALPHABOOT5+ALPHABOOT.-ROTBOOT;
MSD ALLENBOOT5.;
ENDDOT;
?
DOT 7;
GENR ALLENBOOT6.=ALPHABOOT6+ALPHABOOT.-ROTBOOT;
MSD ALLENBOOT6.;
ENDDOT;
```

D. 2 The TSP coding for the HPD

```
OPTIONS MEMORY=2000;
FREQ A;
SMPL 1992 2011;
CONST NOBS 20;
?
TITLE 'VARIABLE DEFINITIONS';
```

```
?1= WEST AFRICA
?2= EGYPT AND SUDAN
?3= CENTRAL ASIA
?4= INDO SUB CONTINENT
?5= AUSTRALIA
?6= USA
?7= REST OF WORLD
?
?
LOAD V1 Q1;
  49220.676          31222.721
    3203.665            1999.812
  12441.52     6825.653
  43984.03    22083.1
  31943.134          16815.44
  76006.262          43907.784
  24990.415          14528.373
    5834.673            3801.686
      957.081              747.429
    3538.164            2584.793
  31980.018          31283.227
187098.571         135729.887
512497.925         308234.758
486232.866         390779.538
485175.149         369038.853
316374.088         229903.395
230105.856         136975.939
244927.036         180569.386
274397.898         155770.84
432888.218         169332.924
;
TREND TIME;
GENR P1=V1*1000/Q1;
PRINT V1 Q1 P1;
?
?
LOAD V2 Q2;
  8134.414   5715.152
    192.541       65.007
53805.348  31430.991
77705.481  37829.54
37069.812  23564.476
20698.362  12720.21
  1007.702     420.468
  1521.454    2079.827
  8170.971    4067.883
  5208.626    2064.818
10536.189    5075.735
17966.101    9946.279
32148.306  15728.383
38931.879  21138.3
35574.274  14796.958
24329.122  10248.425
21509.433    8921.349
27260.42    11694.539
67051.801  23435.872
92233.659  20898.123
  ;
```

```
GENR P2=V2*1000/Q2;
PRINT V2 Q2 P2;
?
LOAD V3 Q3;
    3268.297             7115.957
    1410.287             3014.025
  92551.97    91064.938
128624.626         248387.476
  92050.176           91746.716
198616.431         128578.079
  54477.466           79122.662
  18991.074           60397.398
  24749.272           87675.716
  10872.437           31181.393
  24532.992           29111.368
191569.283         176805.807
358854.985         255980.876
417297.918         375245.709
556985.604         475324.941
332242.865         288243.834
305289.57  217317.578
202324.872         200611.577
757460.69  422422.593
559711.239         205069.017
;
GENR P3=V3*1000/Q3;
PRINT V3 Q3 P3;
?
?
LOAD V4 Q4;
    27542.032       18979.892
      4366.697         4961.42
      9500.356       10069.236
    11164.696         7827.255
    77929.04        46801.642
    43866.273       30371.373
    13820.935       14733.498
      2467.94          7837.772
    11619.379         28870.74
    12221.04           28911.601
        444.914           1408.481
      8680.425         15178.48
    82179.08           60227.151
  169950.406       150651.244
  784144.229       637658.544
  888925.674       680155.12
  983404.277       643818.166
  493507.073       383274.98
1861357.617       968442.931
2805763.442        1110873.788
;
GENR P4=V4*1000/Q4;
PRINT V4 Q4 P4;
?
LOAD V5 Q5;

