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An Approach to Forecasting Market Demand in India: A Case Study of Steel

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Abstract

One of the characteristics of growth in emerging economies is the sharp growth in steel consumption resulting from public investment outlays in infrastructure, coupled with outlays in construction as the economy expands. The last decade's healthy growth of the Indian economy has led to steep rises in the consumption of steel. This paper is an attempt to econometrically analyse the growth in market demand for steel in India using aggregate sectoral demand patterns. It seeks to project demand-supply gaps up to 2014 – 2015. The results would be of interest to academics and for business.

I. Demand Planning and Forecasting

Demand forecasting is an integral exercise in the planning efforts of an enterprise. The choice of forecasting model is conventionally preceded by a formulation of the problem/objective and an initial assessment of the available data. Along with these, factors such as complexity of the relationship to be determined, and the desired level of forecasting accuracy sought from the modelling exercise help to decide on the nature and application of the forecasting model.

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Forecasting literature is replete with several models for adoption. The commonly used forecasting methods of demand estimation may be broadly categorised as:

i. Judgemental Methods
ii. Econometric Methods
iii. Other Methods

i. Judgemental Forecasts

This method makes predictions on the basis of intuition and opinions and is highly subjective in nature. This category consists of a number of techniques including the simple survey method, Delphi method (an interactive forecasting method which relies on a panel of experts), analogy method (utilises analogies between the phenomenon to be forecast and some historical event, or popular physical or biological process) and scenario-building methods (a process of analysing possible future events by considering alternative possible outcomes).

ii. Econometric Forecasts

Econometric methods of forecasting primarily include two types: time series forecasting and causal/structural forecasting. Time series methods are often considered as being *atheoretical* in nature as future predictions are made entirely on the basis of historical knowledge/data. The contrary causal/structural forecasting methods enforce *a priori* assumptions or restrictions on the theoretical linkages between the variables.

iii. Other Methods

Other methods include artificial neural networks (essentially simple mathematical models associated with a particular learning algorithm or learning rule), simulation, probabilistic forecasting (a technique conventionally used for weather forecasting which relies on different methods to establish probability of an event occurrence/ magnitude), reference class forecasting (predicts the outcome of a planned action based on actual outcomes in a reference class of similar actions to that being forecast) and SVM (support vector machines, a set of related supervised learning methods that analyse data and recognise patterns).

Among these categories, econometric forecasting methods are conventionally applied to predict shifts in demand and supply patterns. These include a number of methods such as moving average, linear extrapolation or trend estimation, exponential smoothening, autoregressive integrated moving average (ARIMA) models, ARIMAX (ARIMA including explanatory variables) and vector autoregressive (VAR) methods. The relevance and accuracy of these models to estimate demand varies with the nature of the variable that one is forecasting.

In this paper, an attempt has been made to evolve a methodology to predict the supply of and demand for steel in India. Steel is a very important primary metal whose demand movements are often seen to be closely linked to the economic growth of a nation. In fact the quantity of steel consumed is often considered a proxy for the stage of a nation's industrial development. Therefore the need to evolve a robust methodology to forecast steel demand is a national imperative.

Steel Industry in India

The period starting from 2007 till 2010 had witnessed the stabilisation of the steel industry in India at a higher equilibrium of approximately 60 million tonnes (MT) and presents itself as an interesting period of inflection. The dampening of global supply of steel coupled with rising domestic consumption has placed the Indian market, along with that of China's at the heart of the global steel industry.

Riding on the back of robust growth rates and healthy domestic demand, India has risen from being the seventh largest producer of steel in the world in 2005 to the third largest in 2009. The advent of new production technologies and a conducive policy environment, together with firm-level efforts at capacity expansion and increased capacity utilisation, have led to a noticeable transition in the structure and potential of the Indian steel industry. However, despite the promising rise of the steel industry in India, there exists some apprehension on the capability of Indian steel suppliers to meet the expectations arising from a changing demand scenario. This apprehension has reinforced our need to evolve a robust method to analyse the potential gap through the estimation of both the supply for and demand of steel for the future.

Summary of Past Approaches to Estimate Steel Consumption

Several approaches have been used to forecast steel demand in India and abroad. In developed economies, the demand for steel is conventionally estimated through the establishment of an empirical relationship between GDP per capita and metal intensity of use. This was developed by Malenbaum in 1973. Here, a simple relationship is assumed between population and GDP growth and the metal intensity of industrial output. According to Malenbaum, a typical (steel) consumption to GDP ratio will show a rapid increase in use with rising per capita GDP and then a slow reduction.[3]

