Preliminary

Computer Usage and Demand for Paper/Paperboard Products

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COMPUTER USAGE AND DEMAND FOR PAPER/PAPERBOARD PRODUCTS

ABSTRACT

The purpose of this paper is to analyze the effect of computer usage on the demand for paper and paperboard products. A log-linear model is developed to analyze the effect of computer usage on the demand for four categories of paper, newsprint, printing/writing paper, packaging paper and household/sanitary paper. The analysis is divided into two parts. The first part is US monthly analysis. We create computer number index as a measurement for computer usage. Monthly data (from Jan 1992 to Jun 2005) are collected to estimate the effect for four categories of paper. The monthly estimation results support the hypothesis that the increasing usage of computer has a significantly negative effect on the demand for printing/writing paper, and a significantly positive effect on the demand for packaging paper. But it doesn't provide enough evidence for the effect on the demand for newsprint.

The second part is the yearly analysis on 16 main countries, which constitute the major demand for paper/paperboard products and are countries with widespread usage of computer. Using the yearly data from 1961 to 2002 and applying fixone model, we find that computer usage has a significantly positive effect on demand for packaging paper. The small difference in US monthly analysis and 16 countries' yearly analysis may arise from the different measures in computer usage, prices of paper/paperboard products, and income.

Keywords: Computer, demand, income, fixone

1. Introduction

The emergence and development of information and communication technology (ICT) is now playing a more and more important role in every aspect of world economy. Many studies have been made to analyze its effect on various industries. However, little research has been done on the influence of ICT on the paper and paperboard industry.

What we are interested in is the effect of ICT on the demand for paper and paperboard products. According to FAO[1], paper and paperboard products can be divided into three categories: newsprint, printing & writing paper[2], and other paper & paperboard. In other paper & paperboard, there are three subcategories: household & sanitary paper[3], wrapping /packaging paper/board[4], and other paper & paperboard N.E.S (not elsewhere specified). Thus there are four main categories of paper and paperboard products: newsprint, printing/writing paper, wrapping /packaging paper/board, and household/sanitary paper.

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[1] All definitions and categories below are given by Food and Agriculture Organization of the United Nations (FAO).

[2] It includes such papers as: bank note, bible or imitation bible, book and magazine, box lining and covering, bristols, calculator papers, computer paper, duplicating, envelope stock, folder stock, label, lithograph, manifold, offset, onionskin, photographic base paper, poster, stationery, tablet or block, tabulating card stock, typewriter.

Other printing and writing paper is composed of following subcategories:

1) Coated printing & writing paper: a. Coated Wood Containing printing & writing paper, b. Coated Woodfree printing & writing paper;
2) Uncoated printing & writing paper: a. Uncoated Wood Containing printing & writing paper, b. Uncoated Woodfree printing & writing paper

[3] It includes types of creped and uncreped papers such as disposable tissues, facial tissue, napkin, sanitary wadding, toilet tissue toweling, wiper stock, etc.

[4] It is composed of following subcategories:

1) Linerboard: a. Kraft Liner: including Unbleached and Bleached Kraft Liner, b. Other Linerboard
2) Fluting Medium: a. Semi-chemical Fluting Medium; b. Other Fluting Medium
3) Kraft Wrapping and Packaging: a. Sack Kraft; b. Other Kraft Wrapping and Packaging
4) Folding Boxboard: a. Pulp Based Folding Boxboard: including Bleached Chemical Pulp Folding Boxboard, and Other Pulp Based Folding Boxboard; b. Recovered Paper Based Folding Boxboard
5) Other Wrapping and Packaging N.E.S.: a. Other Wrapping Paper; b. Other Packaging Paper

More specifically, newsprint refers to an uncoated paper mainly used for printing newspapers. Other uses are inserts and flyers, newspaper supplements and directories. The weight of a sheet of newsprint is between 40g/m^2 and 57g/m^2. [5] Printing/writing paper is used for printing and writing. Wrapping /packaging paper/board is a kind of paper used to pack and carry market products for protection of the goods. Household/sanitary paper is a type of paper used for sanitary disposable purposes. This basic knowledge of paper and paperboard categories is helpful in analyzing the different effect of computer on the demand for paper/paperboard products.

Clearly ICT may have different effect on demand for different categories of paper/paperboard products. The increasing use of ICT may enable people to read electronic edition rather than the traditional hardcopy of newspapers, magazines, and books, which may decrease the demand for newsprint and printing/writing paper. Secondly, the use of ICT will make it easier to access more information and computer, which may increase the demand for printing/writing paper. Thirdly, the growing-up use of the internet for shopping (e-commerce), due to the convenience and quickness associated with internet, may increase the demand for packaging paper since the demand for shipment may rise. In spite of the fact that the increasing usage of ICT has great impact on the demand for three categories of paper, it is easy to see that ICT may have no impact on the demand for household and sanitary paper.

In this paper we discuss the effect of ICT in two various ways. On the one hand, we use US monthly data to analyze the effect of computer usage on the demand for US paper and paperboard products. One the other hand, we use long-period yearly data of 16

[5] The definition is from Forest Products Association of Canada and Association of European Publication Paper Producers.

main countries to analyze the effect of ICT on the demand for paper and paperboard products. Then we can compare these two results and see whether the effect is robust.

This paper is organized as follows. In section 2, we introduce our methodology and review some relevant studies on paper and paperboard industry. Section 3 develops the empirical models for the paper demand, taking computer number as one of the explanatory variables. Section 4 briefly describes the data. Section 5 presents the estimation results and makes comparisons. Section 6 concludes the paper and gives possible extensions.

2. Methodology and Literature Review

Firstly, we use monthly data to analyze the relationship between demand and computer usage in US paper and paperboard industry. The U.S. paper and paperboard industry is a traditional industry and used to play an important role in the development of U.S. economy. However, nowadays this industry is faced with many problems and not as important as before. One of the problems is the effect of computers and internet usage on the demand for paper/paperboard. Being a remarkable change in the past decade, the widespread use of computers has affected so many aspects of human life, including working, studying, entertainment, and shopping style.

What we are concerned in this paper is the effect of computers usage on the demand for the paper and paperboard products. As we have discussed above, the increasing usage of computer may has great impact on the demand for newsprint, printing/writing paper and wrapping /packaging paper/board, while it may not affect the demand for household/sanitary paper.

As can be seen from Figure 1[6] in the Appendix, it is obvious that the demands for four categories of paper & paperboard products in the past forty-one years have changed at different rates. Does computer usage contribute to these differences? This is the focus of our analysis.

Secondly, we use yearly data of 16 main countries[7] in a longer period to analyze the relationship between demand and computer usage in the paper and paperboard industry.