    6450.296             4289.597
    2419.948             1777.187
```

```
  73786.576          40050.016
  50570.192          23782.936
  73611.056          39434.064
187835.648           101203.232
  50900.728          30459.252
  25688.45    17524.581
  18021.072          13042.439
  25245.626          21129.198
  23575.571          19949.644
  36335.257          24257.634
176852.555        102983.74
274992.503        202638.804
318402.552        227948.617
171702.084        117199.88
133691.173          77037.218
148794.408        102491.544
415792.229        204918.1
1549105.63        529687.275
;
GENR P5=V5*1000/Q5;
PRINT V5 Q5 P5;
?
LOAD V6 Q6;
  273468.736         170574.464
      1998.436            3803.288
  551302.912         317836.896
  964342.144         521284.768
  803832.128         423381.504
  725273.152         420764.544
  195003.6    134663.088
    26733.786          33246.815
    58683.336          72500.555
    50636.182          63796.205
    92672.655         105175.531
  666387.525         529455.53
1782180.804       1091630.801
1471545.67        1213250.332
2302777.003       1747803.744
1615187.655       1154368.382
1666913.921         994313.98
  891642.286         681812.344
2016425.988       1035592.043
2979460.099       1014148.542
;
GENR P6=V6*1000/Q6;
PRINT V6 Q6 P6;
?
LOAD VWORLD QWORLD;
    457584.96         326955.296
    25199.434           44775.296
  936139.776         615757.056
1486725.76        1003366.592
1276438.016         751459.648
1410343.168         848835.264
  381343.84          310285.728
  104825.974         163871.814
  137197.321         250906.032
  116608.617         197097.699
```

```
  199511.78        245061.35
1218245.977      1074961.058
3242122.824      2114129.012
3246197.095      2745287.768
4974642.693      3980021.554
3579753.596      2740434.396
3564706.744      2263696.391
2211367.939      1758926.167
5846449.51       3127633.895
9678595.164      3566339.643
;
GENR PWORLD=VWORLD*1000/QWORLD;
PRINT VWORLD QWORLD PWORLD;
?
GENR V7=VWORLD-V1-V2-V3-V4-V5-V6;
GENR Q7=QWORLD-Q1-Q2-Q3-Q4-Q5-Q6;
GENR P7=V7*1000/Q7;
PRINT V7 Q7 P7;
?
GENR VTOT=V1+V2+V3+V4+V5+V6+V7;
DOT 1-7;
NORMAL P.,2000,1;
ENDDOT;
PRINT P1-P7;


DOT 1-7;
GENR S.=V./VTOT;
MSD S.;
SET SM.=@MEAN(1);
ENDDOT;
PRINT P1-P7;
GENR TOTALS=S1+S2+S3+S4+S5+S6+S7;
PRINT S1-S7 TOTALS;
?
LOAD DUM1993;
0 1 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0;

LOAD DUMWTO;
0 0 0 0 0 0 0 0 0
1 1 1 1 1 1 1 1 1
1 1;
LOAD DUMWTO1;
0 0 0 0 0 0 0 0 0
0 1 1 1 1 1 1 1 1
1 1;
LOAD DUM2005;
0 0 0 0 0 0 0 0 0 0 0 0 0
1 1 1 1 1 1 1;
PRINT DUM1993 DUMWTO DUMWTO1 DUM2005;
?

SMPL 1992 2011;
DOT 1-6;
Y.=LOG(S.)-LOG(S7);
ENDDOT;
PRINT Y1-Y6;
```

```
?
TITLE 'STONE PRICE INDEX WITH CURRENT ''BUDGET SHARES';

GENR
PSTONE_CUR=EXP(S1*LOG(P1)+S2*LOG(P2)+S3*LOG(P3)+S3*LOG(P4)+S5*LOG(P5)+S6*LOG(P6)+S7*
LOG(P7));
PRINT PSTONE_CUR;

DOT 1-7;
GENR LP.=LOG(P.);
ENDDOT;
PRINT LP1-LP7;

GENR LP=LOG(PSTONE_CUR);
PRINT LP;

GENR DUMWTO_TIME=DUMWTO1*TIME;

GENR DUM2005_TIME=DUM2005*TIME;
?


LOAD CONST;
1 1 1 1 1 1 1 1 1 1
1 1 1 1 1 1 1 1 1 1;

?All EXOGENOUS VARIABLES
MMAKE X CONST DUM1993 DUMWTO1 DUM2005 DUMWTO_TIME DUM2005_TIME TIME LP1
        LP2 LP3 LP4 LP5 LP6 LP7;
MAT INVX=(X'X)"X';
MAT XINVX=X*INVX;

?ENDOGENOUS VARIABLES
MMAKE Z LP;
MAT MEANPI=INVX*Z;
MAT EHAT=Z-X*MEANPI;
PRINT EHAT;
MAT S=EHAT'EHAT;
PRINT S;

?SQUARE ROOT OF S
MAT EIGVAS=EIGVAL(S);
PRINT EIGVAS;
MAT EIGVES=EIGVEC(S);
PRINT EIGVES;
MAT SQS=EIGVES*SQRT(DIAG(EIGVAS))*EIGVES';
PRINT SQS;
?
MAT M=IDENT(NOBS)-XINVX;
PRINT M;

?BOOTSTRAP AND 3SLS MAPPING
?