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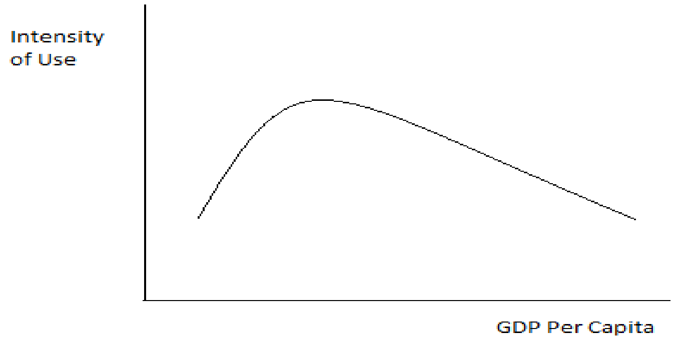
3 Crompton Paul, 'Forecasting Steel Consumption in South-East Asia', *Resources Policy,* Vol. 25, (1999), pp.111-123

<u>Figure 1</u>: Steel Consumption Ratio



The two other popular techniques used to estimate steel is the partial equilibrium and vector autoregression (VAR) approach. In the partial equilibrium approach developed by Labson et al (1997)[4] a dynamic, non-spatial, partial-equilibrium trade model is used to forecast crude steel consumption. Under this approach, crude steel consumption is forecast for each region using a single linear econometric equation, which explains variations in consumption using an index of steel prices, industrial production and a time trend. On the other hand, through the vector autoregression technique, the historical correlations between variables in a system of dynamic, linear equations are analysed to extrapolate future values of all variables involved. Chen et al. use this approach to forecast crude steel consumption in China.[5]

In India, the most traditional approach to estimating steel demand consists of using econometric equations in which the demand for steel is modelled as a broad function of economic variables such as index of industrial production (IIP), gross domestic product (GDP), gross capital formation (GCF) and public expenditure, among others. However, this method is beset with a number of problems. The most important among them is the presence of weak and unclear transmission mechanisms between macro-variables and steel consumption. In fact, the over ambitious targets often set by governments are described as being a 'crisis in forecasting' by an UNIDO/ICIS report published in 1975.[6]

<u>The Model</u>

Given the aforementioned difficulty with forecasting the demand for steel, in this paper an attempt has been made to overcome some of the pertinent problems associated with data through the construction of 'tailor-made' approaches to estimate steel consumption within all major industries/sectors. As an *end-use method*, this model is based on the premise that to determine the demand for steel one must determine the demand of various commodities and activities that consume steel. Here, the output estimates for all final products or services

5 Labson B. Stephen, 'Changing patterns of trade in the world iron ore and steel market: An econometric analysis, *Journal of Policy Modeling*, Vol 19 (3), (1997), pp-237-251.

6 Chen D et al, 'Forecasting steel demand in China', *Resources Policy*, Vol 17 (3), (1991), pp. 196–210.

consuming steel within each sector is estimated and the changing patterns in growth are captured. The sectors for which demand is estimated include construction, machinery/equipment, automobiles, railways, power, consumer durables, fasteners and shipbuilding.

Once the output patterns of each industry/ sector are captured, the model attempts to capture the material composition of product (MCO) (where applicable) to identify the amount of steel used in the creation of a product. This approach helps us overcome concerns over the presence of weak and unclear transmission mechanisms between macro-economic indicators like GDP and IIP and steel consumption. Further, by disaggregating the model in this manner, we are capable of estimating finished steel consumption in each industry and identifying those industries that are expected to remain drivers of domestic demand for steel.

Limitations

This model however makes two important assumptions:

- First, we assume that the input-output technical coefficients that guide steel use remain constant over the period for which steel demand is being estimated. This is based on the assumption that there will be no substantial shift in the manufacturing processes and product design over the period for which steel is being estimated.
- Second, the model does not entirely capture the price effect of steel and assumes that consumption patterns are relatively inelastic and non-responsive to changing prices in the short run.

Outside the limitations imposed by the model, the findings of the study are also restricted in its scope to select sectors on account of lack of access to or non-availability of data.

Scope and Methodology

The model restricts itself in scope to the estimation of demand for and supply of finished steel for the fiscal year 2015-16. A combination of primary and secondary data was used to estimate steel consumption patterns within each sector. Primary data collection involved holding direct interviews with industry experts and bureaucrats. Secondary information was compiled from a number of sources such as the annual survey of industry, Ministry of Statistics and programme implementation (MOSPI), Reserve Bank of India publications, Society of Automobile Manufacturers (SIAM), Construction Industry Development Council (CIDC), Planning Commission, Cement Manufacturers Association (CMA), Indian Electrical and Electronics Manufacturers Association (IEEEMA), World Steel Association and Steel Scenario yearbooks among others.

The paper primarily used time-series tools to forecast steel consumption. A combination of auto regressive integrated moving average (ARIMA) and the vector autoregression (VAR) technique was used (wherever applicable) to forecast the demand for steel across sectors.

Outline

The model is used to predict the movement in the supply and demand patterns of 'finished steel' for the period starting from 2010-11 till 2015-16. Section II of the paper describes the methodology that was used to arrive at supply estimates for steel for the year 2015-16. Section III describes the approach used to establish demand for steel in each sector and the aggregate demand estimate. Section IV evaluates the validity of the model by comparing the demand and supply estimates with alternative studies that were conducted. Section V makes a broad set of observations and conclusions based on the established supply and demand estimates.