In the world yearly level analysis, what we need to point out is the countries we are interested in. In this paper we select 16 countries to analyze the effect of ICT on demand for paper and paperboard products. There are two reasons for the selection of these 16 countries. The first reason is that these 16 countries account for more than 60% of the world demand. The other reason is that these 16 counties have high or medium ICT (See Hetemaki and Nilsson (2005)), which enable us to make statistical analysis.

Thirdly, these two results are compared to check the robustness of our model.

There are some relevant studies on the demand or production estimation of paper industry. Zhang and Buongiorno (1997) developed a model to estimate the demand for printing and publishing papers, and the data are during the period of 1960-1991. They use a two-stage almost ideal demand system (AIDS) representing the consumer demand for communication (stage one) and for printed materials, computers, and televisions and radios (stage two). Their results suggest that printed materials and computers were luxury

[6] This graph is drawn according to the data provided by FAO.
[7] The 16 countries included in our analysis are: Australia, Austria, Canada, Denmark, Finland, France, Germany, Italy, Japan, Netherlands, New Zealand, Norway, Spain, Sweden, United Kingdom, and United States of America.

goods; the demand for printed materials was independent of the price of the computers and slightly complementary of the demand for the televisions and radios.

Roger Brown and Daowei Zhang (2004) analyze the paper products supply in the United States for the period of 1981-2001. They presented the product-level econometric models using two stage least squares geometric distributed lag model in log-log form , and estimate the long-run and short-run output price elasticities, and the input elasticities.

Hetemaki and Obersteiner use new methods, Bayesian model, to compute projections for US newsprint demand up to 2020, which allows industry experts' prior knowledge about the future demand for newsprint to be included in the projections. They also use an ad hoc model which assumes that newsprint demand is a function of changes in newspaper circulation.

Li, Luo, and McCarthy (2004) investigate the demand pattern and structural changes during the China's economic transformation, using instrumental variables estimations, cointegration analysis and error-correction models. The data they used are yearly data from the paper and paperboard industry in China.

Although these literatures are on demand or production of pulp and paper industry, little has been done on the effect of computer usage on paper and paperboard industry. In this paper we try to make some basic analysis of this problem. As the data on internet usage are not long enough, we only analyze the effect of U.S. computer number on the U.S. demand of paper. The next section specifies the model we use.

3. Model Specification

Firstly, we derive the demand model for paper/paperboard products without computer number. According to Chas-Amil & J. Buongiorno (2000), the demand for paper and paperboard products is derived from the demand for final products, thus the demand D is a function of its price P and output Y. Similar as assumed in relevant studies, the model we adopted is derived from a cost minimization problem subject to a Cobb-Douglas production function:[8]

$$\begin{aligned} &\min_{D_t^*, O_t} C_t = D_t^* P_t^D + O_t P_t^O \\ &\quad s.t. \quad Y_t = a(D_t^*)^b (O_t)^c \end{aligned} \tag{1}$$

where C_t is the total cost for producing final products Y_t[9], D_t^* is the equilibrium demand for paper/paperboard products at time t, O_t is the other inputs at time t, P_t^D *and* P_t^O denotes the price of paper/paperboard products, and other inputs at time t respectively, a, b and c are parameters.

Using the Lagrange method to solve this problem, the demand function is as follows:[10]

$$D_t^* = a^{-\frac{1}{b+c}} \left(\frac{b}{c}\right)^{\frac{c}{b+c}} \left(\frac{P_t^D}{P_t^O}\right)^{-\frac{c}{b+c}} (Y_t)^{\frac{1}{b+c}} \tag{2}$$

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[8] According to Hetemäki and Obersteiner, the forest products, including newsprint, act as intermediate input in the production function.

[9] Y_t is the production of final products, which is generally measured by GDP in related studies.

[10] Applying the first order condition to D_t^* and O_t, we get $\frac{P_t^D}{P_t^O} = \frac{bO_t}{cD_t^*}$. Plugging this equation into the Cobb-Douglas production function, we obtain the demand function for paper after optimization computation.

Secondly, we extend this static model into a dynamic model, that is, we allow for partial adjustment. We assume $\frac{D_t}{D_{t-1}} = (\frac{D_t^*}{D_{t-1}})^e$ (3)

, where D_{t-1}, D_t is the actual (i.e., observed) demand at time t-1 and t, and $0 \le e \le 1$ is the adjustment speed.

Plugging equation (2) in equation (3), we obtain the dynamic model:

$$D_t = (D_t^*)^e (D_{t-1})^{1-e} = a^{-\frac{e}{b+c}} (\frac{b}{c})^{\frac{ce}{b+c}} (\frac{P_t^D}{P_t^O})^{-\frac{ce}{b+c}} (Y_t)^{\frac{e}{b+c}} (D_{t-1})^{1-e} \quad (4)$$

Next, we try to include computer number in the above function. Since computer number can be regarded as a shock which may affect the demand for paper/paperboard products, we just add computer number as a part of the constant a. Hence, we obtain the following model:

$$D_t = (D_t^*)^e (D_{t-1})^{1-e} = [a^O (COMP_t)^d]^{-\frac{e}{b+c}} (\frac{b}{c})^{\frac{ec}{b+c}} (\frac{P_t^D}{P_t^O})^{-\frac{ec}{b+c}} (Y_t)^{\frac{e}{b+c}} (D_{t-1})^{1-e} \quad (5)$$

, where $COMP_t$ is the number of computer a time t, a^O and d are parameters. Making logarithmic transformation, we get

$$\begin{aligned} \ln(D_t) &= -\frac{e}{b+c}\ln(a^O) + \frac{ce}{b+c}\ln(\frac{b}{c}) + \frac{e}{b+c}\ln(Y_t) - \frac{ce}{b+c}\ln(\frac{P_t^D}{P_t^O}) - \frac{de}{b+c}\ln(COMP_t) + (1-e)\ln(D_{t-1}) \\ &= \beta_0 + \beta_1 \ln(Y_t) + \beta_2 \ln(P_t) + \beta_3 \ln(COMP_t) + \beta_4 \ln(D_{t-1}) \quad (6) \end{aligned}$$

The last step is to add error terms ε_t, which leads to the empirical model:

$$\ln(D_t) = \beta_0 + \beta_1 \ln(Y_t) + \beta_2 \ln(P_t) + \beta_3 \ln(COMP_t) + \beta_4 \ln(D_{t-1}) + \varepsilon_t \quad (7)$$

Since what we are interested in is the difference affect of computer usage on different categories of paper/paperboard, the above model changes into:

$$\ln(D_{it}) = \beta_0 + \beta_1 \ln(Y_t) + \beta_2 \ln(P_{it}) + \beta_3 \ln(COMP_t) + \beta_4 \ln(D_{i,t-1}) + \varepsilon_{it} \qquad (8)$$

, where the subscript i denotes newsprint, printing/writing paper, packaging paper and household/sanitary paper respectively.