CONST NBOOT 1000;
CONST NCOEFF 21;
MFORM(TYPE=GENERAL,NROW=NBOOT,NCOL=NCOEFF) MCOEFF;
```

```
DO I=1 TO NBOOT BY 1;
  SMPL 1 NOBS;
  RANDOM (UNIFORM) BOOTS;
  GENR U=NOBS*BOOTS+1;
  GENR INTU=INT(U);
  GENR ESAMPB=0;
  DO J=1 TO NOBS BY 1;
    SET ORD=INTU(J);
    SET ESAMPB(J)=EHAT(ORD);
  ENDDO;
  MMAKE ESAMPX ESAMPB;

  SMPL 1992 2011;
  MAT ESAMPXX=M*ESAMPX;
  MAT OMBOOT=ESAMPXX'ESAMPXX;
  MAT SIGSTA=S*OMBOOT"S;
  MAT EIGVASIGSTA=EIGVAL(SIGSTA);
  MAT EIGVESIGSTA=EIGVEC(SIGSTA);
  MAT SQSIGSTA=EIGVESIGSTA*SQRT(DIAG(EIGVASIGSTA))*EIGVESIGSTA';
  MAT ESAMP=ESAMPX*SQS"SQSIGSTA;
  MAT PIBOOT=MEANPI-INVX*ESAMP;
  MAT ZBOOT=X*PIBOOT;
  UNMAKE ZBOOT LPBOOT;

  DOT 1-6;
  FRML EQBOOT. Y.=CBOOT.+CBOOT.93*DUM1993+(CBOOT.WTO*DUMWTO1
                 +CBOOT.2005*DUM2005)+(CTBOOT.WTO*DUMWTO1+
                 CTBOOT.2005*DUM2005)*TIME+CTBOOT.*TIME+
                 BBOOT.*(LP.-LPBOOT)-BBOOT7*(LP7-LPBOOT);
  ENDDOT;

  PARAM CBOOT193-CBOOT693;
  PARAM CTBOOT1-CTBOOT6;
  PARAM CTBOOT1WTO-CTBOOT6WTO;
  PARAM CTBOOT12005 CTBOOT22005 CTBOOT32005 CTBOOT42005 CTBOOT52005
        CTBOOT62005;
  PARAM BBOOT1-BBOOT7;
  PARAM CBOOT1-CBOOT6;
  PARAM CBOOT1WTO-CBOOT6WTO;
  PARAM CBOOT12005 CBOOT22005 CBOOT32005 CBOOT42005 CBOOT52005 CBOOT62005;

  ?
  SMPL 1992 2011;
  DOT 1-6;
  LSQ (NOPRINT,SILENT)EQBOOT.;;
  ENDDOT;
  ?
  LSQ(NOPRINT,MAXITW=50,MAXIT=1000,SILENT)EQBOOT1-EQBOOT6;
  ?

  MCOEFF[I,1]=BBOOT1-BBOOT2;
  MCOEFF[I,2]=BBOOT1-BBOOT3;
  MCOEFF[I,3]=BBOOT1-BBOOT4;
  MCOEFF[I,4]=BBOOT1-BBOOT5;
  MCOEFF[I,5]=BBOOT1-BBOOT6;
  MCOEFF[I,6]=BBOOT1-BBOOT7;
  MCOEFF[I,7]=BBOOT2-BBOOT3;
  MCOEFF[I,8]=BBOOT2-BBOOT4;
```