II. Supply

Domestic steel in India is produced in a highly fragmented industry with major integrated producers contributing to merely 50 per cent of the total supply. The remainder comes from a large number of mini steel mills and re-rollers. Further, these small secondary producers contribute 70 per cent of the country's steel exports. As of 2009-10, the total steel production in the country was estimated to be 60 million tonnes. Conventionally targets set by major and secondary steel producers are taken to be the estimates of steel production by the Ministry of Steel. However, targets often have a tendency to possess strong upward bias. For example, the steel production target for the year 2011-12 was estimated to be 124 million tonnes by the Ministry of Steel. But the likely addition may not exceed 75 million tonnes, which is 49 million tonnes short of the Ministry of Steel estimates.

Thus, in order to make a realistic estimate on domestic steel production in 2015-16, we undertook a new approach. We began by establishing for ourselves the potential range within which supply would lie. Here, the total steel supplied in a 'business as usual' scenario, in which one assumes that the past growth patterns and trends continue, was deemed to be the lower limit of the range, while the ambitious targets set by the Ministry of Steel was used as the upper limit.

In order to estimate the production of steel in a 'business as usual' scenario, the study used a VAR model in which future growth was estimated based on the historical correlation between steel supply and certain endogenous and exogenous variables through the construction of a system of dynamic linear equations. The VAR model was chosen on account of the flexibility that it offered and its proven capability to describe the dynamic behaviour of multiple economic time series and forecasting. However, no theoretical or structural restrictions were imposed in the current model. In this model GDP was considered to be an endogenous variable, while the iron and steel price index (ISPI) and coke price index (CoPR) weree introduced as exogenous variables. The lag order was taken to be five.

$$TSP = \alpha TSPt - 1 + \alpha 1GDPt - 1 + \alpha 2TSPt - 2 + \alpha 3GDPt - 2 + \alpha 4TSPt - 3 + \alpha 5GDPt - 3 + \alpha 6TSPt - 4 + \alpha 7GDPt - 4 + \alpha 8TSPt - 5 + \alpha 9GDPt - 5 + Const + Trend + ISPI + CoPr +$$

Figure 2: Diagram of Fit and Residuals for TSP

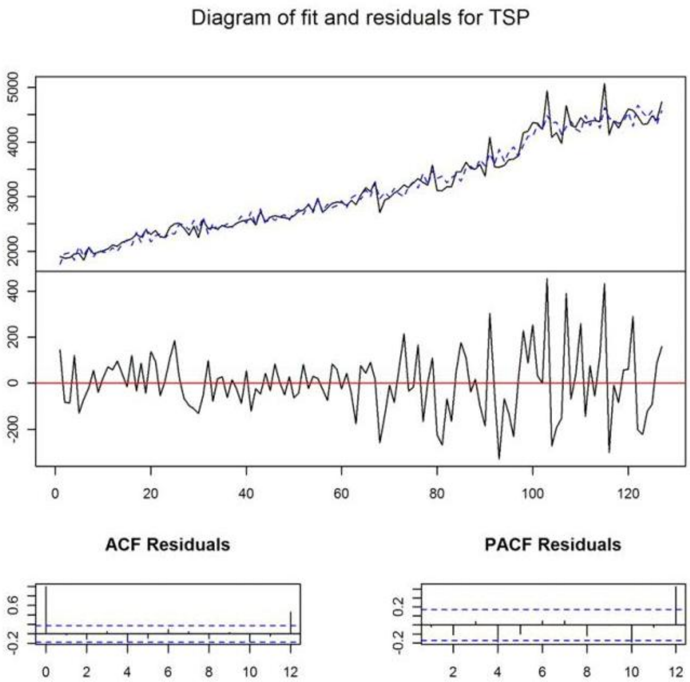
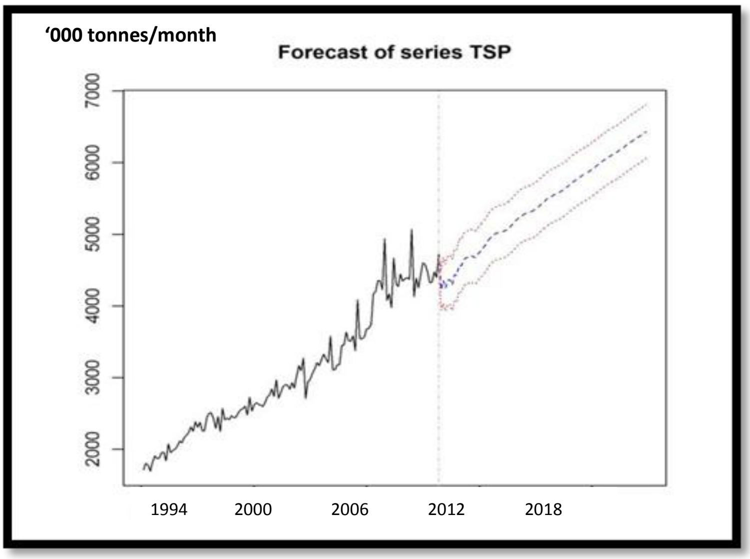


Figure 3: Total Finished Steel Production - Forecast



The VAR model gave us an estimate which formed the lower limit. The estimates as established by the Ministry of Steel were given to be 150 million tonnes, which were used as the upper limit.