Equation (8) is the model that we use to analyze the effect of computer usage on demand for different paper/paperboard categories. But in empirical analysis it is necessary to test serial correlation of the error terms as it is time-series data. Therefore this model may be revised to include more lagged variables according to the existence of serial correlations arising from our data.

4. Data and Descriptive Statistics

(1) Monthly Data of US analysis

The range of monthly data is from January 1992 to June 2005. There are some missing values in some specific months. The number of observations ranges from 132 to 162. Due to the availability of data, we use demand data of tissue as a substitute for the demand data of household/sanitary paper in monthly analysis.

The monthly demand data for four categories of paper are apparent demand data, which is calculated by adding production and import minus export. The monthly production data is collected from 'Pulp & Paper Week'. [11] The monthly import and export data are calculated from the dataset of U.S. International Trade Commission.[12]

[11] The production data of printing/writing paper is the sum of uncoated ground woods, coated papers, uncoated free sheet, and other printing/writing papers.

[12] Since the trade data available are arranged in HS code, we construct a correspondence between HS code and four categories of paper/paperboard. Newsprint corresponds to HS four-digit code 4801(Newsprint); printing/writing includes HS four-digit code 4802 (Uncoated paper for writing, printing, office machines, excluding 480220 since its unit is square meters), 4804 (Uncoated kraft paper and paperboard) and 4805 (Uncoated paper and paperboard nes); packaging paper corresponds to HS code 4819 (Paper, board

The monthly price data we use are producer price index data, which are obtained from the U.S. Bureau of Labor Statistics.[13]

As to the measurement of computer number, we define the number of computers used at time t as the number of computers that have been sold in the past thirty-six months, since computers are durable goods and normally the computer one bought three years ago can still be used.[14] And monthly data of computer number sold is calculated by using the formula: monthly value of shipment of computer /monthly PPI of computer[15], where the monthly data on value of shipment of computer are obtained from U.S. Census Bureau, and the monthly computer prices are price index data which are collected from the U.S. Bureau of Labor Statistics. [16]Thus the computer number we have created through the above procedure is actually a computer number index. Its trend is shown in Figure 2 (Appendix).

When it comes to income, we choose industrial production value as a proxy for income[17], since it is the production value of all goods and closely related the total income of the economy. [18] The data are obtained from Board of Governors of the Federal Reserve System, Federal Reserve Bank[19].

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containers, packing items, box files, et); tissue includes HS code 4803 (Paper, household, sanitary, width >36 centimeters) and 4818 (Household, sanitary, hospital paper articles, clothing).

[13] a. Newsprint, Series Id: WPU091302, not seasonally adjusted, base date: 8200; b. Packaging and industrial converting paper, Series Id: WPU091303, not seasonally adjusted, base date: 8200; c. Writing and printing papers, Series Id: WPU091301, not seasonally adjusted, base date: 8200; d. Sanitary paper products, including stock, Series Id: WPU091501, not seasonally adjusted, base date: 8200

14Computer number index in 1992, 1993 and 1994 are calculated according to the past three years' yearly computer output index.

[15] M3 series data, Item: 34A (Electronic Computer Manufacturing), Not Seasonally Adjusted.

[16] Item: Electronic computers, Series Id: WPU115101, Not Seasonally Adjusted, base Date: 0412.

[17] Most related studies use GDP to measure income, but in this paper we use monthly data and monthly GDP converted from quarterly GDP data are not accurate. So we just use industrial production value.

[18] Another choice is disposable personal income, but we don't use this one when taking into account that some percent of demand for paper products are from non-individual side (such as companies and governments).

[19] Industrial production value is based on 2000 US dollars.

The descriptive statistics of monthly data are shown in Table 1.

Figure 1 and Figure 2 in the Appendix show the US demand and computer index change respectively.

(2) Yearly Data of 16 countries' analysis

The apparent demand is calculated using the same method above, based on the data collected from FAO dataset.[20] These are yearly data from 1961 to 2002.

As to real GDP, for the convenience of comparison, we use the data in 1995 constant dollars, which is from United Nations Common Database (UNCDB) and the period is from 1961-2002. The total real GDP for the 16 countries as a whole is obtained by summing up the country-level real GDP data. The yearly GDP data start from 1961 and end at 2002.

Under the assumption of perfect competition, the price can be approximated by the import price. The nominal price for a country is calculated through dividing country's import value by import quantity. The country's real price is calculated by using this formula: Import Price=Import Value*GDP deflator/Import Quantity. Then the 16 countries' average real price is the weighted sum of the real price data at country-level, where we use the population share as the weight.[21] The import value and quantity data are obtained from FAO dataset and the GDP deflator are collected from UNCDB. Since the

[20] Note: The production data for United States in year 1994 and 1995 are extremely small, with the value of 4286000 and 3879000, while the values in 1991, 1992, 1993,1996 and 1997 are 37929008, 39265008, 39874000, 47440000, and 49674000, respectively, all of which are one-digit longer than the values in 1994 and 1995. Therefore it is obvious that there is a mistake of missing one digit in these two years. In this paper we think that a last-order digit "0" is missing in the front of the values for 1994, and that a first-order digit "4" is missing in the front of the values for 1995, thus the production data for United States in year 1994 and 1995 are corrected into 42860000 and 43879000, respectively. Consequently the production and apparent data of Wrapping Paper/Paperboard category for world and North America Free Trade Area are corrected.

[21] An alternative is to use demand share as weights, but it may cause the problem of endogeneity.

GDP deflator we found is for the period 1970-2002, the real price data is also for the period 1970-2002.

The data for ICT, including number of personal computers[22], internet users[23], TV receivers and mobile subscribers, are collected from UNCDB. The periods for these data are 1980-2002, 1990-2002, 1980-1999, and 1980-2002, respectively. According to Hetemaki and Nilsson (2005), ICT index= (Internet users+ mobile users+ PCs+ TVs)/1000 people.

Figure 3 and Figure 4 describe the total demand share and the total demand value of the 16 countries from 1961 to 2002. Since household/sanitary paper is not the focus of our analysis, we don't include the change in this subcategory in the graphs. Thus the categories shown in these two graphs are total paper/paperboard, newsprint, printing/writing paper and wrapping/packaging paper/board. It is obviously that the demand share is decreasing. For the total paper and paperboard products, the demand share decreased from 81% in 1961 to about 64% in 2002. The changes in newsprint and printing/writing paper are very similar as that of the total industry. For the household/sanitary paper and wrapping/packaging paper/board, their demand shares are more than 97% in 1961, while in 2002 it decreased to 67% and 62%, respectively.

