THE DETERMINANTS OF INTERNATIONAL MARKET SHARE IN THE U.S. STEEL MARKET: AN APPLICATION OF SEEMINGLY UNRELATED REGRESSION**

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CONTENTS

I. Introduction

One of the most important industries in a developing as well as a developed economy is its steel industry. This industry provides a vital input, either directly or indirectly, into virtually every commodity marketed within the country. In order to achieve the objective of import substitution, the target of economic developers is to supply the intermediate product of steel for more advanced industries. Since steel production entails substantial economies of scale whereas domestic demand for steel is intially limited, facilities designed for import substitution generally have overcapacity, necessitating export to achieve efficient levels of output.

Twenty-five years ago the U.S. steel industry was the largest and most efficient in the world, but its condition has deteriorated while foreign competition has intensified. U.S. steel imports have growth in both tonnage and market share since the 1950s: in the 1950s, imported steel took 2.3 percent of the U.S. market, which grew to 9.3 percent in the 1960s, and then to 15.3 percent in the 1970s, and finally to 23.9 percent in 1985. This increase in steel imports has seriously injured U.S. produceres by reducing sales and production volume, and by decreasing cash flow for modernizing or expanding their facilities. The mix of suppliers has been shifting from the European Economic Community to Japan and now to South Korea and Brazil. Other potential suppliers exist among Third World countries. The purpose of this study is to identify the determinants of current shares of the U.S. steel market so that those determinants can be used to

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** The author gratefully acknowledges the useful ideas, encouragement and insightful discussions provided by Dr. Garth Mangurn, chairman of his Ph.D. dissertation committee. This paper is derived from the author's doctoral dissertation.

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The United States has an important impact as a consumer on the world steel markets. Not only has it traditionally utilized its own output, but recently it has imported a growing proportion of the output of the rest of the world as well. Since the United States has long been the largest consumer of steel in the world, major steel exporting countries have sought vigorously to increase their market share of the U.S. market. In order to understand the historical causes of the current problems which confront the U.S. steel industry and determine predictors for the future international market shares in the U.S. steel market, it is essential to review the historical development of each country's steelmaking and estimate the relative importance of the factors determining each major steel exporting country's market share in the U.S. market during the past 25 years. Knowing what factors have determined each country's market share should make it possible to predict which ccountries will obtain what share in the future.

To estimate the determinants of international market share in the U.S. steel market, this study uses a linear market share model. Because the study attempts to estimate the parameters of market share equations for several major steel exporting countries to the American market, the contemporaneous correlation[1] between the disturbance terms across different equations at the same time is expected. Under this situation, ordinary least squares estimates (OLS) may be inefficient. Therefore, in order to avoid the problem resulting from contemporaneous correlation in disturbance terms and to improve the efficiency of the estimation, this study employs a Generalized Least Squares (GLS) method known as the Seemingly Unrelated Repgression (SUR) method developed by Zellner (1962).

II. Steel in The Industrializing Economy

According to the arguments of the linkage effect among industries, steel production is a key ingredient of economic growth. Steel is an essential component of most manufactures and the machinery of manufacturing. The developing country without steelmaking capacity is either precluded from industrialization or condemned to importation. Therefore, most underdeveloped countries are eager to possess their own steel industries. But efficient steel production is characterized by economies of scale. Hence newly industrializing countries often generate domestic excess capacities because of their low per capita income and their relatively small domestic market capacity. Steel export is necessary in the beginning stage of the industrializing process due to this

1) This correlation arises because of restriction that the sum of the individual market shares approached to 100% or 1. For details, see Robert S. Pindyck and Daniel L. Rubinfeld, Econometric Models and Economic Forecasts (New York: Mcgraw-Hill Book Company, 1981), p. 332.

excess domestic supply. Yet a steelneedy developing world lacks the purchasing power for its importation. The force of the steel export drive, therefore, is the developed countries which already have their own capacity in place.

The first target of economic development planners is usually import substitution. High wage capital-intensive imports require export of labor intensive products into which multiple hours of labor have been invested. Labor intensive consumer goods begin the industrializing process because of their low capital requirements in production. Domestic markets for these particular goods are characterized as being easily accessible, with demand for these same goods being generally reliable. However, soon the developing nation seeks enhance its own income by moving in the direction of more capital intensive production.

Industrialization generally begins when productivity in the primary and extractive sectors industries of agriculture, fishing and forestry rise above the subsistence level, freeing labor for manufacturing activities. Mining as an extractive industry, with the exception of precious metals, is more likely to be the handmaiden of manufacturing. The latter begins with simple products and simple production processes, previously homemade or imported, labor intensive and performed by unskilled labor and serving potentially widespread domestic markets. To the textiles, clothing and shoes, which characterized the earliest industrial development have been added in modern times toys and basic electronic assembly, the latter farmed out from already developed countries, and tapping the cheap labor of nations not yet prosperous enough to provide a market for what they are producing. After meeting domestic need, export of these labor intensive products to nations with higher wage levels or still at the extractive stage helps pay for necessary imports.

