Economic Transition and Demand Pattern: Evidence from China's Paper and Paperboard Industry

Haizheng Li
Jifeng Luo
Patrick McCarthy*

School of Economics
Georgia Institute of Technology
Atlanta, GA 30332-0615

September 2004

* The corresponding author, School of Economics, Georgia Institute of Technology, Atlanta, GA 30332-0615, USA, phone: 404-894-4914, fax: 404-894-1890, email: mccarthy@econ.gatech.edu. This research was sponsored by the Center for Paper Business and Industry Studies (CPBIS), one of Sloan Funded Industry Centers, Atlanta, Georgia. All of the opinions expressed in this paper are attributable to the authors and are not those of CBPIS or the Sloan Foundation. An earlier version of this paper was presented at the International Conference of the Integration of the Greater Chinese Economies Hong Kong, June 2002. We thank Jim McNutt, CPBIS' Executive Director, for providing helpful information.

Economic Transition and Demand Pattern:
Evidence from China's Paper and Paperboard Industry

ABSTRACT

In this study, we investigate the demand pattern and structural changes during the economic transformation using data from the paper and paperboard industry in China. Instrumental variable estimations as well as cointegration analysis and error-correction models are applied to the analysis. Our results show that in the early stages of economic reform before 1993, the demand did not respond to price changes; while in the later stages, the demand shows significant responses to its own price and the price of international markets. In particular, since 1992, the own and cross price elasticity of demand for domestically made paper and paperboard products becomes, respectively, -0.69 and .59, in the range found in some market economies. We also find that imports are substitutes for domestically made paper and paperboard products, but the reverse is not true; and in the later stage of economic transition, the reliance on international market has increased, as reflected by the lower price elasticity of imports.

J.E.L code: O12, O53, L73

Key words: Paper and paperboard demand, demand elasticities, vector error correction, economic transition, China.

1. Introduction

China's economic transition since 1979 is characterized by rapid economic growth, gradual transformation into a market system, and increasing integration into the world economy. The complex economic dynamics during the transition period affects every aspect of the economic system, including industry demand structure. Understanding the demand for a particular industry is important for policy makers and for the industry stakeholders; as an emerging international market, China is also of especial interest to foreign producers and investors who are ready to tap into the Chinese market.

Moreover, the economic transition and market reforms may add new features to industry demand, and thus poses new questions in studying the demand structure. Over the period of 1979-2001, continuing economic growth and economic reforms have dramatically changed the Chinese economy, providing an opportunity to investigate the demand dynamics. If the economy becomes increasingly market oriented and open, it is expected that the demand responses to price and to international markets would increase. Some studies, such as Young (2000), however, indicate that the Chinese economy has become fragmented internally as a result of economic reform. The demand dynamics for a particular product group will at least shed light on the overall degree of market mechanism in the Chinese economy.

This study investigates the demand for paper and paperboard products in China. The paper and paperboard industry represents Chinese traditional industries. A common feature of a traditional industry in China is that most firms in this industry were state-owned or other publicly owned and thus operated under the government planning system that did not use profits or return on investment as a metric for success. The economic reforms forced state-owned enterprises to adopt more market oriented approaches and are increasingly employing market-related criteria to evaluate the success of the enterprise. This change is having a greater impact on traditional industries (with inefficient organizational structures) relative to 'new economy' industries, such as information technology (IT), which suffer considerably less from these 'legacy costs'. Moreover, traditional industries are facing increasing competition from international producers as China gradually opens its markets. Therefore,

given the combined effects of increasing international competition and market reforms, the demand pattern has important implications for any traditional industry.

At the same time, China possesses a huge market potential for paper and paperboard products. Chinese total paper and paperboard consumption is currently ranked second in the world, only behind the U.S. The consumption of paper and paperboard products in 2001 reached 42.6 million metric tons, increasing at an average annual rate of 10.38% over the last 20 years.[1] By comparison, the average growth rate of the U.S. paper and paperboard consumption over the same period is 1.85%.[2] China's imports of paper and paperboard products grew at an average annual rate of 12.7% for the period 1979-2000, and the share of imports in the consumption increased from 9% to 17% for the same period. In 2001, China imported 5.57 million tons of paper and paperboard products, almost double the amount in 1995.

However, in comparison with the worldwide average of per capita consumption of 53.8 kg and the U.S. per capita consumption of 331.7 kg, China's per capita paper and paperboard consumption remains very low, at 28.4 kg in 2000. Therefore, as the Chinese economy grows, spurred on by continuing economic reforms and an increasingly literate population, the demand for paper and paperboard products will increase rapidly. In addition, with the entry into World Trade Organization (WTO), China import tariffs are expected to fall from 12-15% to 5% for most paper and paperboard grades over the next few year. Overall, there is every expectation that China will be one of the major markets for international pulp and paper producers.[3]

Currently China's small-scale mills and outdated technologies limit its ability to satisfy the growing demand. Its capacity and output are scattered among numerous small mills. On average, Chinese paper mills produce less than 6,500 tons/year, while the world average is over 40,000 tons/year and the average in developed countries is well above 100,000 tons/year. Only 44 of China's 4748 mills

[1] Consumption, import and capacity are defined in metric tons throughout this study.
[2] The statistics source is *FAO Statistical Databases*.
[3] "China and Taiwan Lower Import Tariffs for Pulp, Paper and Board", available at: http://www.paperloop.com.

produce more than 10,000 tons per year and only a handful of them produce products of international quality. Due to the highly capital-intensive nature of the paper and paperboard production, China needs a significant amount of investments to modernize its pulp and paper industry. A number of international companies have invested in China in recent years, including Indonesia-based Asia Pulp & Paper Co., UPM-Kymmene Co. (Finnish), and Stora Enso (Finnish-Swedish).[4] And at least 43 new projects have been scheduled in China's paper and paperboard industry for the period of 2002-2004, adding a new capacity of nearly 6 million tons per year to the industry in the near future.