Figure 5 and Figure 6 illustrate the change of nominal and real price of different categories, respectively.

Thirdly, we relate the trend of demand with GDP. Figure 7 in the Appendix shows the change of GDP and population of the 16 countries in the years from 1961 to 2002.It is

[22] Number of Personal Computers (PC): measures the number of computers installed in a country. The statistic includes PCs, laptops, notebooks etc, but excludes terminals connected to mainframe and mini-computers that are primarily intended for shared use,

[23] Internet is a linked world-wide network of computers in which users at any one computer, if they have permission, get information from other computers in the network.

clear that both the apparent demand and the GDP are increasing through the forty-one years, and their patterns are very close.

Figure 8 describes the development of ICT in the 16 countries and the whole world. It can be seen that the personal computers and internet users in the 16 countries account for about 50% of the world. The shares of TV and mobile users in the 16 countries are about 40% in 2002.

The detailed descriptive statistics of yearly data of 16 countries data are shown in Table 2 - Table 6. The first one is the information of the 16 countries, and the rest 4 tables are the statistics by categories.

5. Empirical Results

(1) US analysis

1) Estimation Using Monthly Data: 01/1993-06/2005

Firstly, due to the use of not-seasonally adjusted monthly data, we add eleven monthly dummies into the model to take into account the impact of different months.

Secondly, since the lagged variable appears in the left side of the model, it may result in a problem of dynamic incompletion if there is a serial correlation in the residuals. To avoid this problem, we use monthly data and run a regression of OLS residuals on the explanatory variables and the lagged residuals. The result (Table 1.2) shows that serial correlation does exist with type AR(2). Consequently, we rewrite the model to include three-ordered lagged demand variable.

The estimation results are reported in Table 1.3. It is clear that most monthly dummies are significant in four models. For newsprint category, the coefficient for the

variable of computer number index is negative and significant (-0.06 with t-value -3.95), which means that the computer number index has a negative and significant effect on demand for newsprint. This is accorded with the intuition that the increase of computer usage will decrease the demand/production of newsprint since people may tend to get information through computer while reducing the demand of hardcopy. The estimated coefficient of Industrial production index, as a proxy of income, is positive and significant. The effect of price is negative and significant in newsprint demand model.

As to printing/writing paper category, the computer number index has a negative but insignificant effect on the demand. This result may be explained by the facts that people may tend to read the electronic information and at the same time they may print more materials since the information they have access are increasing. Therefore, the total effect of computer number is ambiguous, and may be more towards negative due to the gradual change of reading habit.

When it comes to packaging paper, the coefficient of computer number is positive and insignificant, which may result from several factors. One point of view is that with the widespread of e-communication, such as emails and e-cards, people tend to write fewer mails. Consequently the increasing of computer number may decrease the demand/production for packaging paper. On the other hand, with the blooming of internet, e-commerce is developing, and this may increase the demand for packaging paper due to less shopping in physical store. Thus the total effect is ambiguous and may be more toward positive.

As to demand model for household/sanitary paper, it's not surprising that computer number is insignificant. This result is reasonable since by intuition the number of computers used wouldn't affect the demand for household/sanitary paper.

In summary, the increasing of computer number may decrease the demand for newsprint significantly, while it may not affect the demand for printing/writing paper packaging paper, and household/sanitary paper. But the reasons for the insignificance may differ.

2) Estimation Using Annual Data: 1961-2002

To make relatively longer time series comparison, we collected relevant annual data to make regression. For the years before 1987, which is the earliest year for the computer data, we simply give zero to the computer number. The procedure is the same as that when we use monthly data.

First we test for serial correlation, and find that there is no indication of AR(1). The results are reported in Table 2.2. This may arise from the fact that for annual data one year lag is enough, while for monthly data one month adjustment is not enough.

Secondly we estimate the model with only one lagged demand variable. As can be seen from Table 2.3.1 and Table 2.3.2, the computer number has a negative and significant effect on the demand for newsprint, while it doesn't seem to have affected demand for other categories of paper/paperboard significantly. This result is similar as what we find by using monthly data.

Generally speaking, the increasing use of computer and internet only has significantly negative effect on demand for newsprint. As to printing/writing paper and packaging paper, its effect is not significant, and this phenomenon may be altered with

time going on. It is obvious that the living pattern of people has been changing gradually due to increasing usage of computer. For instance, people may become more and more accustomed to reading electronic materials instead of hardcopy magazines and newspapers, which may decrease the demand for both newsprint and printing paper. Another change is the springing up of e-commerce since the end of the 20th century, which may stimulate the use of packaging paper.

(2) 16 countries' analysis

Seeing the high correlation between computer and internet, we only include computer into the model, and we use the data starting from 1981 to run regressions. Thus, to analyze the effect of computer usage on the paper/paperboard industry, we use the same model as in part (1), that is, including price, computer number, income(here is GDP), one lagged demand variable, and time trend. Since this time we have 16 countries instead of one country, fixone model is used instead of previous OLS regression.

The results of aggregate demand estimation are reported in Table 3.3.1 and Table 3.3.2, and the results of per capita demand estimation are reported in Table 3.4.1 and Table 3.4.3, where we have tried both log-linear time trend and exponential time trend.

As can be seen from the tables, computer has a significantly positive effect on the demand for printing and writing paper, while exponential time trend has a significantly negative effect on the demand. For packaging paper, increased computer usage increases the demand, while log-linear time trend has a significantly negative effect on the demand. The results imply that the widespread usage of computer increase the demand for printing/writing paper and packaging paper, which is in accordance with our analysis in the production. On the other hand, as time goes on, people tend to use less

printing/writing paper and packaging paper, which is also reasonable since people are changing their way of living gradually. Another result is that neither computer usage nor time trend has a significant effect on the demand for newsprint and household/sanitary paper.

As to the per capita demand analysis, increasing computer usage increases the demand for packaging paper, but the log-linear time trend will decrease the demand.

6. Conclusions

The purpose of this paper is to analyze the effect of computer usage on the demand for paper and paperboard products. In general, we classified paper and paperboard products into four categories: newsprint, printing/writing paper, packaging paper and household/sanitary paper. In this paper we divide our analysis into two parts.