Now, in order to identify a point estimate, a critical analysis of firm-level capacity expansions was performed on all major steel producers and secondary players. The steel producers considered for the analysis were SAIL, RINL, TATA Steel, Esssar, JSW, JSPL, Ispat (now known as JSW Ispat Steel Ltd), Bhushan Power and Steel, Bhushan Steel and other secondary producers. Data on capacity expansion plans were gathered from the websites, annual reports of the various companies and through direct interviews with members in these industries.

Only Brownfield and Greenfield projects that will be commissioned by 2015-16 were included in the estimate. An assessment of all independent Brownfield and Greenfield expansions that might be carried out by producers gave us a very large estimate. However, discussions with various experts and an assessment of the clearance risk associated with Greenfield projects made it clear that not all of this would materialise. Thus, an optimistic assessment of firm-level expansions was made by speaking to independent producers on a realistic estimate of production before 2015-16. This estimate was based on various parameters such as average time taken for a Greenfield /Brownfield expansion to actually begin operations, the risk of obtaining clearances and other contingencies that a Greenfield expansion may encounter.

This brought down the figure to just around 118 million tonnes of crude steel on 2015-16. However, this figure is the expected capacity that may be created assuming a 100 per cent capacity utilisation. However, most steel producers in India continue to operate at around 90 per cent capacity utilisation. Further, not all crude steel is converted into finished steel as a percentage of crude steel produced by integrated steel plants like Tata steel and SAIL is directly sold as billets and blooms.

Also, secondary steel plants are seen to have functioned at lower capacity utilisation of merely 85 per cent because of the poor quality of the raw material. Thus, after carrying out all the above deductions, total finished steel production was estimated to be 100.7 million tonnes.

III. DEMAND

By virtue of steel being an important intermediate good, the demand for it is always derived from the demand for and production of products or services using steel. The sectors whose demand for steel is estimated include construction, machinery/equipment, automobiles, railways, power, consumer durables, fasteners and shipbuilding. The other sectors such as home appliances, defence, auto components were not taken into account because of non-availability of data and a model to accommodate the steel consumed by these sectors. Also, the steel used for replacement and maintenance has not been entirely accounted for.

<u>Construction</u>

Construction is a very broad term that encompasses within its realm a large number of very different sectors. In India, construction is the second largest economic activity after agriculture. It accounts for nearly 65 per cent of the total investment in infrastructure and is expected to be the biggest beneficiary of the surge in infrastructure investment over the next five years. By virtue of its size and nature construction continues to remain the largest consumer of steel in the country.

However, construction as a sector is not very well regulated and falls almost entirely into the unorganised sector. Further, the heterogeneity in steel consumption within various categories including residential, commercial and industrial made the task of estimating future steel consumption very difficult.

The only source of information on the construction industry was derived from estimates provided by the Construction Industry Development Council (CIDC) established by the Planning Commission of India.

Method

In this report, the scope of what constitutes construction has been narrowed down to construction activities within general infrastructure and construction activities in real estate. Within infrastructure, the sectors considered are roads and bridges, airports, sea ports, water and sanitation, and telecommunication. Demand for steel through construction activities taking place in the railway and power sectors (which are technically an integral part of the country's infrastructure) have been separately accounted for as part of the steel consumption of these sectors respectively. Real estate, a big consumer of steel, is analysed independently of infrastructure. Investments in real estate are primarily categorised into residential, commercial and industrial.

In order to estimate the consumption of steel in the real estate sector, a 'steel intensity ratio' was built. It is the ratio of the price of steel consumed per sq foot to the price of construction per sq foot in a standard residential, commercial or industrial building. The definition of what constitutes a standard residential, commercial or industrial building and the cost of construction per square foot in each of these categories was borrowed from data provided by the Construction Industry Development Council (CIDC).