This first step in the industrializing process offers wages above those of farming. This step is still limited by the labor intensiveness. The use of machinery is the key to increase in the ability to pay higher wages. The second step in the industrializing process, therefore, is into somewhat more capital intensive industries processing available natural resources into intermediate product, moving up the skill ladder to primarily semiskilled labor. Those intermediate products then become the raw materials for producing machinery and equipment for manufacturing, transportation and communication as well as for basic consumer products. Steel is curcurrently the most obvious of these though rubber, petrochemicals, glass and copper refining have most of the same characteristics. In the interdependent modern world, not only higher wages and profits but import substitution, pursuit of industrialization or the hope to achieve exporting capacity may be additional motives at this stage. We will return to steel as the focus of this historical development but first we follow the industrializing process at least as far as the developed nations, such as the U.S., Western Europe and Japan, have progressed.

The next way station is complex assembly, relying on steel as the major intermediate product. Production of automobiles, ships, machine tools, small appliances and consumer electronics characterizes this stage. Capital intensiveness is rising but so is the skill requirement. It is at this point that we currently find the newly industrializing countries.

No one but the U.S., Western Europe and Japan has matured to probe beyond this stage. The emerging stage, the threshold of which they have crossed, appears to involve exotic processes such as precision castings and genetic engineering to produce intermediate products such as specialty steels and chemicals, fine ceramics and fiberoptic cable leading to ever more sophisticated lasers, large scale integrated circuits, advanced aircraft engines, artificial human organs and who knows what. The sophistication of the human skills and the responsiveness of the technology without reliance on mass production appear critical at this point. There will undoubtedly be another step in the future.

Steel's uniqueness lies in its prevasiveness in all of the intermediate and final products of an industrial economy and its symbolism of entry into the industrial club. Both the machinery for production and the product of an industrial society are primarily of steel. That country which would industrialize without its own steel capacity must import large amounts of both machinery made of steel and semifinished and finished steel as raw material for its final products. Vast exports of extractive food or raw materials or labor intensive manufactured product will be required to pay for the import of steel. If import substitution is the preferred policy, steel production capacity will be among the first targets. With that first basic integrated steel mill also comes the badge of membership in the industrial society.

III. The Model

The academic literature on determinants of market share is well developed. Since 1960, numerous efforts have been made to develop econometric models to explain and predict a change in market share. There have been three common market share models[2] in marketing research and practice: (1) linear model, (2) multiplicative model, and (3) market share attraction model. Among these three major marketing share models, this study employes a linear model with explanatory variables which are in relative values terms. In order to use the multiplicative model and atrraction model which are based on logarithmic terms, modifications of data would be necessary as some observations for the empirical test are "zero value."[3] In addition, estimating the parameters for the linear model is less complicated than for the attraction model. For these reasons, this study adopts a linear model as a tool of empirical test.

The explanatory variables in the model are based on relative values. The explanatory variables for a linear market share model can be expressed as absolute value (e.g., capital expenditure based on dollars) or relative values (e.g., capital expenditure relative to those of total competi-

2) Robert D. Buzzell and Frederik D. Wiersema, "Modelling Changes in Market Share: A Cross-sectional Analysis," In Perspectives on Strategic Marketing Management Edited by Roger A. Kerin and Robert A. Peterson (Boston: Allyn and Bacon, Inc., 1983), pp. 328-343.

3) For example, in the 1960s, the installation rates of continuous casting technology for South Korea and Brazil are zero.

tors).[4] In order to examine the competitive effects of decision variable, the study employs explanatory variables in terms of relative value. But the variable, which is not included in every country's equation, is used in absolute value term (e.g., wage rate variable).

The model for this study is a linear form with competitive effects specified in relative terms which, for the j country's market share, is denoted by

$$M_{jt} = b_{oj} + \Sigma^{k}_{k=1} b_{kj} X_{kjt*} + U_{jt} \quad (1)$$

where

M_{jt} denotes the U.S. steel market share for country j in period t;
X_{kjt*} is the normalized value of the K-th decision variable for country j in period t (i.e., $X_{kjt*} = X_{kjt}/\Sigma^{n}_{j=1} X_{kjt}$);
U_{jt} is a random disturbance term;
b_{kj}, k = 1, 2, ..., K are parameters to be estimated from the data, and
j denotes the following countries:

1) the United States
2) Japan
3) U.K., West Germany and France (combined)
4) South Korea
5) Brazil.

