Chapter 5

On the Co-movement of Sector Export Prices by Country in the World Market:

An Approach by Principal Component Analysis

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Introduction

As economic globalization advances, the sectoral trade structures of nations and regions worldwide are displaying year-by-year change. One noteworthy feature of such change is a general tendency towards an increase in the weighting of inter-industry trade in the Asian region, centering on machinery-related sectors. In order to conduct an empirical analysis of the factors behind such changes in trade structure from the perspective of price competitiveness, it is essential to clarify the ways in which sector export price are determined.

This paper uses two-digit level sector export unit price indexes for major countries calculated by the Institute of Developing Economies in order to statistically analyze the mode of determination of export prices in these countries, and in particular to analyze the relative importance of common factors and individual factors as demonstrated in time series fluctuations. In addition, the paper evaluates the characteristics and reliability of the calculated sector indexes in an attempt to seek pointers towards improvement of the method of calculation. Please refer to M. Kuroko (2005) for details of the sector unit price indexes employed in this paper.

1. Analytical Model of Determination of Export Prices

Two approaches can be taken in analyzing the extent to which fluctuations in export prices depend upon factors that are common to different countries or country-specific factors. One approach is to select demand factors and supply factors that are considered to have a direct relationship to the determination of export prices, and to conduct a regression analysis using these as explanatory variables. This approach necessitates, in the selection of demand factors and supply factors, distinguishing in advance between the factors that are common to the countries concerned, and the factors that are not.

The other approach is to treat common and country-specific factors as latent variables and to estimate them on the basis of the correlation matrices for the inter-country export price series. This approach employs what is known as a factor model. Using this model, the magnitude of common fluctuations can be determined from the data structure.

Factor models can be divided into models in which there is a static relationship between fluctuations in export prices and the operation of

common factors, and dynamic models that consider the time lag between the two .

This paper employs a static factor model that considers two common factors, and uses principal component analysis to clarify the relative weight of the factors in the determination of export prices. This factor model can be formulated as follows:

$$PE_k(t) = \beta_{k1}Z_1(t) + \beta_{k2}Z_2(t) + \gamma_k EPE_k(t)$$

where $PE_k(t)$: Export price index of the kth country, $Z_1(t)$: Factor 1 determining export prices in the world market, $Z_2(t)$: Factor 2 determining export prices in the world market, $EPE_k(t)$: Individual factor determining export prices dependent on characteristics of specific country, β_{ki} : Coefficient for country k of ith common factor, γ_k : Coefficient of individual factors determining export prices.

This model attempts to explain the export prices in each country as the sum of common and individual factors. The variables in this formula are standardized as mean zero and variance 1. Because the time series of the two Z factors and EPE are assumed to be mutually independent, the following relationship holds:

$$(\beta_{k1})^2 + (\beta_{k2})^2 + (\gamma_k)^2 = 1$$

Given this, if β_{ki} is defined, the ratio of fluctuations in export prices that can be explained by common factors can be determined from the sum of squares. In fact, if the export commodities of each country are assumed to be homogeneous and their prices determined competitively in the world market, then the fluctuations in export prices for each country are entirely due to common factors, and γ_k at 0,

$$\sum(\beta_{ki})^2 = 1$$

holds. Because two-digit export price indices are employed, commodity structures differ for advanced and developing countries, and components and final products are grouped together in sectors in which assembly is a consideration, such as the machinery sector. Export prices are aggregated on the basis of unit prices at the six-digit level, but there is insufficient quality adjustment for each country's export commodities. Given this, fluctuations due to individual factors can be expected to display a magnitude such that they cannot be ignored.

Another point that must be considered in the formulation of the model is whether the correlation between export prices is to be treated in terms of the level or of the rate of change of variables. If it is treated in terms of the level, then the trends and cycles that can be observed in export price fluctuations are treated together. Because of this, the correlation becomes higher the stronger the trend element is, and therefore the weighting of common factors can be expected to be higher. By contrast, if the correlation is treated in terms of the rate of change, the functioning of trends is reduced and the correlation is reduced by the same amount, and it is therefore thought to be possible to determine the weighting of common factors from the actual relationship between commodity prices. Below, we calculate the magnitude of influence of common and individual factors for both cases (treatment in terms of level and in terms of rate of change), and consider the similarities and differences between the results.

2. Formulation of the Model

With respect to the way in which the coefficients for common factors in the determination of export prices by country, β_{k1} and β_{k2}, are calculated, if principal component analysis is employed with the correlation coefficient matrix of （k × k） for PE_k as a constraint, the ratio of contribution of common factors, $S = (\beta_{k1})^2 + (\beta_{k2})^2$, can be

Table 3 Ratio of Contribution of Common Factors - Calculated for Digit Level (Unit: %)

Sector	First-order common factors	Second-order common factors	Ratio of contribution of common factors
Textile	74.9	10.8	85.7
Lumber and wood products	78.1	10.6	88.7
Paper and pulp	69.9	13.6	83.5
Chemical products	60.0	16.8	76.8
Rubber products	69.1	16.0	85.1
Nonmetallic products	66.8	15.6	82.4
Iron and steel	74.6	9.4	84.0
Non ferrous metals	74.6	15.5	90.1
Metal products	80.3	9.9	90.2
General machinery	69.9	16.3	86.2
Electrical equipment and machinery	75.1	16.0	91.1
Transport equipment	80.1	16.7	96.8

(Source) Calculated by the author.

maximized. The rate of contribution of the first-order common factors (global factors) is determined on the basis of the highest eigenvalue of the correlation coefficient matrix, and the coefficient for these common factors for each country, β_{k1}, can be determined based on the corresponding eigenvector. Similarly, the rate of contribution of the second-order common factors (regional factors) is determined using the eigenvalue next in magnitude, and the corresponding coefficient for each country, β_{k2}, can be calculated.