Table 1: **Unit Construction Cost (INR/sq ft)**

	Residential (terrace) **		Residential (high rise)		Commercial office		Industrial	
	Standard	**Luxurious**	**Standard**	**Luxurious**	**Standard**	**Prestige**	**Light**	**Heavy**
1997	825	1,100	650	1,100	625	950	600	800
1998	870	1,200	650	1,100	625	950	600	850
1999	890	1,300	650	1,100	625	950	600	850
2000	865	1,350	640	1,150	610	1,050	600	870
2001	875	1,370	685	1,225	640	1,225	615	890
2002	918	1,430	719	1,286	672	1,286	646	934
2003	964	1,502	755	1,350	705	1,350	678	981
2004	1,012	1,577	793	1,417	740	1,417	712	1,030
2005	1,050	1,600	805	1,500	760	1,500	750	1,080
2006	1,123	1,712	861	1,065	813	1,606	802	1,155
2007	1,202	1,830	920	1,717	870	1,717	858	1,236
2008	1,286	1,960	986	1,837	931	1,837	918	1,323
2009	1,376	2,097	1,055	1,966	996	1,966	983	1,415
2010(Oct)	1,470	2,244	1,130	2,103	1,065	2,103	1,051	1,514

Source: **Construction Industry Development Council (CIDC), Planning Commission**

The amount of steel consumed per square foot of construction was derived through direct interviews with a number of civil engineers and construction contractors. The cost of steel was estimated by taking the average of price of channels, sections, joists, TMT bars, etc., and was estimated to be an average of R32 a kilogram. The steel intensity ratio gives us that percentage of the investment on real estate construction that is spent on the consumption of steel. Annual investments, both public and private in the residential sector, were also obtained from CIDC and projections were made on expected investments by fitting a trend on the past values of investment in these sectors.[7]

Similarly, under infrastructure, expected steel consumption in bridges and roads, telecommunication, irrigation, water and sanitation, seaports and airports and storage sectors were analysed using a common strategy. As mentioned earlier, railways and power, two of the largest consumers of steel within the infrastructure sector were analysed separately and in greater detail. In order to estimate steel consumption in infrastructure construction (excluding railways and power), we used the steel utilisation norms provided by the Planning Commission and a research report by ICICI titled 'Steel Sector' published in May, 2009. The steel utilisation norms used were:

[7] The ARIMA Technique was not used to forecast future investments on account of inadequate number of data points.

Figure 4: Investment in Construction

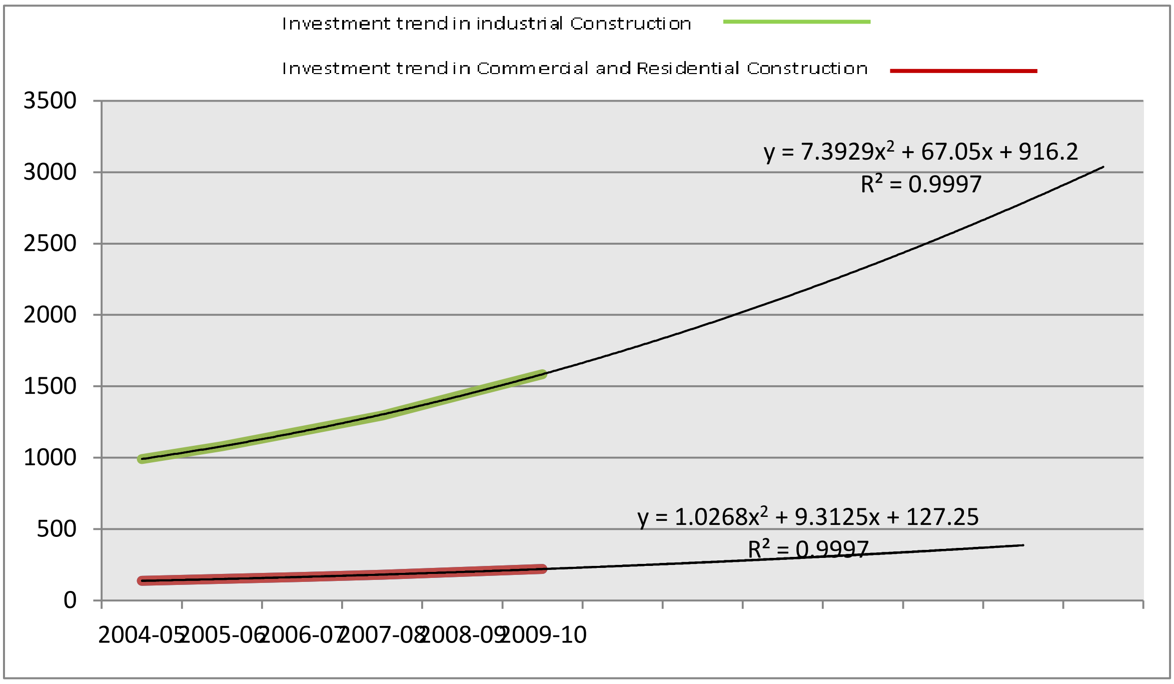


Table 2: Steel Utilisation Norms

Sector	Roads and Bridges	Telecom	Irrigation	Water and Sanitation	Airports	Storage	Oil & Gas Pipelines	Ports
Civil Construction (% of Investment)	100	15	50	60	40	75	35	70
Steel Component (% of Construction)	14	20	15	18	25	24	43	25

Source: ICICI Direct Research Report on Steel and Planning Commission

These steel utilisation norms were used to estimate the growth of steel consumption in infrastructure construction. An aggregate of steel consumption in real estate and infrastructure was used to give us the total steel consumed in construction. Steel consumption in the construction industry is expected to grow at an average rate of 10 per cent till 2015-16.