The system model of this study is tested by the following independent variables which are expected to be significant determinants for each country's market share:

$$M_{jt} = b_0 + B_1 M_{t-1} + b_2 W_{jt} + b_3 CC_{jt} + b_4 OH_{jt} + b_5 DS_{jt} + b_6 UP_{jt} \cdots \quad (2)$$

where variables are:

M_{jt} : U.S. steel market share for country j at period t,
M_{jt-1} : one period lagged dependent variable for country j,
W_{jt} : the value of wage rates of steel production for country j at period t,
CC_{jt} : the normalized value of installing rate of continuous caster for country j at period t,
OP_{jt} : the normalized value of steel production rates by Open Hearth furnace for country j at period t,
DS_{jt} : the normalized value of domestic excess supply of steel mill products for country j at period t, and
UP_t : U.S. share to the world steel production at period t.

The model for this study incorporates the following explanatory variables such as the wage rates and the adopting rate of new technology which are important factors in determining international competitive ability in the world steel market.

4) Ibid., p. 329.

One period lagged dependent variable. In order to examine how rapidly each country's market share is adjusted to its target share, the one period lagged dependent variable was selected. Adjusting the current marketing share to the target level can be explained by Stock Adjustment[5] Model as follows:

$$Y_{t*} = \beta X_t \tag{3}$$

where Y_{t*} is a vector (k by 1) of target market shares in time t. X_t is a vector (m by 1) of the determinants of the target market share. The adjustment process is represented as

$$Y_t - Y_{t-1} = A(Y_{t*} - Y_{t-1}) \qquad 0 < A < 1. \tag{4}$$

In this equation, the difference between Y_t and Y_{t-1} respond partially to the difference between the target market shares (Y_{t*}) and the previous market shares (Y_{t-1}). This equation can be changed as

$$Y_t = AY_{t*} + (1-A)Y_{t-1}. \tag{5}$$

Substituting for Y_{t*} in equation yields

$$Y_t = ABX_t + (1-A)Y_{t-1}. \tag{6}$$

Here, based on the coefficient of the one period lagged dependent variable, we can evaluate how rapidly the market share is adjusted to its target share. A low value to (1-A) implies rapid adjustment. If (1-A) is close to 1, the adjustment is slow. In such a case one might be inclined to examine the effect of a distributed lag.

Wage rate variable. In classical trade theory,[6] labor cost is a unique factor in determining commodity trade between countries. The theory states that the trade patterns are determined by difference in labor cost of production between countries. As discussed in some of the literature,[7] most international competitiveness in the world steel market largely depends on each country's labor cost. In this study wage rates are selected as an explanatory variable based on the classical Labor Cost Advantage Theory.

Technological variables. The major new technologies for steel making are furnacing technology and casting technology. These new technologies can affect both capital and labor

5) For details, see Robert S. Pindyck and Daniel L. Rubinfeld, Econometric Models and Economic Forecasts (New York: McGraw-Hill Book Company, 1981), pp. 235-236.

6) David Richardo, The Principles of Economy and Taxation (London: J.M. Dent & Sons Ltd., 1911), pp. 82-83.

7) Garth Mangum, Stephen Mangum, and Sae-Young Kim, "The High Cost of Peace in Steel," Challenge (July-August 1986), pp. 47-50; Richard S. Thorn, "Steel Imports, Labor Productivity, and Cost Competitiveness," Western Economic Journal 6 (December 1968), pp. 375-84.

productivity. As a result, these factors are essential determinants for international competitiveness. This study adopts two technological factors that have distinct properties as explanatory variables. One is open hearth furnace variable which is in an decreasing trend; the other is continuous caster variable which is in an increasing trend.

Excess Domestic Supply variable. As the world's largest domestic steel market, the United States is the natural target for all foreign countries with excess domestic steel supply. As a result, one of the major causes of the current problems which confronts the U.S. steel industry is a worldwide excess supply. In order to examine this fact empirically, the Excess Domestic Supply variable is selected as an explanatory variable.

The United States showed a negative value in excess domestic supply during the testing period. The excess domestic supply for South Korea and Brazil, in the mid-1970s, has changed from negative values to positive values. The West European countries and Japan maintained positive excess domestic supply with Japan having the highest. Thus the amount of Japanese steel exports has been higher than any other country. The excess domestic supply for the West European group has been relatively stable throughout the whole period.

U.S. steel production share to the world steel prouction. One of major causes of the increase in U.S. steel imports is the decline in U.S. domestic steel production. In order to test how each country's steel production portion to world total production, this variable is adopted as a expanatory variable. The U.S. domestic production share has declined dramatically from 15.9 percent in 1960 to 11.8 percent in 1984.

Pohang share in South Korean national production. Significant Korean steel exports to the U.S. market began at the same time when Pohang Steel Company (POSCO) commenced production. Almost all of the South Korean steel imported by the U.S. states is produced in POSCO. As a result, POSCO's production share to South Korean national production is major factor in determining Korean market share in the U.S. market. POSCO's share to South Korean national production have increased from 36 percent in 1975 to 71 percent in 1984.

