A Short review of steel demand forecasting methods

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This paper undertakes the present and past review of steel demand forecasting to study what methods should be used in any future attempt to project steel consumption. Some times ago, some studies identified fundamental changes in the relationship between steel consumption and general developments in the economies of the industrialized countries and threw serious doubts on the continued ability of previously used forecasting models to predict future steel consumption with any satisfactory degree of accuracy. Some study once used an input-output method in order to predict steel demand in the developing countries for success.

1. Steel demand forecasting models used in industrialized countries

Steel demand forecasts are a necessary part of a number of different aspects of internal steel company planning. Many investment proposals must be evaluated against an analysis of likely market opportunities. This will certainly include a detailed forecast of the home market requirement for the produce or products involved and also an assessment of overseas demand prospects if exports sales form part of the marketing strategy. Even if exports sales are an insignificant part of the total, demand forecasts for overseas markets may be necessary for an analysis of likely future pressure from imports on the home market and also for an appraisal of the likely relationship between home and export prices in the future. The time horizon used for investment appraisal will vary between companies and with the type of project, but a three year construction period followed by an assumed economic life of fifteen years is not uncommon and implies that steel companies are already making forecasts of steel demand for the 2015 and beyond. On a shorter time horizon the preparation of medium term steel demand forecasts will form part of the company sales plan which in turn forms part of general financial and business planning.

The most important point to stress is that demand forecasting forms part of the internal business decision making process. In any large organization such processes require consensus between managers of different functions but also of different background and skills. As a consequence the steel demand forecasting techniques used must be clear, capable of non-expert examination and scrutiny, and command a broad consensus of acceptance. For this to occur 'black box' econometric models can only be part of the approach used and the results of such analysis must be matched against other sources of forecasts such as the judgment of sales departments in the field, etc. Although the above remarks might not seem to apply to forecasts made by trade associations on behalf of their members, in practice, there is a similar requirement for clarity, consensus and an explicit exposition of the key macro-economic assumptions underlying the projection made.

The major division in time horizons of forecasts is between the long term projections required for investment decision making and the medium term sales forecasting exercise. In the former the emphasis is on trends while the latter requires an attempt to plot the cyclical pattern of demand and changes in inventories. The medium term forecasts involve a much greater degree of detail regarding individual markets, steel products, and steel consuming sectors. There are a number of reasons for this: firstly, the availability of information-many external sources may be able to provide forecasts for the next five years, few venture any further. Secondly, it is important to distinguish the cyclical changes in the sector pattern of an economy (which is determined by the phase of the business cycle) from structural changes which are likely to be less pronounced in the medium term. For long term forecasts, structural changes in the sector pattern are considered to be of great importance-hence the greater emphasis on the general economic framework in longer term forecasting work.

There are two main alternative methods of analysis used: forecasting demand by major steel consuming sectors; or total demand, by direct relationship with macro-economic variables. Both these techniques are used in parallel by international major steel institutes, with the use of one approach to check against the other. For this to be valid it is necessary to set a common and consistent economic framework covering both methods of approach. It is therefore at this stage that the search for consensus must start. Many International institutes carry out their own general economic forecast, but all also draw upon the results of external forecasting agencies and many participate in forecasting syndicates with other industrial enterprises. The smaller the internal resources of the institute, the more likely macro-economic forecasts and frameworks will be taken ‘off the shelf’, i.e. from outside.

The main macro-economic variables commonly used by international institutes in global models to link with steel consumption include: GNP or GDP and GNP or GDP per capita, Gross Fixed Capital Formation (GFCF), industrial Production and Investment share. Investment share, i.e. the proportion of Gross Fixed Capital Formation in GNP or GDP is generally used in analyses of steel intensity whereas the level and rate of growth of investment itself is used for analyses of steel consumption since an increase/decrease in investment share only indicates whether investment is growing slower or faster than GNP or GDP. Even if the investment share remains unchanged, steel consumption will increase when the close correlation of steel demand with expenditure on investment goods is also reflected in the common specification of relationships in logarithmic form-emphasizing the rate of changes in GNP or GDP or GFCF. Restriction to a smaller number of explanatory variables in these global steel demand models is done only after an extensive process of research and elimination of alternative formations. Most importantly, to be of practical value, the econometric equations must only include explanatory variables for which forecasts exist or can be made with some degree of accuracy.