The first part is the analysis on US. Paper and paperboard industry is one of the largest manufacturing industries in the United States. We collect relevant data and develop a log-linear model to analyze the effect of computer usage on the demand for paper. On the one hand, we use monthly data from Jan 1992 to Jun 2005 to estimate the effect of computer usage on demand for four categories of paper. (Tissue is used as a comparing category.) We create computer number index as a measurement for computer usage. We also calculate monthly apparent demand data for four categories. The test results show that there is serial correlation in the error terms, and we include three-ordered lagged demand to correct for serial correlation. The estimation results support the hypothesis that the increasing usage of computer has a significantly negative effect on the

demand for newsprint. But it doesn't provide enough evidence for the effect on printing/writing paper and packaging paper. The reason may be that there are both positive and negative effects on these two categories, which lead to the insignificance of total effect.

On the other hand, we also employ annual data from 1961 to 2002 to make statistical analysis. Only first-order lagged demand is included in the model after the serial correlation test. This may due to the adoption of annual rather than monthly data. The estimation results are similar as above, and computer number index only affect the annual demand for newsprint significantly.

The insignificant effect of computer number on printing/writing paper is due to the negative effect resulted from reading electronic edition and the positive effect caused by having access to more information and convenience to print. Thus the result may be different several years later, since people's reading habits are changing in an increasing speed.

The second part is the analysis on 16 main countries, which constitute the major demand for paper/paperboard products and are countries with widespread usage of computer. Using fixone model, we find that computer usage has a positive effect on demand for printing/writing paper and packaging paper, while time trend affects the demand for these two categories of paper negatively. The above results hold for both aggregate demand and per capita demand.

The difference in US analysis and 16 countries' analysis may arise from the different measures in computer usage, prices of paper/paperboard products, and income.

This study calls for several possible extensions. One extension is to improve the model specifications. Another improvement is related with finding better data on computer numbers and demand for paper[24], which would increase the accuracy of the regression results.

[24] Another available data on computer number is computer output index, which is a longer time series data from Jan 1972 to Oct 2004. And the basic results of using computer number index and compute production index are very close. Thus it may be possible to use compute production index as independent variable, since a larger sample size may be better for the analysis.

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Appendix:

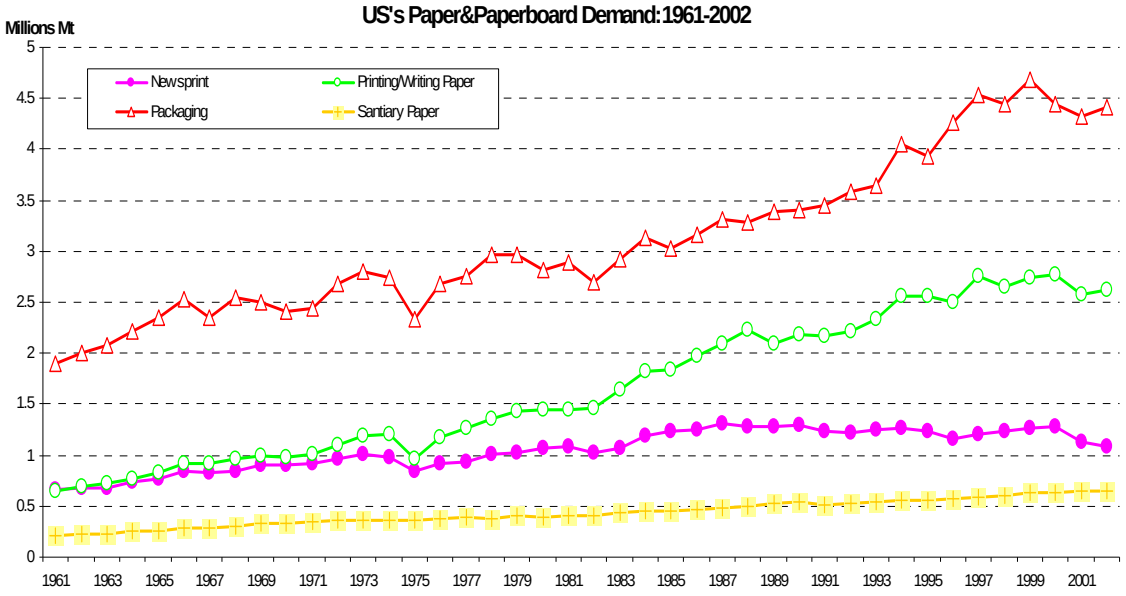

Figure 1. US's Paper/Paperboard Demand: 1961-2002

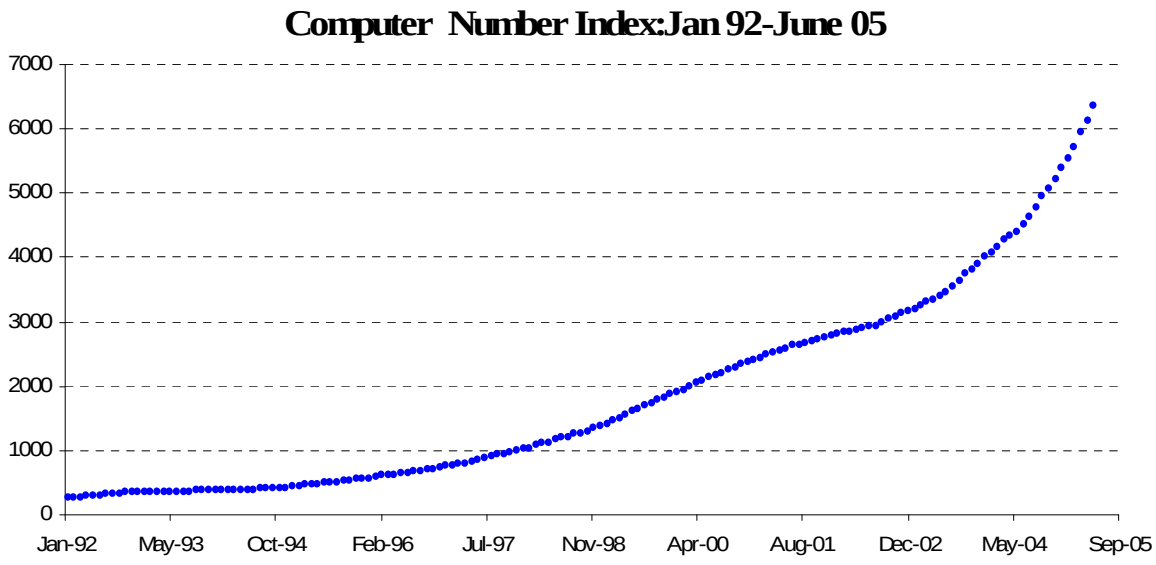

Figure 2. Computer Number Index: Jan 92-June 05

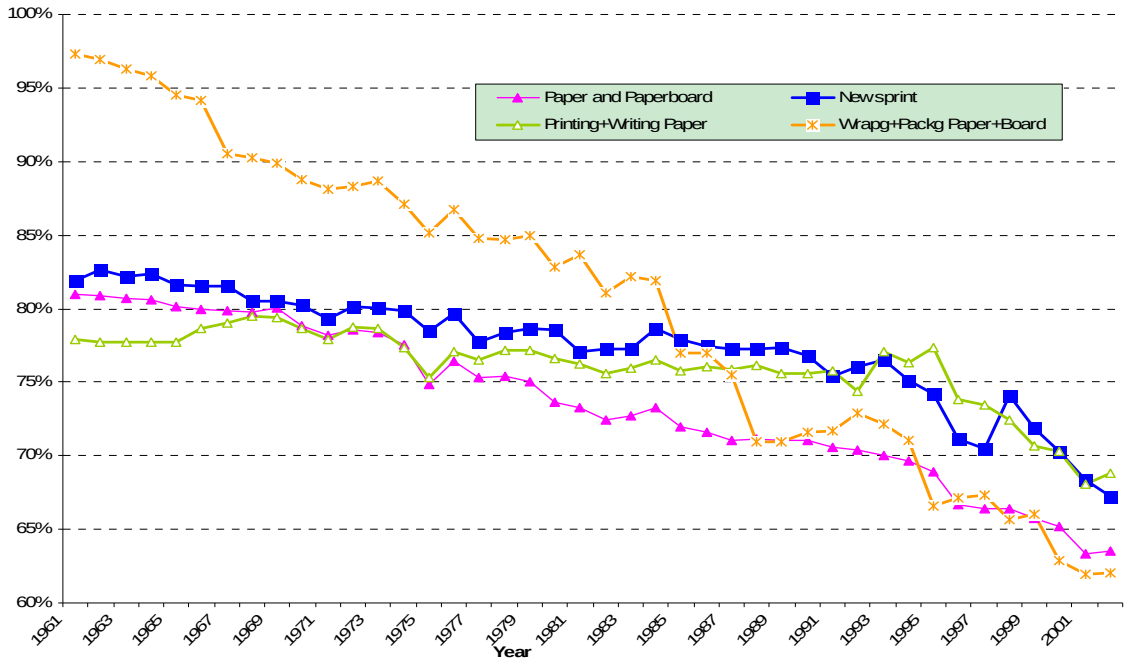

Figure 3. World Share of Paper/Paperboard Demand-16 Countries: 1961-2002

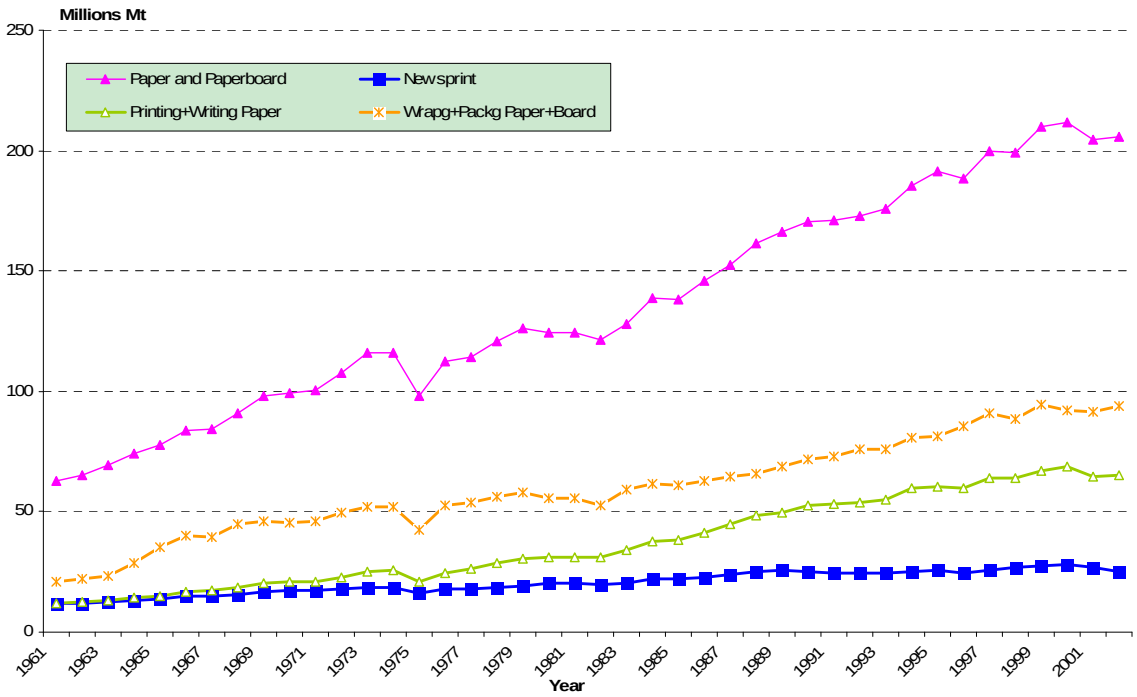

Figure 4. Paper/Paperboard Demand-16 Countries: 1961-2002

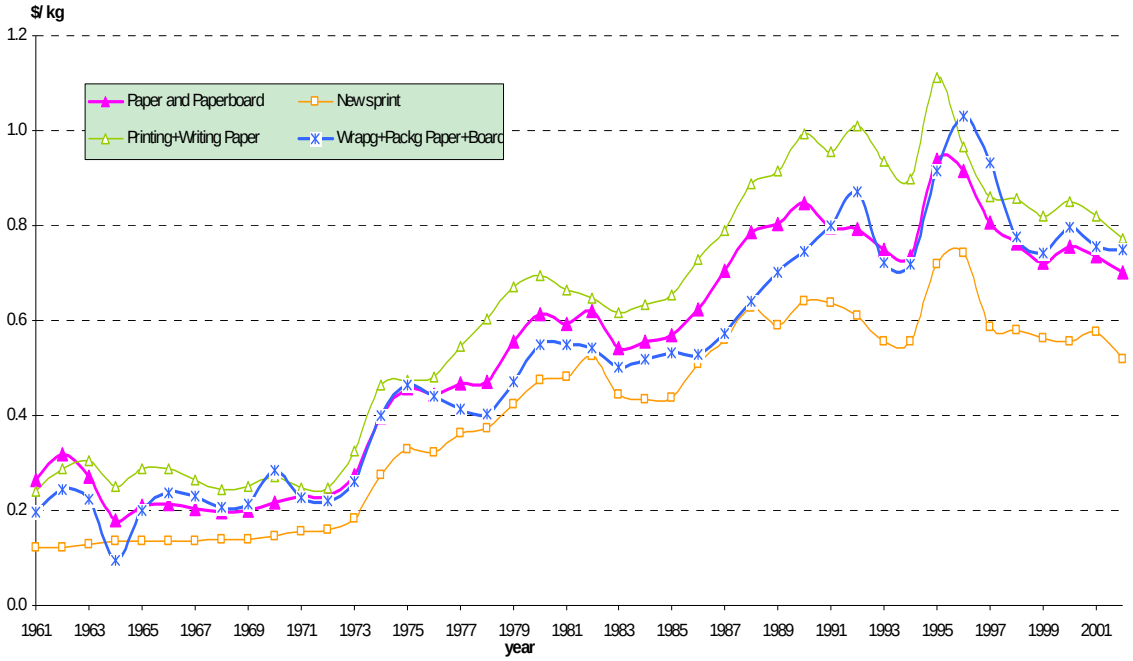

Figure 5. Nominal Price of Paper/Paperboard: 1961-2002

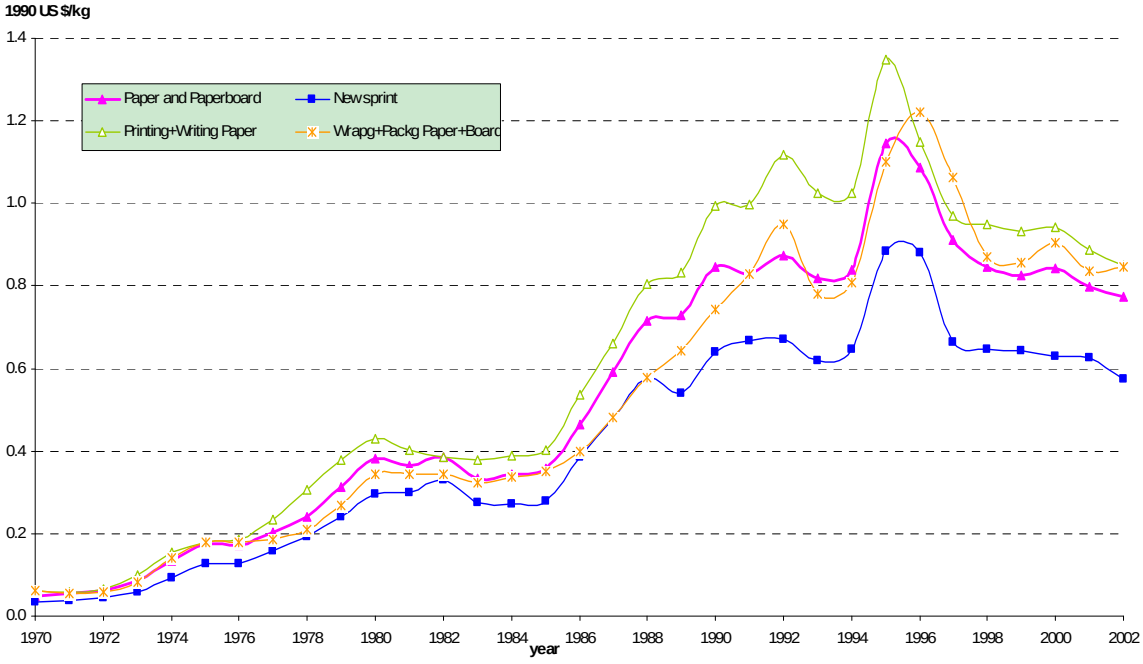

Figure 6. Real Price of Paper/Paperboard: 1970-2002

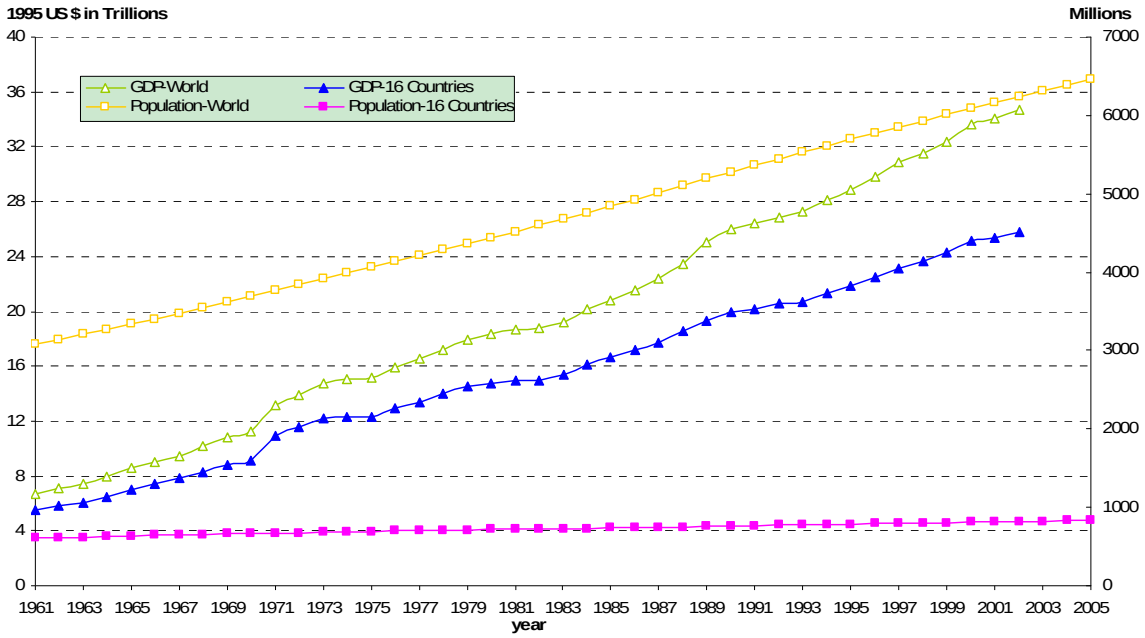

Figure 7. GDP & Population: 1961-2002

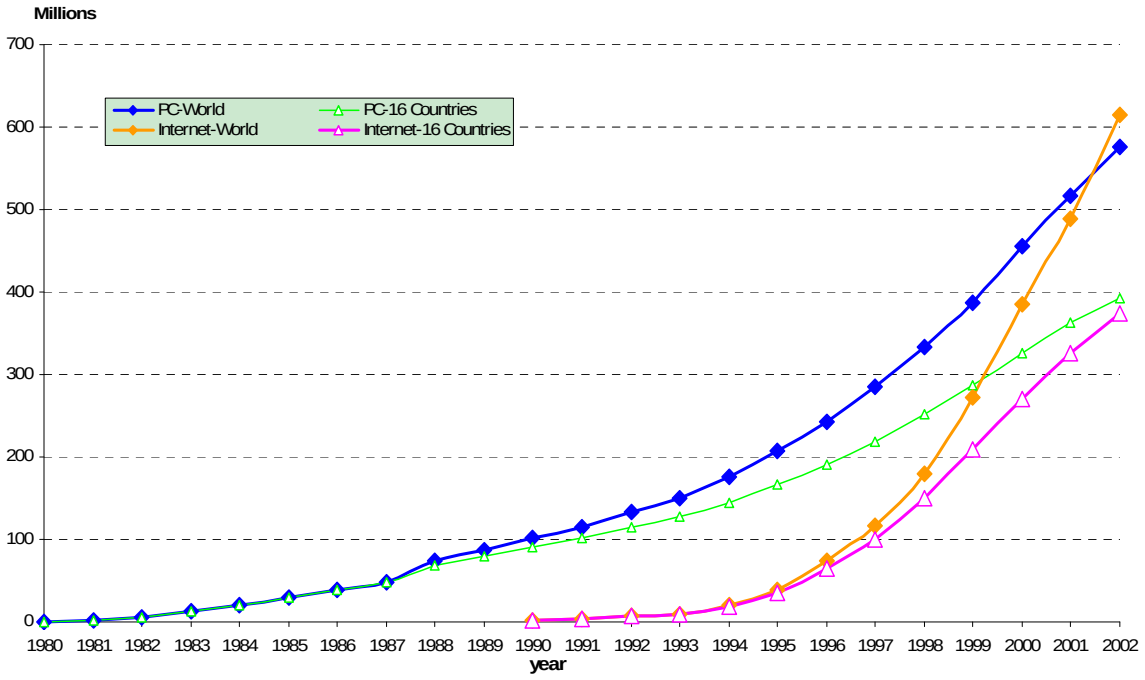

Figure 8. Personal computers and Internet users: 1980-2002

Table 1: Descriptive Statistics- US Monthly Data

Variable	N	Unit	Mean	Std Dev	Min	Max
Newsprint demand	160	1000 metric ton	983.91	85.46	771.73	1148.60
Printing/writing demand	159	1000 metric ton	1830.05	211.48	1001.98	2205.09
Packaging demand	135	1000 metric ton	275.18	24.36	212.08	329.29
Tissue demand	132	1000 metric ton	494.41	49.86	400.25	588.38
Industrial production value	162	Billion, in 2000 USD	2530.98	291.79	1951.95	2963.48
Value of shipment-Comp	162	million dollars	4549.29	1264.34	2522.00	7926.00
Computer number index	198		506.68	319.35	121.41	1245.37