Major sources of data are (1) International Iron and Steel Institute, Committee on Statistics. Steel Statistical Yearbook. Brussels, Belgium: 1151, various years., (2) Korean Iron and Steel Federation. Statistical Yearbook. Seoul, Korea: KISF, various years., (3) American Iron and Steel Institute. Annual Statistical Report. Washington, D.C.: AISI., various years.

In this system model, it is expected that there is the potential for contemporaneous correlation among the disturbance terms for different countries. Contemporanous correlation in the residuals implies that OLS estimates may be inefficient and that estimation efficiency can be improved by the use of GLS estimation.[8] Therefore, the models included in the study will be tested with GLS estimates which are based on the method of Zellner (1962) and are generally more efficient than OLS estimators when error terms of different equations for the same period

8) A. Zellner, "An Efficient Method of Estimating Seemingly Unrelated Regression and Tests for Aggregation Bias," Journal of the American Statistical Association 57 (June 1962): 348-68.

are not independent. Hence, this study employes the Seemingly Unrelated Regression method[9] with Generalized Least Squares (See Appendix).

IV. Review of Previous Empirical Studies on Steel

Even though not too many works have been done using a formal model, several econometric model studies of this topic have been performed. Most of these works sought to measure the impact of selected variables on world steel exports and steel imported by America, by estimating relevant parameters. The works of Kawahito (1972), Friden (1972), Ault (1972), Crandall (1981), and Cima (1982) belong to this category of study.

Kawahito (1972) builds a model in order to estimate several projections of United States steel imports from Japan up to 1975 based on different assumptions such as continuation of voluntary export quotas, free trade with constant and increasing price differentials, and free trade with a 10 percent yen appreciation in 1972. One of major findings in the book is that Japan's continuing improvement in productivity will result in the U.S. steel industry facing a problem of steel imports from Japan.

Crandall outlines a four-equation model which is used to estimate steel pricing and market shares. His empirical tests provide some interesting results regarding the U.S. steel industry. Crandall finds that the steel import share in the U.S. market is not inelastic with respect to the price of imports relative to U.S. domestic producers' prices of steel. Also he finds that American steel prices in the domestic market are significantly influenced by the steel import price. One further finding is that the trigger price mechanism benefited foreign steel suppliers almost the same as domestic steel producers.

In his Ph.D. dissertation, Cima specifies a quantifiable model of world trade in Japanese rolled steel within the Cournot-Yntema-Blackhurst-Armington frame work. His model accounts for the separate influence of Japanese, U.S., and the rest of the world demands for Japanese steel, and total Japanese steel supply, on U.S. steel imports. A form of two-stage-least squares is employed to estimate an empirical version of the model for the 1952-75 period. The empirical results of Cima's study show that the price elasticity of the Japanese steel export to the U.S. steel market is substantially greater than the price elasticity of total Japanese steel supply.

9) A summary of Zellner's regression method can be found in R. Carlson, "Seemingly Unrelated Regression and the Demand for Automobiles of Different Sizes, 1965-75: A Disaggregate Approach," Journal of Business 51 (1978): 243-62; Robert B. Avery, "Error Components and Seemingly Unrelated Regressions," Econometrica 45-1 (January 1977): 119-210; V.K. Srivastava and T.D. Dwivedi, "Estimation of Seemingly Unrelated Regression Equations: A Brief Survey," Journal of Econometrics 10 (April 1979): 15-32. A recent work about comparison between OLS and GLS estimates is given by Roderick Brodie and Cornelis A. Kluyver, "Attraction Versus Linear and Multiplicative Market Share Models: An Empirical Evaluation," Journal of Marketing Research 21 (May 1984): 194-201.

V. Results for Empirical Tests

The regression of the five equations by the method of seemingly unrelated regression produced the results contained in Table 1. The adjusted R^2 (multiple coefficient of determination) in systems of equations ranged from .9402 in the case of Brazil to .6884 in the case of the West European countries group (the United Kingdom, France, and West Germany). Most of the coefficients for the countries are intuitively and reasonably "signed," and of these coefficients, several achieve high levels of significance. The relative importance of each independent variable varied according to each equation for country or country group. The determinants for each country's equation and their importance on the market share are summarized below.

In determining the U.S. market share at home, three variables are critical: the Lagged Dependent, the Excess Domestic Supply, and Continuous Caster Variable. Based on β coefficients, the Excess Domestic Supply variable is the highest value. The next highest is the one-period Lagged Dependent variable, followed by the Continuous Caster variable. The Excess Domestic Supply factor has been the most important in determing the U.S. market share. By closing obsolete capacity without capital replacement, the U.S. decreased its domestic steel supply. In addition, some major steel producers withdrawal from the steel business has made them lose their market to foreign producers. Insufficient investment expenditure during the 1960s and 1970s substantially lowered the rate of productivity improvement in U.S. steel production. Since 1970, the rate of the U.S. installation of continuous caster technique has increased, but this rate is still lower than those of others. As a result, the lagging U.S. adoption of new casting technology has negatively affected its market share.