```
    MCOEFF[I,9]=BBOOT2-BBOOT5;
    MCOEFF[I,10]=BBOOT2-BBOOT6;
    MCOEFF[I,11]=BBOOT2-BBOOT7;
    MCOEFF[I,12]=BBOOT3-BBOOT4;
    MCOEFF[I,13]=BBOOT3-BBOOT5;
    MCOEFF[I,14]=BBOOT3-BBOOT6;
    MCOEFF[I,15]=BBOOT3-BBOOT7;
    MCOEFF[I,16]=BBOOT4-BBOOT5;
    MCOEFF[I,17]=BBOOT4-BBOOT6;
    MCOEFF[I,18]=BBOOT4-BBOOT7;
    MCOEFF[I,19]=BBOOT5-BBOOT6;
    MCOEFF[I,20]=BBOOT5-BBOOT7;
    MCOEFF[I,21]=BBOOT6-BBOOT7;
ENDDO;


FREQ NONE;
SMPL 1 NBOOT;
UNMAKE MCOEFF D1-D21;
MFORM(TYPE=GENERAL,NROW=1,NCOL=NCOEFF) FLAG;
MFORM(TYPE=GENERAL,NROW=1,NCOL=NCOEFF) HPDP;
MFORM(TYPE=GENERAL,NROW=1,NCOL=NCOEFF) MMIN;
MFORM(TYPE=GENERAL,NROW=1,NCOL=NCOEFF) MMAX;

DOT 1-21;
MSD D.;
SET DMIN.=@MIN;
SET DMAX.=@MAX;
ENDDOT;

MMIN[1,1]=DMIN1;
MMIN[1,2]=DMIN2;
MMIN[1,3]=DMIN3;
MMIN[1,4]=DMIN4;
MMIN[1,5]=DMIN5;
MMIN[1,6]=DMIN6;
MMIN[1,7]=DMIN7;
MMIN[1,8]=DMIN8;
MMIN[1,9]=DMIN9;
MMIN[1,10]=DMIN10;
MMIN[1,11]=DMIN11;
MMIN[1,12]=DMIN12;
MMIN[1,13]=DMIN13;
MMIN[1,14]=DMIN14;
MMIN[1,15]=DMIN15;
MMIN[1,16]=DMIN16;
MMIN[1,17]=DMIN17;
MMIN[1,18]=DMIN18;
MMIN[1,19]=DMIN19;
MMIN[1,20]=DMIN20;
MMIN[1,21]=DMIN21;

MMAX[1,1]=DMAX1;
MMAX[1,2]=DMAX2;
MMAX[1,3]=DMAX3;
MMAX[1,4]=DMAX4;
MMAX[1,5]=DMAX5;
MMAX[1,6]=DMAX6;
```

```
MMAX[1,7]=DMAX7;
MMAX[1,8]=DMAX8;
MMAX[1,9]=DMAX9;
MMAX[1,10]=DMAX10;
MMAX[1,11]=DMAX11;
MMAX[1,12]=DMAX12;
MMAX[1,13]=DMAX13;
MMAX[1,14]=DMAX14;
MMAX[1,15]=DMAX15;
MMAX[1,16]=DMAX16;
MMAX[1,17]=DMAX17;
MMAX[1,18]=DMAX18;
MMAX[1,19]=DMAX19;
MMAX[1,20]=DMAX20;
MMAX[1,21]=DMAX21;


DO CR=1 TO NBOOT BY 1;
  DO CC=1 TO NCOEFF BY 1;
    IF MMIN[1,CC]<=0&MMAX[1,CC]>=0&MCOEFF[CR,CC]<=0;
    THEN;    FLAG[1,CC]=FLAG[1,CC]+1;
  ENDDO;
ENDDO;

DO J=1 TO NCOEFF BY 1;
    IF FLAG[1,J]<=(NBOOT/2);
        THEN; HPDP[1,J]=((NBOOT-2*FLAG[1,J])/NBOOT);
    ELSE; HPDP[1,J]=((2*FLAG[1,J]-NBOOT)/NBOOT);
ENDDO;

PRINT HPDP;

DOT 1,12,20,21,14,5;
SORT D.;
ENDDOT;
MMAKE MSORT D1 D12 D20 D21 D14 D5;

DO J=1 TO 6 BY 1;
    PRINT MSORT[26,J];
    PRINT MSORT[975,J];
ENDDO;
```