Newsprint PPI	159	1982=100	128.58	20.12	98.90	186.20
Printing/writing PPI	162	1982=100	139.84	12.04	116.80	166.70
Packaging PPI	162	1982=100	162.19	13.37	137.20	185.20
Tissue PPI	162	1982=100	144.78	6.10	132.10	154.50

Table 2: Descriptive Statistics-16 Countries Information

Variable	Unit	N	Mean	Std Dev	Min	Max
GDP	billion $	2499	1015.57	1588.49	27.48	9196.4
population	billion	2538	0.05	0.06	0	0.29
GDPpercap	$/person	2499	20948.69	7601.35	5511.82	44897.18
GDPdefla	base 1990	2104	72.14	31.02	14.6	161.3
computer	million	1016	11.93	25.93	0.1	190
internet	million	824	7.55	20.8	0	159

Table 3: Descriptive Statistics of 16 countries- Newsprint

Variable	Unit	N	Mean	Std Dev	Min	Max
demand	million metric ton	654	1.3	2.57	0.01	13.13
dempercap	kg/person	654	27.08	13.9	1.29	79.08
pricenominal	$/ton	539	0.43	0.2	0.06	1.2
pricereal	base 1990	445	0.72	0.22	0.13	1.97
Production	metric ton	654	1377291.9	2156184.2	0	9970000
Export	metric ton	654	733529.24	1812786.1	0	9029000
Import	metric ton	654	655179.82	1571550.2	0	8142800
ImValue	1000 $	654	284701.17	720671.59	0	4650760
ExValue	1000 $	654	300198.58	814068.29	0	5638797

Table 4: Descriptive Statistics of 16 countries-Printing/Writing

Variable	Unit	N	Mean	Std Dev	Min	Max
demand	million metric ton	656	2.37	4.52	0.02	27.64
dempercap	kg/person	656	43.92	27.99	4.3	213.27
pricenominal	$/ton	656	0.72	0.34	0.17	1.88