In the Japanese equations, the determinant variables consist of adopting new furnacing technology, the wage rate, the U.S. production share, and adopting new casting technology. According to the β coefficient for each determinant, the strongest variable is the adoption of new furnacing technology, followed by the wage rate, the U.S. production share, and finally, adoption of new casting technology. Since 1960s, most Japanese steel plants were replaced by Basic Oxygen Furnaces (B.O.F.). Therefore, Japanese furnace equipment is newer than that of the U.S. and West European countries. Perhaps this is why the new furnacing technology variable is most important in the determination of the Japanese market share. Additionally, a lower wage level, which was achieved by a good relationship between management and labor, allowed the Japanese steel industry to capitalize on its competitive advantage and attack the existing market position of Western Europe. The statistical significance of the U.S. production share variable in the Japanese equation supports that some parts of the decline in the U.S. share among world steel production have been replaced by Japanese steel products. However, of the determinants of Japanese share, the new casting technology adoption variable is the lowest value based on the β coefficient, and unexpectedly signed. As a pioneer, Japan installed the continuous caster earlier than other tested countries here. However, the trend of its relative installation rate of this technology decreased during the testing period. For this reason, perhaps, the variable for new casting technology has had a negative relationship with the Japanese market share.

The West European equation resembled the Japanese equation in that the adoption or new furnacing technology, the wage rate, and the U.S. production share variable are significant factors. In addition to these variables, the one period lagged-dependent-variable and the Excess Domestic Supply variable are critical in determining these countries' market shares. Based on the size of the β coefficient, the largest is the variable for U.S. share in world production. The second largest β coefficient is the wage rate, then followed by the new furnacing technology adoption variable, the Excess Domestic Supply variable, and the new casting technology adoption variable.

Western Europe was the pioneer in exporting its steel to the American market. As the U.S. share of world steel production has declined, the share of West European steel has increased. This decline in the U.S. share of world production is the strongest factor in determining West European market share in the U.S. steel market. The other determining variables are the wage rate and the adoption of new furnacing technology. During the 1960s, Western Europe enjoyed the advantage of a lower wage level than that of the U.S. industry. Their steel furnacing facilities were also relatively efficient compared with those of U.S. producers. Despite their new technologies and low wage levels, the Japanese were never successful in replacing the Western European countries in the U.S. market. It was only after South Korea and Brazil began exporting steel to the U.S. that the Western European share began to decline. These facts support the results that the adoption of new furnacing technology and the wage rate variables are critical in determining market shares. The steel industries of West European countries continued steel production at surplus domestic levels. Their marginal production was continued as long as the price could cover variable costs and contribute to fixed costs.[10] This fact substantiates the statistical significance of the Excess Domestic Supply variable in West European equation. Lastly the new casting technology adoption variable is the least important determinant among statistically significant variables based on the β coefficients. The reason for this may be because the West European aggressive adoption of this new technology. The technology had been in place in the 1970s when Third World countries emerged in the world steel market.

South Korean steel exportation to the U.S. has depended upon Pohang Steel Company's production, Excess Domestic Supply, and its Wage Level. According to the β coefficients, the Pohang steel production, relative to South Korean total production, has been the most crucial in determining South Korean market share. The South Korean national steel production relies mainly on the Pohang Steel Company (POSCO). After POSCO started production in 1973, its output soon saturated the South Korean national demand for steel and South Korea experienced excess domestic supply pressure. As a result, South Korea began exporting steel to the American

10) U.S., Congress, Senate, Committee on Labor and Human Resources, Employment and Productivity Trends in the Steel Industry, Hearings before a Subcommittee of the Senate Committee on Labor and Human Resources on H.R. 98-816. 98th Cong., 2nd sess., 1984, p. 115; see European profit rates reported in Table 21.

steel market. This excess domestic supply of steel in South Korea created an ideal export supply to the American market. In addition, the South Korean wage rate has been an important factor in determining South Korea's share. Without a labor union, steel workers in major South Korean steel companies must take the wage levels which both the South Korean government and company's management decide. With no fringe benefits, their extremely low wage level, compared with those of other major producers, encouraged an increase in steel exportation.