Despite the worldwide interest in this burgeoning industry, there is no existing study on the demand for paper and paperboard products in China, although there are a number of studies for other countries. Buongiorno and Kang (1982) investigated short- and long-run elasticities of U.S. demand for paper and paperboard. Hetemäki and Obersteiner (2002) examines the demand for newsprint in the United States for the period 1971 to 2000. Chas-Amil and Buongiorno (2000) used panel data to estimate paper and paperboard demands for 14 European Union countries. And Simangunsong and Buongiorno (2001) used panel data on 62 countries during the period 1973 – 1997 to estimate the price and income elasticities for nine groups of forest products

In this study, we investigate the demand pattern for paper and paperboard products in China, focusing on the structural changes caused by economic reform and integration into the world market. The total demand for paper and paperboard products consists of two parts: domestic products and imports. The domestically produced paper and paperboard products are generally low quality products. In particular, over 80% of the pulp produced in China is made from bamboo, reed, rice straw, wheat straw and other non-wood sources, which yield lower quality products relative to those produced from wood pulp. Based on the information from China Paper Association, in 2000, 80% of China's paper and

[4] In March 1999, Singapore based Asia Pacific Resources International Holdings began operating a 350,000 ton/yr uncoated woodfree paper machine at Changshu, China; and Asia Pulp & Paper Co. started two woodfree paper machines at its Dagang mill in China.

paperboard products are low-quality and medium-quality grades, requiring China to rely on imports for high quality grades.[5]

Given the quality difference between the domestic product and imports, simply pooling the domestic and import demands imposes restrictions of homogeneous income and price elasticities on the two different demand functions. Thus, we extend our theoretical model on demand to include imports, and estimate the two demand functions separately, i.e., the demand for domestic products and the demand for imports. Following traditional approach to demand estimation, we first estimate demand functions using an instrumental variable estimator, and test for a structural change in demand. Second, in order to address the concern for nonstationarity of the variables in the demand function, cointegration analysis and error-correction models are applied to the demand functions.

The paper is organized as follows. In Section 2, we outline a theoretical framework for the demand structure and develop empirical models. Section 3 briefly describes the data. Section 4 discusses the results based on instrumental estimations; and Section 5 reports the results based on co-integration analysis and error correction models. Section 6 concludes.

2. A Simple Demand Model

Since paper and paperboard products mostly serve as inputs in many industries, in the classical approaches, the demand is derived from the demand for final products.[6] Paper and paperboard product enters the production function as intermediate good. To capture the quality differences, we generalized the commonly used production function to treat imported paper and paperboard products as a separate input. This specification will also help to control for the institutional changes caused by economic transition, because international markets play an increasing role in China's domestic demands.

[5] "The Tenth Five-year Plan of China's Paper and Paperboard Industry" (in Chinese), China Paper Association, April 12, 2001, available at: http://www.cppi.com.cn/zylt/a18.htm.

[6] According to "The Tenth Five-year Plan of China's Paper and Paperboard Industry", well above 80% of total paper and paperboard products in China are employed as inputs for other industries such as publishing, package and printing, and less than 20% are directly consumed by consumers.

Therefore, as commonly used in other studies (Chas-Amil and Buongiorno 2000, Simangunsong and Buongiorno 2001) and for the simplicity, we assume Cobb-Douglas production function as below

$$Y_t = a\, D_t^{*b} \cdot I_t^{*c} \cdot X_t^{d}, \qquad (1)$$

where Y_t is the production function of final products, D_t^* is paper and paperboard inputs made domestically, I_t^* is the imported paper and paperboard, X_t is a vector of other inputs, *a* is an index for the state of technology, and b, c, and d are positive parameters.[7] Total cost C_t is represented by:

$$C_t = D_t^* P_t^D + I_t^* P_t^I + X_t P_t^X, \qquad (2)$$

where P_t^D, P_t^I, and P_t^X are the paper and paperboard price, imported paper and paperboard price, and the prices of other inputs, respectively. Minimizing cost with regard to D_t^*, I_t^*, and X_t, subject to the production function, we obtain the demand function for domestic paper and paperboard and for imports:

$$D_t^* = F(Y_t, P_t^D, P_t^I, P_t^X) = \delta_0 Y_t^{\delta_1} \left(\frac{P_t^D}{P_t^X}\right)^{\delta_2} \left(\frac{P_t^I}{P_t^X}\right)^{\delta_3} \qquad (3)$$

$$I_t^* = F(Y_t, P_t^I, P_t^D, P_t^X) = \delta_0 Y_t^{\tau_1} \left(\frac{P_t^I}{P_t^X}\right)^{\tau_2} \left(\frac{P_t^D}{P_t^X}\right)^{\tau_3} \qquad (4)$$

where $\delta_1 = \tau_1 = 1/(b+c+d)$, $\delta_2 = -(c+d)/(b+c+d)$, $\delta_3 = c/(b+c+d)$, $\tau_2 = -(b+d)/(b+c+d)$, $\tau_3 = b/(b+c+d)$.