The degree of detail used in sector models depends on the quality of information available within the economy. The most elaborate network is set out for a steel corporation in Japan, but it is based on a level of data which is hardly attainable in other countries than Japan. The sector approach is the one that enables the input of a wide range of alternative sources of information. Thus for each sector, in addition to econometric equations based on historic analysis, information is also provided by the sales function, marketing, and through rounds of interviews with major steel-using companies. The objective is to forecast the level of unit output of each sector and also any changes in the steel intensity of that output. The approach provides not only an insight into total steel use of the sector, but also the product pattern of steel consumption.

The results of this and other known statistical research work show that there is considerable scope for the development of more sophisticated econometric models which would represent an improvement over the continued use of the basic global model. However, the most appropriate explanatory variables are likely to be different in difficult countries, particularly if they are at a different stage of economic development. Therefore the continued use of the same basic global model for forecasting steel consumption in all regions of the world would be an unnecessary handicap to the overall forecasting exercise. Furthermore, because of significant differences in the availability and quality of statistical data between countries there may be several economic indicators which may be used for forecasting in some countries but not available in others. In short, the search for a common denominator for economic activity in all regions of the world is an unnecessary constraint.

There is, of course, a considerable amount of work involved in developing separate macro-economic models for different regions/countries. However, the rapid increase in the data handling capacity of desk computers even over the period were undertaken and the reduction in data handling costs means that such an exercise is becoming an increasingly practical proposition.

Even for those developing countries where the availability of forecast for macro-economic variables is limited, an analytical distinction should be made between different economies depending on their degree of industrialization, whether they are net oil-exporters, primary commodity producers, etc. so that countries with similar patterns of steel intensity in their economies are grouped together. Furthermore, in addition to GNP or GDP per capita, the growth rate of GNP or GDP at least should be included in the explanatory variables used in the forecasting models developed.

2. Steel consumption patterns and models used for Developing countries

UNIDO (United Nations Industrial Developing Organization) uses the Projection 1990/2000 steel demand forecasting model which relates changes in steel intensity to GDP per capita. It also uses the global model for certain regions of the world, but incorporating investment share as an explanatory variable. Forecasts of the latter come from a combination of models, historic analogy, scenario techniques, and external sources. However, generally, the approach is only applied to countries where the absence of better statistics rules out an alternative approach or where the level of probable export opportunities does not justify a more detailed analysis.

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The methodology used in this paper to determine consumption patterns was a standard bivariate and multivariate regression analysis applied to data given for 65 countries. The following expression were selected as an initial attempt to provide a plausible explanation of the relationship between per capita steel consumption(c) and GDP per capita(y):

Log-log: $\ln c = a + b \ln y$

Semi-log: $c = a + b \ln y$

Log-inverse: $\ln c = a - b/y$

Log-log-inverse: $\ln c = a - b/y - d \ln y$

Log-log-square: $\ln c = a + b \ln y - d (\ln y)^2$

where a, b and d are constants

In the case of the log-log function, per capita apparent consumption increases sharply as the level of per capita income rises. The semi-log function shows a less rapid increase in consumption. In the case of log-inverse function, consumption increases more rapidly at a relatively low level of income, but the rate of increase tends to reduce at a higher level of income. The log-log inverse curve has a maximum point, before which consumption increases most sharply; it is reduced after this point.

These equations were tested for several time periods and simple stratifications. The results confirmed the analytical validity of the approach and revealed a slight superiority in the performance of multivariate models when applied to the total sample, and a clear superiority in that of the bivariate model where the samples were stratified according to the level of economic development. Hence, the hypothesis of a common pattern of steel consumption among different countries can be accepted. As confirmed by detailed analysis , the level of economic development is an important factor in specifying the relationship between steel consumption and per capita income.

One of the problems discussed among model builders is that the changes in economic structure which have occurred in the late 1960s and the early 1970s could create a discontinuity with the 1950s as a sample period for data; this would significantly shorten the number of years (degree of freedom) available for econometric analysis. It is, however, held that the existence of two periods of rather different economic circumstances may help in the development of models which avoid the mistake of merely extrapolating trends prevailing in a specific period of economic growth. It also enables a more robust formulation in the model of the underlying relationships, and it should help to avoid high correlations based simply on coincidence.