Like South Korea the Brazilian excess domestic supply of steel has been a major determinant of its market share in the U.S. domestic market. Although it is less important than the excess domestic supply variable based on β coefficient, the U.S. production share variable is one of the crucial determinants in Brazil's equation. Brazilian steel capacity tripled between 1973 and 1984 (from 7 million to nearly 21 million tons), whereas indicators reveal its domestic demand declined precipitously during the last two decades. Brazil has possessed substantially more domestric supply than is needed to satisfy its domestic demand. As its steel industry tried to absorb its surplus capacity through production of steel for the U.S. market, Brazilian exports to America have increased. Additionally, the U.S. Share variable is critical in determining the Brazilian market. This result supports the fact that the historical decline in the U.S. world production share has had a close relationship with Brazilian exports to the U.S. market.

In conclusion, although Brazil is excluded in testing the impact of wage rates on market shares, the other three exporters to the American steel market, i.e., Japan, West European countries, and South Korea, satisfy the hypothesis that the wage rates are the essential factor in determining each country's market share in the U.S. steel market. In addition, results obtained from the developed countries, i.e., the U.S., Japan, and West European countries, support that the technological variables are crucial determinants for their steel exports to the United States. However, this hypothesis which technological variables are significant determinant, is not substantiated by the results for the two newly industrialized South Kore and Brazil perhaps because these two countries adoption rate for new technologies had been less than the rates of Japan and West European countries. Lastly, the hypothesis for Domestic Factor Pressure is statistically satisfied for all countries excluding Japan.

VI. Prospects for Each Country's Future Market Share

So far we have found the determinants for each country's market share in the American domestic steel market during the past 25 years. What will happen in the future to each country's share in the U.S. domestic steel market? The older industrialized countries, such as the U.S., Japan, and West European countries will try to protect their current market shares, whereas the newly emerging countries of South Korea and Brazil will seek to increase their shares. In addition, other countries such as Taiwan, Mexico and South Africa are exporting small amounts of steel to the U.S. market. Based on the above findings, we will now try to predict, at least in

directions of movement and general mangitude, the future market share for each country or group.

The United States

The empirical results substantiate that the critical determinants for the U.S. market share in its own market are the Domestic Excess Supply variable and Continuous Caster variable. During 1960 through 1984, the U.S. industry lagged in adapting new technologies for steelmaking and many obsolete integrated plants were closed. In addition, some major U.S. steel producers have tried to get out of the traditional steel business. These events have made the American industry lose its domestic market share to foreign competitors. Even though the current Voluntary Restraint Agreement (VRA) system is designed to keep steel imports below 20 percent of total U.S. consumption, the U.S. market share will decline slowly after 1990 because of the strengtnened position of certain newly industrialized countries with remarkably low cost production. There are few answers to protect the U.S. current market shares. But encouragement of the mimill and specialty steel components of the industry, placing no obstacles in the way of semifinished importation, improvement in the exchange rate, improved labor-management cooperation in pursuit of productivity betterment, acceptance by steelworkers of a lessened premium over the rest of manufacturing and greater management commitment to its own future could, all together, help in maintaining its current market share in its own domestic market. However, the long run trend is more likely to be a slow decline of the U.S. steel market share because of the withdrawal trends of major steel producers from the steel business.

Japan and Western Europe

For the Japanese market share, the determining variables consist of adopting new furnacing, the Wage Rate and the U.S. Production Share. In determining the market shares for West European countries, the variable for the adoption of new furnacing technology, the Wage Rate variable and the U.S. Production Share variable are crucial factors. In addition to these, the Excess Domestic Supply variable is critical. During the 20 years since 1960, the Japanese and West European countries steel industry has been mired in a depression, resulting in huge losses of hundreds of millions of dollars per year with many of its integrated producers cutting back their capacity sharply. The Japanese steel industry has also suffered a considerable drop in production and shipments, as well as in export tonnage to the U.S. market. As a result, Japan faces the challenge of rationalizing and restructuring its steel companies.

The West European and Japanese steel industries adopted new technologies for steelmaking more rapidly and earlier than other newly industrialized steel producing countries. Their facilities for steelmaking are currently challenged by the new and efficient steelmaking equipment of the later arrivals such as South Korea, Brazil, Mexico, Taiwan and South Africa. Even though the wage levels of both Japan and West European countries have been relatively low compared

with those of American producers, they are currently facing the disadvantage of a high wage level relative to the above named newly industrializing nations. In order to maintain their current share, continuous and adequate investment for modernizing their steel facilities is required. Innovating new products and technology will help protect their shares in the U.S. market from the challenge of the newly industrializing countries. However, because of the newly industrializing countries' efficient plants and extremely low wage levels, the market shares for Japan and Western Europe will be slowly replaced by those of the newly industrializing countries.