pricereal	base 1990	528	1.25	0.47	0.46	3.11
Production	metric ton	656	2495082.6	4134408.5	0	24331000
Export	metric ton	656	678194.78	1117233	0	7592020
Import	metric ton	656	548788.52	948089.93	43	6490525
ImValue	1000 $	656	441940.91	796498.84	25	5185090
ExValue	1000 $	656	538297.55	913177.67	0	5442820

Table 5: Descriptive Statistics of 16 countries-Packaging

Variable	Unit	N	Mean	Std Dev	Min	Max
Demand	million metric ton	618	3.84	7.52	0.01	46.88
Dempercap	kg/person	618	70.83	37.21	0.37	256.42
Pricenominal	$/ton	580	0.56	0.27	0.11	1.45
Pricereal	base 1990	502	0.91	0.37	0.26	4.71
Production	metric ton	618	4090768.1	8042804.1	0	50675000
Export	metric ton	618	771005.95	1108186.7	0	6774000
Import	metric ton	618	517280.06	685733.26	0	3444000
ImValue	1000 $	618	316740.96	492241.44	0	3063170
ExValue	1000 $	618	459512	745553.75	0	4448808

Table 6: Descriptive Statistics of 16 countries- Household/Sanitary

Variable	Unit	N	Mean	Std Dev	Min	Max
Demand	million metric ton	610	0.55	1.12	0	6.51
Dempercap	kg/person	610	10.09	6.41	0.02	33.51
Pricenominal	$/ton	512	1.16	0.59	0.1	4.16
Pricereal	base 1990	467	1.86	1	0.11	6.82
Production	metric ton	610	552339.52	1115945.8	0	6447328
Export	metric ton	610	30000.55	41878.65	0	327000
Import	metric ton	610	26519.83	44036.97	0	264000
ImValue	1000 $	610	30207.01	56142.36	0	459439
ExValue	1000 $	610	32939.49	51114.13	0	364980