Railways

Indian Railways has a symbiotic relationship with the country's industry and economy. The railway's share in the country's GDP has been more or less constant at a level of 1.18 from 2003-04 till 2007-08.

Conventionally, steel consumption of the railways is captured through proxies such as the growth in railways as a percentage of GDP and public expenditure. However, in the current study an attempt has been made to break down the railway sector into various steel-consuming sub-segments to arrive at a more accurate estimation of steel use.

Method

To calculate the steel requirement for the railways, major areas where steel is predominantly used was taken into account. These primarily includes rolling stock (which comprises the locomotives, wagons and coaches), rail track material, concrete sleepers, clips to hold rails to sleepers, posts to carry overhead traction lines and construction in the railways.

With respect to the rolling stock, the number of units produced by the year 2020 was derived from the *Vision 2020* report published by the Ministry of Railways. The weight of steel in each unit was derived through direct interviews with design engineers and coach/locomotive manufacturers. The average weight of a locomotive was established to be 120 tonnes, wagons around 20 tonnes while coaches around 50 tonnes. The steel weight to total weight ratio was taken as 1.00, 0.8 and 0.75 for wagons, locomotives and coaches, respectively. The product of these weights with the expected number of units was estimated to be the total steel consumed by rolling stock.

In the case of track material, all the possible areas of use including new lines, gauge conversion, doubling and track renewal by the railways was estimated and the total consumption of steel was established. The amount of steel used in railway sleepers was calculated by multiplying the steel used in one concrete sleeper with the number of sleepers estimated to be used in the laying of new tracks. Similarly, the steel used in clips was calculated by taking the product of the number of clips used in a sleeper with the length of the new tracks.

In the case of traction posts, the weight of each traction post was estimated to be one tonne and the total amount of steel consumed was calculated by taking the product of route length electrified with the number of such posts in a kilometre of electrified track.

The amount of steel used for other construction purposes in the railways such as bridges, over/under bridges, stations, etc., was calculated using the amount spent on steel per rupee of investment in each of these sectors using the steel utilisation norms laid down by the planning commission. The aggregate of all these individual steel consuming sub-segments was taken to estimate the total consumption of steel by the railway industry.

Power

Power like the railways is an important consumer of steel. The growth in the power sector and the steel consumption norms are well documented by the Central Electricity Authority.

Method

Estimation of steel demand in the power sector was divided into generation and transmission sectors. Generation is further divided into hydro, thermal and nuclear power plants.

Generation

The amount of steel required, i.e., tonnes/MW in the case of a hydro, thermal or a nuclear plant has been formulated by NHPC (National Hydro Power Corporation) and BHEL (Bharat Heavy Electricals Limited). This formula is based upon the amount of steel that is required for electrical and mechanical packages (generators and turbines) and civil work. The table below gives the set norms in the case of hydro, thermal, gas and nuclear power projects.

Table 3: Steel Utilisation Norms – Hydro Power Plant

Steel Type	Steel Required (Tonnes/MW)
Structural Steel	34
Reinforcement Steel	93
Total	**127**

Source: Central Electricity Authority (CEA)

Table 4: Steel Utilisation Norms for Thermal, Gas and Nuclear Power Plants

Type	Imported Steel (Tonnes/ MW)	Indigenous Steel (Tonnes /MW)	Total
Thermal	18.89	111.707	**130.597**
Gas Powered	6.36847	44.53545	**50.90392**
Nuclear	19.14	111.67	**130.83**

Source: Central Electricity Authority (CEA)

In India, on an average it takes five years to build a hydro power plant. Therefore, the consumption of steel will start five years before the date of commissioning of a hydro plant. Similarly, on an average it takes a minimum of three years to construct a thermal/nuclear project or a gas-based power plant. Thus, steel consumption by hydro power plants is assumed to be distributed over the previous five years in the ratio 10:10:20:30:30 while steel consumption by thermal, nuclear and gas plants is distributed in the ratio 20:30:50. The capacity additions in the power sector for the past 10 years are given in the table below.

Table 5: Capacity Additions in the Power Sector

Year	Installed Capacity (MW)	Capacity Addition (MW)
2000-01	97,885	3.741
2001-02	101,626	3.420
2002-03	105,046	2.831
2003-04	107,877	4.807
2004-05	112,684	5.742
2005-06	118,426	5.861
2006-07	124,287	8.042
2007-08	132,329	10.732
2008-09	143,061	13,694
2009-10	156,755	10,523

Source: CEA

Assuming 80 per cent of the targets set by the 12th Five Year Plan is achieved, the hydro sector is expected to add 24,000 MW in 2017, the thermal sector is expected to add 44,500 MW and the nuclear sector is expected to add 1,200 MW. The potential capacity that might be added by 2020 was estimated from the data given in the above table using the auto regressive moving average (ARIMA) technique. The results are given in the table below.