South Korea and Brazil

The crucial determinants for the South Korean market share are the ability of POSCO to increase its steel production and its low wage levels. The construction of the new Kwangyang plant, which belongs to Posco, is scheduled for completion in late 1987. Its 3 million metric tons per year steel works will push South Korea's domestic steelmaking capacity to 15.5 million tons per year by 1988. As Korean excess domestic supply increases, and assuming its steel industry is able to maintain low wage levels, there is little doubt that South Korea will maintain one of the most efficient steel industries in the world and steadily increase its share in the U.S. market for the next one or two decades. As South Korean steel consuming industries such as automobile and military equipment are rapidly developing, the future domestic steel consumption in Korea is expected to grow fast.[11)]

The Brazilian market share has also been mainly affected by the level of its excess domestic supply of steel. Since Brazil will continue to press ahead with additional steel capacity expansion in the next decade the Brazilian market share is surely expected to increase and it will take some of the existing market shares of older developed countries such as the U.S., Japan, and the West European countries in the American domestic market. On the other hand, Brazil is one of the major arms exporters among Third World countries and its military equipment and heavy machinery industries are growing rapidly. Because these industries are expected absorb a lot of its steel, Brazil has the potential for greater domestic steel consumption.

New Challengers

Other countries are panting to join in exporting steel to American market. South Africa, Mexico and Taiwan are already involved. South Africa steel exportation to the American market jumped to 411 thousand tons in 1985, while Taiwan and Mexico went up to 218 thousand tons and 272 thousand tons, respectively, in the same year.[12)] The advanced six[5)] developing countries – Brazil, India, Mexico, South Africa, South Korea, and Taiwan – now account for more

11) Jong-Hyun Nam (1979) predicts that Korea will consume 25 million ton of steel in 1991.
12) American Iron and Steel Institute (1986), pp. 53-59.

than 75 percent of all LDC steel capacity.[13] Of these, Taiwan, Mexico, and South Africa are building large, integrated exportoriented steel plants seeking to export increasing amounts of steel to the American market. South Africa has good raw material for steelmaking and a relatively low wage rate but its domestic political problems are expected to be an obstacle in its international business. Taiwan's steel exportations to the U.S. market have increased steadily. In addition, Taiwanese steel output is expected to reach 11 million tons in 1990. Therefore, Taiwan remains a strong future competitor. As mentioned above, Mexico places a higher priority on job creation rather than on the efficient steel production. However, with its advantage in transportation cost to the U.S. market, Mexico is a potential contender if it can improve its efficiency and get its production costs in line. These new exporters to the U.S. market have the potential for taking market shares from Japan, the West European countries and the U.S. industry. They are unlikely to wrest shares away from Korea and Brazil unless the latter lose control of their labor costs or expand their domestic consumption sufficiently to absorb their excess domestic supply.

In conclusion, as more U.S. steel companies withdraw from producing steel, the U.S. steel industry's market share will decline slowly and continuously. Japan and the West European countries will also lose part of their shares in the U.S. steel market through competition with newly industrializing countries because their facilities will lose efficiency sonner and their costs of production will be relatively higher than those of the new producers.

The newly industrializing countries, including Brazil and South Korea, whose market shares are critically dependent on their domestic supplies of steel, will continue to increase their shares in the U.S. market since they have embarked on ambitious programs of steel expansion which will allow them additional tonnage for export, thereby improving their balance of payments position. In addition to the fact that Brazil and South Korea and threatening the market shares of older developed countries, other Third World countries such as South Africa, Taiwan and Mexico are emerging as new competitors in the U.S. domestic steel market. The factors identified in this dissertation will be the major determinants of their success and can be used to watch and predict the outcomes over time.

13) Author's calculation from Korean Iron and Steel Federation (1986), pp. 242-245.

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APPENDIX

Zellner's estimator (seemingly unrelated regression)

The basic idea of Zellner's estimator regression is to utilize Aitken's generalized least squares method on all observations from the countries tested here in regression. The set of h countries with n observation can be estimated by conjoining them thus:

$$\begin{bmatrix} Y_1 \\ Y_2 \\ \\ Y_h \end{bmatrix} = \begin{bmatrix} X_1 & 0 & \dots & 0 \\ 0 & X_2 & \dots & 0 \\ & & & \\ 0 & 0 & \dots & X_h \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \\ \\ \beta_h \end{bmatrix} + \begin{bmatrix} \mu_1 \\ \mu_2 \\ \\ \mu_h \end{bmatrix}$$

where $Y = hn \times 1$ matrix
$X = hn \times (\Sigma k_i)$ matrix
$\beta = (\Sigma k_i) \times 1$ matrix
$\mu = hn \times 1$ matrix,

which is more simply denoted:

$$Y = X\beta + u$$

The disturbance vector u is assumed to have mean zero and covariance matrix, denoted ϕ:

$$\phi = E(UU') = \Omega \otimes 1$$

where $\Omega = E(\mu_{it}\mu_{it'})$ is the matrix of contemporaneous covariances between the several countries; 1 the identity matrix of a size equal to the number of observations per country, n; and $\otimes$ the Kronecker product operation.[1] The covariance matrix ϕ is of size (hn x hn) and consists of (n x n) diagonal submatrices, each equal to the corresponding scalar element of Ω times 1 (matrix).