Equations (1) and (2) represent a static demand model assuming that equilibrium is achieved within time period t (one year for this analysis), and D_t^* and I_t^* is the equilibrium consumption for paper and paperboard products. If the adjustment takes longer time, there will be a dynamic adjustment process. In order to allow for such possibility, we assume that during time period t, the adjustment process can be represented by the following model:

$$\frac{D_t}{D_{t-1}} = \left(\frac{D_t^*}{D_{t-1}}\right)^{\alpha_1} \qquad \text{or} \qquad \frac{I_t}{I_{t-1}} = \left(\frac{I_t^*}{I_{t-1}}\right)^{\alpha_2} \qquad (5)$$

[7] It is possible to use a more sophisticated demand function such as AIDS (see Deaton and Muellbauer, 1980). However, this type of functions generally requires additional data information such as cost shares, which is unavailable in our data. More importantly, as one of the first studies on demand for paper/board in China, we adopt the simpler approach in order to focus on the structural changes in demand as a result of economic transition.

where α is the speed of adjustment, $0 \le \alpha \le 1$, and D_{t-1} is consumption in the previous time period. Substituting equation (5) in equations (3) and (4), we obtain a dynamic demand model:

$$D_t = \gamma_0 Y_t^{\beta_1} \left(\frac{P_t^D}{P_t^X}\right)^{\beta_2} \left(\frac{P_t^I}{P_t^X}\right)^{\beta_3} D_{t-1}^{\beta_4} \quad (6)$$

$$I_t = \varphi_0 Y_t^{\lambda_1} \left(\frac{P_t^I}{P_t^X}\right)^{\lambda_2} \left(\frac{P_t^D}{P_t^X}\right)^{\lambda_3} I_{t-1}^{\lambda_4} \quad (7)$$

where $\gamma_0 = \delta_0^{\alpha_1}$, $ß_1 = \delta_1\alpha_1$, $ß_2 = \delta_2\alpha_1$, $ß_3 = \delta_3\alpha_1$, $ß_4 = 1 - \alpha_1$, $\varphi_0 = \delta_0^{\alpha_2}$, $\lambda_1 = \tau_1\alpha_2$, $\lambda_2 = \tau_2\alpha_2$, $\lambda_3 = \tau_3\alpha_2$, and $\lambda_4 = 1 - \alpha_2$.

Taking logarithms of equation (6) and (7) yields the following empirical demand functions:

$$\ln D_t = ß_0 + ß_1 \ln Y_t + ß_2 \ln P_t + ß_3 \ln PA_t + ß_4 \ln D_{t-1} + u_t \quad (8)$$

$$\ln I_t = \lambda_0 + \lambda_1 \ln Y_t + \lambda_2 \ln PA_t + \lambda_3 \ln P_t + \lambda_4 \ln D_{t-1} + \varepsilon_t \quad (9)$$

where D_t is the domestic demand in year t, I_t is the import demand in year t, Y_t is represented by real gross domestic product (GDP), P_t is the real domestic price index of paper and paperboard, PA_t is the real international price index of paper and paperboard, and both u_t and ε_t are disturbance terms. In the domestic demand function, $ß_1$, $ß_2$, and $ß_3$ represents, respectively, the income elasticity, own price elasticity, and cross price elasticity of domestic demand; in the import demand function, λ_1, λ_2, and λ_3 are the income elasticity, own price elasticity, and cross price elasticity of import demand, respectively.

The above models do not control for possible structural changes caused by China's economic transition. The transition can be characterized by a rising degree of market-oriented mechanisms and an increasing integration into the world market. Such changes which will affect the demand structure for paper and paperboard products. For example, state-owned enterprises (SOEs) used to operate under a state planning system, and were not responsible for profits and losses. In this situation, SOEs may not respond to price signals. The reforms have forced most SOEs to enter the market system. In order to survive in competitive markets, SOEs have to be more sensitive to input prices. On the other hand, during the economic transition, non-state-owned enterprises represent an increasing share of the economy. Like other capitalist firms, these enterprises are sensitive to input costs. Therefore, as the

economic transition continues, the economy should become more responsive to price changes and the demand should be more price elastic. Similarly, the greater access to international markets may also influence the demand pattern for imported paper and paperboard products.

As a result, these institutional factors must be taken into account. Prior to 1992, the Chinese economy was still largely a command economy under the old planning system. The economic reforms accelerated after 1992, subsequent to Deng Xiaoping's dramatic political campaign visit to south China. Since that time, China has moved more quickly towards an open economy market system. The share of state-owned enterprises in gross industrial output value decreased from 77.63% in 1978 to 46.95% in 1993 and 23.53% in 2000. In order to capture this structural effect, we define a dummy variable (R_t) that equals 0 prior to 1993 and 1 for 1993 and after.

3. The Data

We use annual data from 1979-2001 for this analysis. The demand for domestic paper and paperboard products is measured by total domestic output minus exports and the demand for imports is measured by actual imports. The statistical sources for the analysis included '*China Statistical Yearbook 2002'*, the *'Almanac of Paper Industry of China 1999'*, the World Bank Development Indicator Database, and the US Bureau of Labor Statistics. Following previous studies, China's real GDP is used as a proxy for economic activity. Nominal GDP is converted to real GDP, with 1979 as base year. We use the ex-factory price indices to measure the domestic real price for paper and paperboard, deflated by the GDP deflators based on 1979 purchasing power.[8]

When we measure the price for imported paper and paperboard products, three factors need to be considered. One is the shipping cost, which has dropped considerably during this 23-year period. The second factor is the exchange rate. The official exchange rate of Chinese yuan varied from 1.55 to 8.28

[8] Chinese State Statistic Bureau gives the following definition: Ex-factory Price Index of Industry Products reflects the change in general ex-factory prices of all industrial products, including sales of industrial products to commercial enterprises, foreign trade sector, materials supplying and distribution sectors as well as sales of production means to industry and other sectors and sales of consumers goods to residents.

during the period of this analysis. The variation will significantly affect the cost of imported paper and paperboard. The last factor is the tariff.