2.1 Analysis of Export Prices in terms of Digit Level

Table 3 shows the results of calculations of the ratio of contribution of the two categories of common factors by sector for fourteen sectors, conducted for twelve countries that recorded usable export price data for the period 1980-2002.

These results indicate that more than 75% (in the case of electrical equipment and machinery and transport equipment, more than 90%) of export prices by sector can be explained in terms of the two common factors.

If a weighted average of the export price indexes per country is taken using the factor loading calculated as shown above for each country as a weighting, a time series of export prices determined by common factors can be calculated for each of the twelve sectors. The fluctuations in export prices that are due to individual factors can then be calculated by subtracting the matrix of export price indexes determined by common factors from the matrix of actual export price indexes.

2.2 Analysis of Export Prices in terms of Rate of Change

Table 5 shows the results of a principal component analysis of fluctuations in export prices based on a year-on-year comparison (%) of export price indexes.

As predicted, the rate of contribution of the common factors declines in all sectors when calculated by rate of change in export prices. At their maximum, the common factors can explain 78.4% of export prices in the non-ferrous sector, and at their minimum 51.7% of export prices in the transport equipment sector. The ratio of contribution of the

Table 5 Ratio of Contribution of Common Factors - Calculated by Rate of Change (Unit: %)

Sector	First-order common factors	Second-order common factors	Ratio of contribution of common factors
Textile	49.4	21.2	70.6
Lumber and wood products	48.1	15.6	63.7
Paper and pulp	58.1	12.7	70.8
Chemical products	52.3	22.7	75.0
Rubber products	53.3	19.4	72.7
Nonmetallic products	49.1	14.1	63.2
Iron and steel	62.4	12.9	75.3
Non ferrous metals	74.5	3.9	78.4
Metal products	48.1	17.9	66.0
General machinery	45.8	15.6	61.4
Electrical equipment and machinery	43.4	13.2	56.6
Transport equipment	35.9	15.8	51.7

(Source) Calculated by the author.

common factors is lowest in the three machinery-related sectors and the nonmetallic products sector. Other than the metal products sector, common factors have a contribution ratio of more than 70% in all other sectors, which represents a high level of explanatory power for fluctuations in export prices.

3. Comparison of the Contribution of Common Factors to Export Price Determination

3.1 Characteristics by Sector

Using the coefficients for common factors estimated above, time series for first-order and second-order common factors can be calculated for each of the twelve sectors. Here, we compare the characteristics of the common factor matrices calculated by rate of change for each sector.

Looking first at the characteristics of change in first-order common factors, we can roughly divide the sectors into three groups.

Group 1: General machinery, Electrical equipment and machinery, transport equipment, Metal products, Textile products, Lumber and wood products, Paper and pulp products, nonmetallic products, Rubber products

Group 2: Iron and steel, Non-ferrous

Group 3: Chemical products

Increases in the fluctuation of prices due to common factors can be observed in 1986, 1990 and 1995 for Group 1, 1988 and 1995 for Group 2, and 1987, 1990 and 1995 for Group 3 (chemical products). All three groups showed increases in 1995, but there was a lag of one year between the first increases (1986, 1987 and 1988).

If we consider what common factors could have affected the export markets for products in all of these sectors, we can conjecture energy prices (crude oil, etc.) and exchange rates against the dollar, i.e. the effective dollar rate. In addition to these, the effect of the trade cycle, in terms of world GDP growth rate, may be considered. The export price of crude oil fell between 1980 and 1985, but displayed stability between 1985 and 2002. It is therefore difficult to consider it as a factor in significant fluctuations in export prices.

The effective rate of the Japanese and European currencies against the dollar displayed an increasing

tendency from 1980. In addition to this, the Plaza Accord of autumn 1985 resulted in a sharp increase in the effective rates of the currencies of advanced nations against the dollar, and the period 1993-1995 saw an upward adjustment of the dollar. All of these may be conjectured as having had an effect on export prices recorded in dollars.

3.2 Characteristics by Country

Above, we investigated the extent to which fluctuations in export prices by sector can be explained in terms of two sets of common factors. We discovered that the two sets of factors could explain 70% or more of price fluctuations in 10 or more sectors in the case of Germany (11 sectors), France (11 sectors), and Italy (10 sectors), and between six and seven sectors in the case of Denmark (7 sectors), Holland (7 sectors), Spain (6 sectors) and Finland (6 sectors). In Asia, by contrast, the factors explained 70% or more of export price fluctuations in only four sectors in the case of Taiwan, two sectors in the cases of Hong Kong and South Korea, and one sector in the cases of Malaysia and Japan. The figure was three sectors in the case of the US.

Overall, the rate of contribution of shared factors to export price fluctuations in the western European countries was higher than in Asia or the US, and the fluctuations displayed similar patterns. By contrast, in the US and Asia, excluding Taiwan, the influence of common factors was lower, and the influence of individual factors was correspondingly higher.

The specific characteristics of major export markets and differences in the commodity makeup of different sectors may be implicated in these results. Another possibility is that specific fluctuations are at work in the time series for the estimated export price indexes. For example, as pointed out in Kinoshita (2006), in the case of the US, the value coverage is low and inconsistent in calculations of unit price indices for the machinery and other sectors. These factors could be predicted to cause a decline in the influence of common factors on fluctuations in export prices. This phenomenon will require further detailed investigation.