For the sector approach to produce satisfactory result it is necessary to have an accurate assessment of steel consumption by individual sectors. Unfortunately, the data available are unsatisfactory. In the virtually complete absence of statistics on actual consumption of steel, the major problem is in tracing the final destination of steel which is either imported or handled by stockholding merchant (service centers). While the steel industry monitors its own domestic deliveries by consuming industry, in many industrialized countries imports and merchants' deliveries are a significant part of the total.

For longer term forecasting a number of major international steel companies reported the use of scenario technique, using alternative hypotheses on general economic developments and providing a range of alternative steel demand projections. Typically, such scenarios examine the inter-action of alternative oil price developments, the degree of protectionism, and social attitudes towards industry. The reasons for the use of scenarios are the possibility to reduce to some extent the high degree of uncertainty of future economic or political events, and the absence of authoritative and reliable macro-economic forecasts. Since, however, long-term forecasts are mainly needed for investment appraisal, an assessment of sensitivity of the project to significantly different alternative outlooks is an important requirement for decision making, arrange of steel demand forecasts derived by the scenario technique is of great practical value.

3. Some statistical problems in testing of models

There is not one unique model which describes steel consumption in the right way and which is therefore natural to use for prediction purposes. Rather, there are several models that are plausible from an economic point of view. The trouble is that, in general, they give different predictions, even if fed with the some exogenous information.

How should we among these models to get one single forecasts?

One very common way to make this choice is to let the performance of the models during a historical period be decisive. The fit is often measured with the coefficient of determination, R^2, sometimes corrected for the number of degrees of freedom and then denoted $\overline{R}^2$. Then $(1-\overline{R}^2)$ shows the ratio between the variance of residual and the variance of the variable to be analyzed. Thus, in a broad sense, a high $\overline{R}^2$ indicates a good fit of the model. For this reason, it seems natural to choose the model with the highest R^2 and use it for prediction.

Unfortunately, however $\overline{R}^2$ for different models are not necessarily comparable. In the models used earlier, the dependent variable is often S_t , but may be log S_t or A_t or E_t. A model that minimizes residual variance of S_t does not necessarily minimize residual variance of E_t, etc, Thus, a model with log S_t as dependent variable and $\overline{R}^2 = 0.90$ may be better than one with log S_t and $R^2 = 0.95$ in the sense that the variance of residuals$(S_t - S_t)$ is smaller. Better criterion would be to compare directly these residual variances. The smaller its residual variance, the better the model fits the historical data. It is only necessary to decide which variable is the crucial one. The estimates are then expressed in terms of this variable, and the residual variance is calculated. In our case it seems natural to have S_t as the crucial variable.

Unfortunately, ordinary regression programs do not give the opportunity of computing the variance of these transformed residuals. Thus, only in a few cases we have made this computation. Instead, $\overline{R}^2$ or R^2 is given for all models. When judging the historical performance of the various models, it should be kept in mind that these measure are strictly comparable only for models with the same dependent variable.

Beside the historical fit, other criteria should be used for judging whether a model is appropriate or not. The most important one is the size of the parameter estimates. Usually the parameters have some economic significance, and it is then possible to have some a priori information about their possible magnitudes. If, for example, a parameter estimate has a sign opposite to what is expected from an economic point of view, this indicates that other influences have been stronger than those taken care of by the model. Very probably the model is not appropriate for forecasting purposes.

Unfortunately, it is not always possible to use this criterion, since the estimated parameters are sometimes not automatically meaningful, but functions of two or more economic parameters. Such is the case in a contribution where the estimated parameters are products of long-term and short-term equation parameters. Here it is possible to have an idea of the sign, but not of the magnitude of the combined parameter that is estimated.

A related case appears when two or more of explanatory variables used are intercorrelated. In this situation, the estimates are very sensitive to small changes in the variables and thus not very reliable. This happens in some of the models described in this note. In this case, each parameter is in fact not identifiable by itself, only some function of two or several parameters. Thus, it is here as in the previous situation very difficult to judge the appropriateness of the model. It may be useful for prediction, but if the relation between the explanatory variables changes during the prediction period, it may give peculiar results. If possible, such models should be avoided.

The purpose of the present paper has not been to push for one particular model, pretending that it is better than the other ones. It has rather been to show how general ideas about the determining factors and common background data can be interpreted differently by different experts in the field. Each model, considered by itself, may look quite satisfactory and describe very well the historical data, yet it may give forecasts widely differing from other, equally satisfactory models.

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