In order to control for these factors, we fist calculate the import price based on US dollars. In particular, for all grades of paper and paperboard, the Chinese statistics reported both the imported value in US dollars and the total imported volume in tons. The total value of imported paper and paperboard is calculated on C.I.F. base (i.e., costs, insurance, and shipping costs).[9] Thus the import price is calculated by dividing the value of paper and paperboard imports by the volume of imported paper and paperboard. The import price is converted into Chinese currency by multiplying the calculated import price in US dollars with official exchange rates. The *China Statistical Yearbook* does not contain the values of imports for 1979 and 1980. These two missing observations are extrapolated by regressing import price on the U.S. producer price index (PPI) for all grades of paper and paperboard products (excluding converted and building paper).[10] Finally, the calculated import price is converted into a real price using Chinese GDP deflator, with 1979 as the base year. The adjusted import price controls for shipping costs and exchange rate but it may not capture the effect of tariffs. Unfortunately, such information is not available. Since the period covered in this study is mostly before China's joining the WTO, the change in tariff for paper and paperboard product is not expected to be dramatic, and thus we assume that the effect of tariff on import price is relatively small. Descriptive statistics are reported in Table 1.

[9] The C.I.F. price is the purchaser's price that would be paid by an importer taking delivery of the good at his own frontier, before paying any import duty or other tax levied at the frontier.

[10] Based on US Bureau of Labor Statistic, the Producer Price Index (PPI) measures the average change over time in the selling prices received by domestic producers for their output. The prices included in the PPI are from the first commercial transaction for many products and some services.

4. Instrumental Variable Estimation

In estimating the demand equation, we first apply the traditional regression analysis based on the structural model discussed in the above section. Since demand and price are jointly determined in the market, price should be endogenous in the demand function. Existing studies of paper demand treat this issue differently. For example, Chas-Amil and Buongiorno (2000) used unit values of imports and/or exports to construct price indices. They argue that such a price index is exogenous because the demand in each country is too small to affect the international price. Hetemäki and Obersteiner (2002) investigated U.S. newsprint demand, and they addressed the possible simultaneity between newsprint consumption and prices using a vector autoregression model (VAR).

In this study, we use instrumental variable (IV) estimation to control for price endogeneity.[11] Given the data limitations, we follow the traditional practice in time series analysis by using the previous price as instrument for the current price. Presumably, the current demand is not determined simultaneously with the previous price. The import price is mainly determined in the international market, and hence it is treated as exogenous because Chinese imports of paper and paperboard products are still relatively small in the world market and do not affect the world price.

4.1 The Demand for Domestic Paper and Paperboard Products

In preliminary work, we applied ordinary least squares (OLS) to estimate the demand function for domestic paper and paperboard products.[12] We then use instrumental variable estimation to estimate the demand function. The estimation results from two-stage-least-squares (2SLS) are reported in Table 2. Given the possibility of serial correlation in the regression error, we tested each model for serial

[11] Since the consumption for paper product is part of GDP, it is also possible that GDP is endogenous. However, paper and paperboard consumption are generally a very small portion of the GDP, comprising, for example, only 1.78% in China in 2000 (*China Statistical Yearbook 2001*). Thus, the endogeneity for GDP is not considered here, but will be addressed in VAR model estimation in next section.

[12] The estimated short run income elasticity was 0.52 and statistically significant at 0.05 level; the estimated price elasticity was 0.39 prior to 1993 and -0.11 after 1993, but was not statistically significant; the short run cross price elasticity had the expected sign (-0.05 prior to 1993, and 0.38 after 1993) but was insignificant. OLS results suggest that there was a structural shift in China's demand for paper and paperboard after 1993.

correlation.[13] The test result on the correlation coefficient is also reported in the table, and indicates no evidence of serial correlation. This result is not surprising because we are estimating a dynamic model using annual data. As discussed below, the adjustment of paper and paperboard demand to its equilibrium level appears to be completed in the year (for most models, the lagged dependent variable is not significant). Therefore, the demand models estimated are "dynamically complete" with one lag of the dependent variable, and thus the regression error should not be serial correlated.

In Table 2, Model 1 is the base model and does not control for institutional changes in China caused by the economic transition. In this model, only the lagged demand variable is statistically significant. In order to control for possible structural changes, we interact the economic transition dummy with prices and GDP. In different specifications, the interaction between the dummy and GDP never appears statistically significant. Since the transition dummy mainly captures the progress of moving to a market system, it is likely that the relationship between the demand for paper and paperboard products and GDP has not undergone a significant change in these two periods.[14]

After including structural change terms, the lagged demand variable becomes insignificant. As discussed in the theoretical model, lagged demand controls for the process of demand adjustment toward equilibrium. The result indicates that the demand adjustment is complete within a year. In order to save degrees of freedom, we do not include lagged demand in model 2. Based on the results, GDP has a significant impact on the demand, with a unitary income elasticity (i.e., the demand grows at the same speed as GDP). A unitary income elasticity of demand is higher than that found for developed countries. For example, depending upon the type of paper and paperboard grades, Baudin and Lundberg (1987) reported income elasticities ranging from 0.54 to 0.66 for all major consuming countries for the period

[13] Because the model included a lagged dependent variable, we follow Durbin (1970) to test for AR(1) error. We first regress consumption on all explanatory variables including lagged consumption by 2SLS, and obtain the residual $\hat{e}$. We then regress the residuals on all explanatory variables and the lagged $\hat{e}$, and test whether the coefficient of lagged $\hat{e}$ is significant.