Table 6: Capacity Additions till 2020

Year	Hydro	Thermal	Nuclear	Capacity Addition
2011-12*	2,282	9,654	1,050	12,986
2012-13*	2,701	4,006	1,080	7,787
2013-14*	3,360	4,984	1,344	9,688
2014-15*	4,073	6,041	1,629	11,743
2015-16*	4,939	7,327	1,976	14,242
2016-17*	5,927	8,792	2,371	17,090
2017-18 *	7,063	10,477	2,825	20,365
2018-19 *	8,459	12,548	3,384	24,391
2019-20 *	10,171	15,086	4,068	29,325

**Estimates based on ARIMA*

These capacity additions together with the steel utilisation norms were used to estimate the amount of steel that may be consumed till 2015-16.

Transmission

A detailed assessment has been made to calculate steel requirement for towers, power transformers, sub-stations, conductors and earth wires. Different norms have been set according to the design of different transmission voltage levels. The amount of steel consumed in metric tonnes per circuit km for each of the above voltage lines is given below along with the steel requirement during the 12th Five Year Plan.

Table 7: Steel Utilisation Norms for Transmission Lines

Line Voltage (kV)	Norms for weight of steel for transmission lines MT/Km	(12th Plan)		2012-13		2013-14		2014-15		2015-16	
		ckt Km	Total Weight of steel for transmission lines (MT)	ckt. Km	Total Weight of steel for transmission lines (MT)	ckt. Km	Total Weight of steel for transmission lines (MT)	ckt. Km	Total Weight of steel for transmission lines (MT)	ckt. Km	Total Weight of steel for transmission lines (MT)
500 HVDC	4.64	5,400	14,848	1,061	4,925	1,193	5,538	1,240	5,756	843	3,913
765	3.5	3,200	18,900	629	2,201	707	2,475	735	2,573	500	1,749
400	4.53	44,440	201,313	8,735	39,568	9,822	44,492	10,209	46,245	6,941	31,441
220	1.79	23,000	41,170	4,521	8,092	5,083	9,099	5,283	9,457	3,592	6,430
TOTAL			**276,231**		**54,786**		**61,604**		**64,031**		**43,534**

Source: CEA

Special Steel-CRGO[8] Requirement for Power Transformers

Based on statistics of the Central Electricity Authority, an assessment has been made using the norms to calculate the steel requirement of power transformers in terms of metric tonnes per million volt amperes.

Table 8: Steel Utilisation Norms for Power Transformers

Line Voltage (kV)	CRGO Requirement (MT/MVA)	(11th Plan)		2012-13		2013-14		2014-15		2015-16	
		Total MVA Capacity	CRGO Weight (MT)	Total MVA Capacity	CRGO Weight (MT)	Total MVA Capacity	CRGO Weight (MT)	Total MVA Capacity	CRGO Weight (MT)	Total MVA Capacity	CRGO Weight (MT)
500 kV	0.8	12,500	10,000	3,031	2,425	2,316	1,853	2,091	1,673	1,830	1,464
765 kV	0.4	44,310	17,724	10,744	4,298	8,211	3,284	7,412	2,965	6,486	2,594
400 kV	0.4	73,700	29,480	17,871	7,148	13,657	5,463	12,328	4,931	10,788	4,315
220kV	0.5	52,000	26,000	12,609	6,305	9,636	4,818	8,698	4,349	7,611	3,806
Total			**83,204**		**20,175**	**33,820**	**15,418**	**30,530**	**13,918**	**26,714**	**12,179**

Source: CEA

[8] Cold-rolled grain oriented silicon steel

Total steel used in transmission and distribution systems was aggregated to understand steel consumption by the power sector.

Machinery

Production of heavy engineering equipment and machinery is closely interrelated with the growth and development of other capital goods-intensive industries. The machinery/general engineering sector emerges as the second largest consumer of steel after construction and is an excellent proxy for a nation's industrial growth. In India, demand is greatest for building machinery and plastic-moulding machines as well as machine tools and textile machinery. Makers of building machinery are benefiting from the large-scale infrastructure projects planned by the Indian government, while machine-tool makers are being buoyed by the upturn in the automobile and auto- parts industries.

To estimate steel consumption norms for a sector as heterogeneous and complex as the machinery and heavy engineering equipment sector is a very difficult task. The machinery sector constitutes a large number of sub-sectors varying from industrial, textile, printing and office machinery to heavy construction and agricultural equipment such as agricultural implements, tractors, dumpers, cranes, etc.