14) For details, see George G. Judge, R. Corter Hill, William E. Gariffiths, Helmui Luikepohl, and Tsoung-Chao Lee, Introduction to Theory and Practice of Econometrics (New York: John Wiley & Sons, Inc., 1982), pp. 317-9.

Table 1. Parameter Estimates for Steel Market Share Equations (1).

Variables	U.S.	Japan	Western Europe	South Korea	Brazil
Intercepts	.5105*	.1131*	.0839*	-.0051	.0080
	(.1233)	(.0349)	(.0258)	(.0073)	(.0048)
Lagged	.4324*	.1178	.4254*	-.0246	.1963
Dependent	(.1238)	(.1577)	(.1638)	(.2744)	(.1562)
	[.4021]	[.1263]	[.4263]	[.0214]	[.1580]
Wage (b1j)	-.0012	-.0038*	-.0062*	-.0070(*)	
Rate	(.0043)	(.0016)	(.0020)	(.0043)	
	[.1046]	[.4688]	[.6146]	[.5966]	
Open (b2j)	.0047	-.1710*	-.0677*	-.0044	.0018
Hearth	(.1121)	(.0737)	(.0307)	(.0167)	(.0057)
	[.0079]	[.5630]	[.3987]	[.0441]	[.0404]
Continuous	-.0752(*)	-.0203*	.0194*	-.0024	-.0049
Caster (b3j)	(.0450)	(.0072)	(.0075)	(.0095)	(.0062)
	[.1287]	[.2646]	[.3418]	[.0359]	[.0820]
Excess	.1668*	-.0047	.0650*	.2570*	.0404*
Domestic	(.0410)	(.0251)	(.0289)	(.0827)	(.0077)
Supply (b4j)	[.6685]	[.0430]	[.3624]	[1.333]	[.5708]
U.S. Share	-.0023	-.0018(*)	-.0033*	.0002	-.0003*
in World	(.0034)	(.0010)	(.0010)	(.0002)	(.0001)
Production (b5j)	[.2180]	[.4581]	[1.5442]	[.1750]	[.3775]
Pohang Share				.0271*	
in Korean				(.0081)	
Production				[2.137]	
Adjusted R^2	.9111	.8654	.6255	.8904	.9414

* Significant at the 0.95 confidence level or better.

(*) Significant at between the 0.90 and the 0.95 confidence levels.

( ) denotes standard error.

[ ] denotes β coefficient.

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〈國文要約〉

美國鐵鋼시장의 국가별 시장점유율 決定요소에 關한 연구

金 世 榮

本稿에서는 1960년대 이후 큰 변화를 가져온 미국철강시장의 주요공급국들의 시장점유율 추이를 분석하고 그 결정요소들을 Zellner的 회귀분석방법(Seemingly unrelated regression)을 이용하여 추정하였다. 本 연구의 모형검증을 위한 설명변수로는 임금수준, 기술수준, 그리고 국내초과공급능력 등이 사용되었다.

실증분석 결과는 미국의 시장점유율의 결정에는 노후 철강생산설비의 괘쇄로 인한 국내 철강재 공급감소와 낮은 자동주조기 설치율이 크게 영향을 미치는 것으로 나타났으며 구라파와 일본의 경우는 기존생산설비의 노후화로 인한 生産의 効率性감소와 신흥공업국들에 비해 임금의 상대적 고위로 말미암아 그들의 美國市場 점유율이 신흥공업국(한국과 브라질 등)에 依해 잠식된 것으로 밝혀졌다. 한국은 포항제철의 급격한 철강 生産能力 증대와 저수준의 임금이 美國市場에서 그들의 시장점유율 증가에 크게 기여한 것으로 보이며 브라질의 경우도 국내과잉철강공급능력이 그들의 미국시장점유율을 증가시키는 중요한 요인가 된것으로 나타났다.

本 연구결과를 근거로 할때 선진철강공업국인 미국, 구라파 및 일본의 시장점유율은 기존시설의 효율성상실과 임금의 상대적 고수준으로 因하여 합리성을 찾는 시점까지 지속적인 감소가 예상되며 한국과 브라질은 그들의 상대적 저임금 수준과 국내수요를 초과하는 과잉생산설비의 증대로 인하여 당분간 미국시장에서의 시장점유율의 증대가 지속될 것으로 보인다. 끝으로 철강산업에 밝은 전망을 가진 신생공업국들인 남아프리카 공화국, 대만, 그리고 중공등도 머지않은 장래에 미국철강시장에서의 새로운 경쟁국으로 등장하게 될 것이다.