[14] Studies find that the demand response to GDP has changed for some specific grades of paper products, such as newsprints and printing papers, in some countries due to the development IT technology (Hetemäki and Obersteiner, 2002)

1961-81. Chas-Amil and Buongiorno (2000) found income elasticities ranging from 0.18 to 0.39 for the European Union.[15]

Given that China is still at a relatively low level of economic development, the higher income elasticity of demand found is plausible and consistent with the finding that the demand for paper and paperboard becomes less income elastic as a country's income increases. For instance, Baudin and Lundberg (1987) found that the income elasticity was highest in the low income groups (per capita GDP under $2000). In the study of Buongiorno (1978), in which 43 countries were divided into low-income countries and high-income countries, the author found that, with the exception of printing and writing paper, the income elasticities are higher in low-income countries.

Interestingly, both the domestic price elasticity and the international price elasticity are statistically insignificant before 1993. As discussed in the above section, in the early stage of economic reforms, SOEs still produced a large portion of the product and they were not yet transformed into market oriented enterprises. Therefore, to a large extent, SOEs did not have to meet market criteria for continued operation. As a result, the demand was relatively insensitive to price changes. Thus, we cannot reject the hypothesis that the own-price elasticity of demand is zero.

This situation has changed as China deepening its economic reforms. Most SOEs have been transformed to a so-called modern enterprise system and are now required to satisfy market criteria for continued operations and, accordingly, implying that demand will be more sensitive to price changes. From the results, the own-price elasticity after 1993 is -0.69 and statistically significant at the 10% level. This price elasticity is similar to that found in market economies. For example, Chas-Amil and Buongiorno (2000) reported price elasticity in European Union from -0.30 to -0.89.[16] Notwithstanding this, demand is price inelastic, suggesting that few substitutes are available.

[15] Chas-Amil and Buongiorno (2000) also provided elasticities for the individual countries. The estimated income elasticity ranged from 0.15 in Portugal to 0.64 in Denmark.

[16] The demand seems to be even more price sensitive than that found in some other countries. For example, Baudin and Lundberg (1987) reported price elasticity in the range of (-0.48, -0.31).

The response of the demand for domestic paper and paperboard products to international price is positive and significant at about the 10% level after 1993. This cross-price elasticity is 0.59, indicating that the demand for domestic paper and paperboard products is affected by the international markets as China becomes more integrated into the world. If the international price is high, the demand for domestic products increases; otherwise, China increases imports and reduces demand for domestically produced products. Therefore, imports appear to be a substitute for domestically made products. Clearly, the international markets can offer almost all types of paper and paperboard products needed in China, and these products can certainly substitute for the products that China produces domestically. As expected, the demand for domestic products is more responsive to own price change than to international price change.

4.2 The Demand for Imported Paper and Paperboard Products

China's imports of paper and paperboard products have increased rapidly. The share of imports in total paper and paperboard consumption, for example, has grown from 9% in 1979 to 17% in 2000. As China becomes a major player in the international paper and paperboard market, its demand for imports will have an increasing impact on the world market. Therefore, we also estimate the demand function for imports.

Since imports account for almost 20% of the total consumption in recent years, it is possible that the domestic price is affected by the amount of total imports, and thus is considered endogenous. Hence, we estimate the demand using IV estimation with lagged domestic price as an instrument. Since it is unlikely that Chinese imports affected the world price for the period studied, we assume that the international price is exogenous.

The results are reported in Table 2. We do not include lagged dependent variable because it is insignificant. The demand elasticity with respect to GDP is 0.89 and is significant at the 5% level (there is no significant change in the two periods). We cannot reject that the income elasticity is 1, suggesting that as the Chinese economy continues to grow, the demand for imports will also grow rapidly and

China will be an important potential market for international producers. The income elasticities of demand for both domestic products and imports appear to close to unitary elasticity. This result is somewhat surprising because if imports are mostly high quality products, thus like luxury good, the income elasticity should be higher than that for domestic products. A possible explanation is that some trade barriers (especially administrative barriers) may exist and have depressed the demand. Another explanation would be that, as discussed in Section 1, the demand is also affected by increasing the amount of foreign direct investment (FDI) to produce high quality products in China.

Import demands are also sensitive to changes in the international price, with price elasticity equal to -0.60, in the same range of price elasticity for domestic demand. The inelastic response to price changes also suggests that relatively few substitute are available for imported paper and paperboard products as a whole. This observation is also confirmed by the insignificant cross-price elasticity. The import demand does not seem to be affected by the domestic price, although the demand for domestic products is responsive to international price as discussed above. Therefore, these results are consistent with the notion that imports are a substitute for domestically produced paper and paperboard produces but that domestically produced products are not a substitute for imports. Such a difference can almost certainly be attributed to quality differences, and thus the two demand functions are in fact consistent with each other.

As the economic reforms deepen, the own-price elasticity appears to drop slightly. In other words, the import demand response to own-price becomes even less price elastic in the second period starting from 1993 (the difference of 0.10 is significant at the 10% level). One explanation is that as China's ability to produce higher quality products increase (for example, due to FDI), the imports focuses increasingly on some specific grades of products. Thus, demand becomes less elastic. If this is case, we may expect that the income elasticity of imports for high quality imports will increase as the

economic transition continues. Yet we cannot discern this effect in our model, probably because the effect has not fully materialized in our period of study.[17]

5. Vector Error Correction Model Estimation

The above traditional regression analysis provides estimates of various elasticities, and can conveniently test the possible structural change in the demand. One particular concern for the regression analysis using time series data is the possibility of nonstationarity of the variables. Nonstationarity (for example, caused by unit root) may result in spurious regression. To explore this, we analyze the stationarity property of some time series used in the regression and apply cointegration techniques to study the demand.

Although cointegration analysis has advantages in dealing with non-stationary data, it can only identify long-run relationship and is generally difficult to test structural changes. Moreover, the Chinese economy is evolving as the economic transition continues. It is unclear whether China has reached the long-run equilibrium demand relationship or the stability of such a relationship, given the rapid structural changes in the Chinese economy. In this sense, the results from the regression analysis in the section above and the results based on non-stationary time series in this section should be viewed as complementary.

Although most previous studies on paper and paperboard demand have ignored the stationarity issue, a number of other studies have applied techniques for non-stationary data in studying pulp market and paper imports. Sarker (1996) used cointegration analysis to investigate the effects of price, income and other factors on Canadian softwood lumber exports to the United States. Riis (1996) adopted an error correction model to forecast Danish timber price. Alavalapati et al. (1997) investigated the determinants of Canadian pulp price. Laaksonen et al. (1997) estimated short- and long-run export demand for Finnish printing and writing paper in the United Kingdom.

[17] It is likely that the import demand structure will change with China's joining the WTO in 2000. With the availability of future data, the WTO effect can be evaluated.

We first employ Augmented Dickey-Fuller (ADF) unit root tests (Dickey and Fuller 1979) for demand, GDP, and domestic price.[18] The results of the ADF test are presented in Table A1 at the appendix (lags are selected based on F-tests and Schwarz criterion). These variables appear to be nonstationary in levels; however, the unit root hypothesis is rejected for first differences, implying that they are I(1). Based on the ADF test, we conduct cointegration analysis and estimate a vector-error-correction model (VEC) based on Johansen methodology (Johansen 1988, 1991). For a kth order unrestricted VAR model:

$$X_t = \pi_0 + \pi_1 X_{t-1} + \pi_2 X_{t-2} + \cdots + \pi_k X_{t-k} + \varepsilon_t \qquad (10)$$

where X_t is an (n×1) vector of I(1) variables, π_i are (n×n) parameter matrices (i = 1, …, n), k is the lag-length, and $\varepsilon_t \sim$ iid(0, σ^2), an error correction representation is,

$$\Delta X_t = \pi_0 + \Pi X_{t-1} + \sum_{i=1}^{k-1} \Gamma_i \Delta X_{t-i} + \varepsilon_t \qquad (11)$$

where Δ is the first difference operator, $\Pi = \sum_{i=1}^{k} \pi_i - I$, $\Gamma_i = -\sum_{j=i+1}^{k} \pi_j$, and I is the identity matrix.

This VEC model is a traditional first difference VAR model plus an error correction term ΠX_{t-1}. The matrix Π contains information on the long-run co-movement of the variables. If r, the rank of Π, is $0 < r < n$, we have r cointegrated vectors. A likelihood ratio (LR) test is used to determine the optimum number of lags (Sims 1980).[19] The LR statistic is obtained by estimating the unrestricted and restricted VAR, each with different lags. Due to limited sample size, the unrestricted equation started with lag-length k equal to 4. The test is then conducted sequentially by reducing k one at a time. The results show that the appropriate lag-length in the VAR model is 3, and thus for the VEC model is 2.

[18] The ADF test for the international price gives an insignificant ADF statistic of -1.7 for the level series, and a highly significant statistic of -5.23 for the first differenced series, indicating that the international price is I(1).

[19] LR = -2 ($\ell_k - \ell_{k+1}$), where ℓ_k is the log likelihood of VAR with lags k. The LR statistic is asymptotically distributed with degrees of freedom χ^2 equal to the number of restriction.

Johansen's maximum likelihood cointegration tests are applied to find the cointegrated series. Johansen's method tests the restrictions imposed by cointegration on the unrestricted VAR. The method entails two tests for the number of cointegrating vectors r: the trace and the maximum eigenvalue tests (see also Hamilton 1994 for more discussions). The results are summarized in table A2. The trace test suggests two cointegrating vectors but the maximum eigenvalue test suggests that there is one cointegrating vector. Our estimated cointegration relationship is following:

$$\ln D_t = \underset{}{-7.99} + \underset{(0.03)}{1.01}*\ln Y_t - \underset{(0.66)}{0.22}*\ln P_t + \underset{(0.09)}{0.42}*\ln PA_t \qquad (9)$$

Table 3 lists the elasticities from both the IV estimation (model 2) and the cointegration analysis. The elasticity estimates based on cointegration analysis is in line with that from the IV estimation. The own-price elasticity based on cointegration is lower than the IV estimates for the period after 1992, and it is statistically insignificant. This is because the cointegration analysis does not control for structural change, and thus it pools the two periods before and after 1993 together. It appears that the demand-price relation prior to 1993 dominates such a relationship, and thus the price effect becomes insignificant overall. This is also the case for the cross-price relationship. As for the income elasticity, the IV results do not show any structural change, and the estimated income elasticities based on both approaches are very close to each other.

Since the cointegration relationship represents a long-run equilibrium, it is desirable to examine the short-run dynamics. Thus, we estimate a VEC model to study the demand adjustment. Based on the results summarized in table 4, the error-correction term in the demand function is -1.13 and significant at 1 percent level. The negative coefficient of error-correction term ensures that the long-run equilibrium is achieved when there was a deviation in the previous period. More specifically, if there is a one percent positive deviation of demand from the long-run equilibrium in last period, the growth rate of demand falls by 1.13 percentage point in current period. Thus the system automatically adjusts to eliminate the positive discrepancy from long-run equilibrium. In addition, to check for the statistical

adequacy of the VEC model, various diagnostic tests are conducted; and the test statistics, also presented in table 4, shows no clear evidence of serial correlation, heteroskedasticity, and non-normality.

6. Conclusions

Employing instrumental variable and vector error correction procedures, we analyzed the demand for domestic and imported paper and paperboard products in China. As predicted by economic theory, income and price are important determinants of demand. For domestically made paper and paperboard products, the estimated income elasticity of the demand is about 1, indicating that the demand increases at the same speed of the economic growth. However, the demand does not respond to own-price in the early stage of economic reform; and it becomes about -0.7 as the reforms deepen. This result demonstrates that, because of the old centrally controlled planning system, the economy to a large extent was operated based on non-market oriented criteria and the demand is less sensitive to price. This phenomenal changed with China's economic reforms. The demand response to international price also shows the same pattern: it is only responsive to price in the second stage of economic reform starting from 1993 with the elasticity of approximately 0.6.

The demand for imports is also about unitary elastic with respect to economic growth. As expected, the demand for imported paper and paperboard respond negatively to increase of prices in the world market. The estimated own-price elasticity is -0.6. As economic transition progresses, the response appears to be even more inelastic. This is probably caused by the difference in quality between domestically made and imported products. As the reliance on some specific grade of high quality paper and paperboard increases, the demand becomes less elastic. The relatively high income elasticity and low price elasticity of the demand for imports indicates that China has a huge market potential for international producers in this industry.

The demand for domestic product appears to respond to the price in world market with an estimated cross-price elasticity of 0.59. This is not surprising because imports can certainly be used as substitutes for domestically produced products. On the other hand, the demand for imports does not

respond to domestic price, indicating that domestically made products may not be used as substitutes for imports.

In order to address the issue of nonstationarity for variables in the demand function, we also estimated an error correction model to study the cointegration relationship and short run dynamics for the demand system for domestic products. The results from cointegration analysis are in line with the IV estimates. In addition, the error-correction term in the VEC model has a negative and statistically significant coefficient, which ensures a return to the long-run equilibrium if there is any deviation in the short-run.

Based on the results, it is clear that, as economic transition progresses, the Chinese economy is becoming an increasingly market-oriented system. This is particularly evident from the increasing response of demand to both domestic price and international price. Although some studies claimed that the Chinese economy becomes increasingly disintegrated internally (like Young 2000), the results from this study at least do not offer any direct support for the claim. The implication is that, even if some interregional distortions exist during the course of economic transformation, the overall economy is still becoming a more market-oriented system.

Notwithstanding the small number of observations for this analysis, we are able to obtain interesting results, especially related to structural changes in demand. Among the implications of this analysis for future work is the need for a larger sample. With larger sample, we may be able to discern other structural changes and the effect of joining the WTO. A related limitation deriving from the sample size is an inability to test alternative econometric specifications based upon a richer set of explanatory variables.

Reference

Alavalapati, J.R.R, Wiktor L. Adamowicz, and Martin K. Luckert (1997), "A Cointegration Analysis of Canadian Wood Pulp Prices", *American Journal of Agriculture Economics,* 79, 975-986.

Baudin and Lundberg (1987), "The World Model of the Demand for Paper and Paperboard", *Forest Science,* 33, 185-196.

Buongiorno, J. (1978), "Income and Price Elasticities in the World Demand for Paper and Paperboard", *Forest Science*, 24, 231-246.

Buongiorno, J. and Kang (1982), "Econometric Models of the United States Demand for Paper and Paperboard", *Wood Science,* 15, 119-126.

Chas-Amil, M. L. and J. Buongiorno (2000), "The Demand for Paper and Paperboard: Econometric Models for the European Union", *Applied Economics*, 32, 987-999.

China Technical Association of Paper Industry (1999), *The Almanac of Paper Industry of China.* China Light Industry Publishing House.

Chou and J. Buongiorno (1984), "Demand functions for United States Forest Product Exports to the European Economic Community", *Wood and Fiber Science*, 16, 158-168.

Davidson, R. and J. MacKinnon (1990), "Specification Tests Based on Artificial Regressions", *Journal of the American Statistical Association*, 85, 220-227.

Deaton, A. and J. Muellbauer (1980), "An Almost Ideal Demand System", *The American Economic Review* 70, 312-26.

Dickey, David and Wayne A. Fuller (1979), "Distribution of the Estimates for Autoregressive Time Series with Unit Root", *Journal of the American Statistical Association*, 74, 427-31.

Durbin, J. (1970), "Testing for Serial Correlation in Least Squares Regression When Some of the Regressors are Lagged Dependent Variables", *Econometrica*, 38, 410-421.

Enders Walter (1995), *Applied Econometric Time Series*. John Wiley & Sons, INC.

Hetemäki, L. and Obersteiner, M. (2002), "US Newsprint Demand Forecasts to 2020", working paper, available at: http://groups.haas.berkeley.edu/fcsuit/publications.html#publications.

James D. Hamilton (1994), *Time Series Analysis*. Princeton University Press.

Johansen, S. (1988), "Statistical Analysis of Cointegration Vectors", *Journal of Economics and Control,* 12, 231-254.

Johansen, S. (1991), "Estimation and Hypothesis Testing of Cointegration Vectors in Gaussian Vector Autoregressive Models", *Econometrica,* 59, 1551-1580.

Laaksonen, S., Anne Toppinen, Riitta Hhanninen, and Jari Kunuluvainen (1997), "Cointegration in Finnish Paper Exports to the United Kingdom", *Journal of Forest Economics,* 3, 171-185.

Osterwald-Lenum, Michael (1992), "A Note with Quartiles of the Asymptotic Distribution of the Maximum Likelihood Cointegration Rank Test Statistics", *Oxford Bulletin of Economics and Statistics,* 54, 461-472.

Riis, J. (1996), "Forecasting Danish Timber Prices with an Error Correction Model", *Journal of Forest Economics,* 2:3, 257-271.

Sarker, R. (1996), "Canadian Softwood Lumber Export to the United States: a Cointegrated and Error-corrected System", *Journal of Forest Economics,* 2:3, 205-231.

Simangunsong, B.C.H. and Buongiorno, J. (2001), "International Demand Equations for Forest Products: A Comparison of Methods", *Scandinavian Journal of Forest Research*, 16: 155-172.

Sims, C.A. (1980), "Macroeconomics and Reality", *Econometrica,* 48, 683-691.

State Statistical Bureau, People's Republic of China (2001), *China Statistical Yearbook.* China Statistical Publishing House.

Stock, James and Mark Watson (1988), "Testing for Common Trends", *Journal of American Statistical Association*, Vol. 83 (December), 1097-1107.

Young, Alwyn (2000), "The Razor's Edge: Distortions and Incremental Reform in the People's Republic of China." *Quarterly Journal of Economics*, 115 (November 2000): 1091-1135.

Table 1. Descriptive Statistics

Variable	Variable Description	Mean	Standard Deviation	Minimum Value	Maximum Value
Domestic Demand	Paper and paperboard output minus exports, in million metric tons	15.62	8.88	4.77	37.09
GDP	Real gross domestic product, in 100 million Yuan	13432.77	8131.61	4038.20	29718.47
Domestic Price	Real ex-factory price indices in China	107.04	11.52	91.03	129.13
Import Price	Real prices of paper and paperboard imported.	203.53	40.04	137.05	278.39
Import Demand	Imports of paper and paperboard into China, in million metric tons	2.44	2.11	0.49	6.52
R_t	Dummy=1 for 1993 and subsequent years, zero otherwise				

Table 2. Demand for Domestic Paper and Paperboard in China by IV estimation

Variable	Domestic Demand		Import Demand
	1	2	3
Constant	4.42 (6.86)	-8.11*** (2.74)	-9.30* (5.11)
GDP	0.19 (0.32)	1.01*** (0.20)	0.89** (0.38)
Domestic Price	-1.46 (1.14)	0.35 (0.90)	0.96 (1.64)
Import Price	0.13 (0.19)	-0.07 (0.25)	-0.60* (0.30)
Lagged Domestic Demand	0.98** (0.45)		
Lagged Import Demand			
Reform dummy * Domestic Price		-0.69* (0.39)	
Reform dummy * Import Price		0.59* (0.34)	0.10* (0.05)
Test for autocorrelation ρ	0.41 (0.68)	0.52 (0.33)	0.08 (0.31)

Note:
*, **, *** = significant at 0.10, 0.05 and 0.01 level.
ρ = coefficient of AR(1) serial correlation.

Table 3. The long-run elasticities from IV and Cointegration test

	Long-run elasticities		
	GDP	Domestic Price	Import Price
IV estimates after 1992	1.01*** (0.20)	-0.69* (0.39)	0.59* (0.34)
Johansen's Maximum likelihood	1.01*** (0.03)	-0.23 (0.23)	0.42*** (0.09)

Note: *, **, *** = significant at 0.10, 0.05 and 0.01 level.

Table 4. Estimates of the vector error correction model

Dependent Variable: ΔDomestic Demand$_t$		
Regressors	Coefficients	Standard error
Error Correction Term	-1.13	0.18
ΔDomestic Demand$_{t-1}$	0.92	0.20
ΔDomestic Demand$_{t-2}$	1.02	0.21
ΔGDP$_{t-1}$	-1.61	0.67
ΔGDP$_{t-2}$	-0.38	0.80
ΔDomestic Price$_{t-1}$	-0.58	0.25
ΔDomestic Price$_{t-2}$	0.19	0.26
ΔImport Price$_{t-1}$	-0.12	0.10
ΔImport Price$_{t-2}$	0.10	0.10
Adj. R^2	0.78	
LM(1)	17.39 [0.36]	
White test	184.93 [0.39]	
Jarque-Bera	38.51 [0.96]	

Note:
Test assumption: linear trends in the data but the cointegration equations have only intercept.
Figures in blanket denote probability value.

Appendix

Table A1. Augmented Dickey-Fuller Tests for individual variable

Variables	ADF-Statistics	LAGS	Trend	Intercept
Level				
Domestic Demand	-1.90	8	Yes	Yes
GDP	-3.61	6	Yes	Yes
Domestic Price	-2.06	1	No	Yes
First Difference				
Domestic Demand	-4.10**	3	No	Yes
GDP	-3.26**	6	No	Yes
Domestic Price	-4.01**	0	No	No

Note:
** = significant at 0.05 level.
The null hypothesis is the series has unit root.

Table A2. Johansen's cointegration test

Null Hypothesis	Alternative Hypothesis		5% Critical Value	1% Critical value
λ_{trace} test		λ_{trace} value		
R = 0	r > 0	93.49	47.21	54.46
R ≤ 1	r > 1	39.28	29.68	35.65
R ≤ 2	r > 2	14.21	15.41	20.04
λ_{max} test		λ_{max} value		
R = 0	r = 1	54.21	27.07	32.24
R = 1	r = 2	25.06	20.97	25.52
R = 2	r = 3	12.33	14.07	18.63

Note:
Test assumption: linear trends in the data but the cointegration equations have only intercept.
The 5 and 1 percent critical values for the trace statistics are calculated by Osterwald-Lenum (1992).
L.R. test indicates 1 cointegrating equation at 0.01 significance level in maximum eigenvalue tests.