Method

Thus, in order to estimate steel consumption patterns by the machinery sector we had to entirely depend on growth proxies. In the current study the machinery sector was broadly classified into electrical, non-electrical and electronic.

In order to estimate total steel consumption within the machinery sector, a sample of equipment was chosen in both the electrical and the non-electrical category. The electronic equipment category was ignored on account of the negligible amount of steel consumed by this sector.

The sample equipments chosen in the non-electrical category included:

- Dumper
- Ball and roller bearings
- Gear boxes
- Lifts
- Material handling equipment
- Cutting tools
- Machine tools
- Valves
- Diesel engines

The sample equipment included in the electrical category included:

- Electric generators (including alternators)
- Power and distribution transformers
- Electric motors
- Turbines

Independent ARIMAs were carried out on each of these sample equipment items to forecast their production value/number in 2015-16. After having forecast output for each sample component, the average growth rate in the production of these components was calculated for the year 2015-16.

Table 9: Average Growth Rates of Machinery Components

Year	Growth Rate* (%)
2010-11	4.57
2011-12	6.63
2012-13	4.97
2013-14	4.39
2014-15	4.06
2015-16	3.81

**Growth rates calculated on the basis of ARIMA estimates*

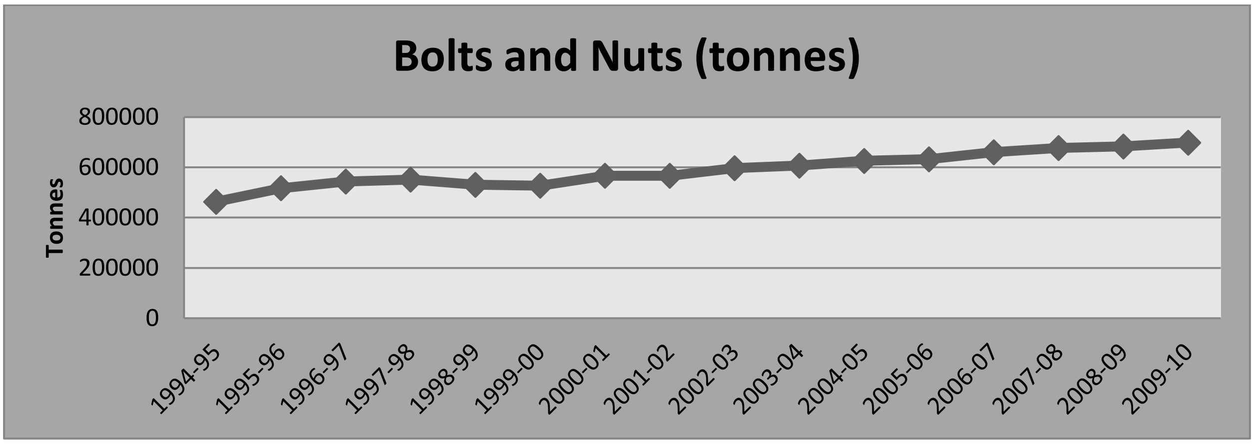
Finally, a weighted average of the various growth rates was taken to assess the overall growth in the machinery sector. The weights were assigned on the basis of intensity of steel consumption. Here, a 1:1 relationship has been assumed between growth in the number of units produced and steel consumption. Steel consumption is 14.1 million tonnes in 2009-10 and was expected to grow at the same rate as the various component machinery sub-sectors in 2015-16.

Fasteners

Method

Steel consumed in the fastener and hardware industry was calculated by using the production of bolts and nuts as a proxy. The ARIMA technique was applied on the production of bolts and nuts for the last 14 years and production forecasts and growth rates were obtained for the next five years. The industry was established to be growing at an average rate of 2 per cent per annum. Current consumption of steel by the fastener and hardware industry is 575,000 tonnes. An average yearly appreciation of 2 per cent was considered to derive estimates for 2015-16.

Figure 5:



Source: Annual Survey of Industries, Ministry of Statistics and Programme Implementation.

Consumer Durables

Method

A similar strategy was adopted to estimate steel consumption in the consumer durable industry. A sample consisting of time series data on the production of washing machines, refrigerators and air conditioners was taken up. Three independent ARIMAs were performed on the three sample components to get their future growth rates. The weighted average growth rate of the three products was used as proxy for the growth of the consumer durable industry. This was estimated at 11 per cent. In 2009-10, the industry was estimated to have consumed 0.78 million tonnes of steel[9]. Thus, if the industry grows at an average rate of 11 per cent, steel consumption is expected to go up to 1.40 million tonnes of steel by 2015-16.

Automobiles

The automobile sector is a boom sector that is expected to evolve as a major consumer of steel in the future.

Method

In order to predict the total de**m**and for steel in this industry, the sector was divided into six components as specified in the National Industrial Classification Code by the Reserve Bank of India. The six components consists of: 1) commercial vehicles, 2) passenger cars, 3) jeep vehicles, 4) auto rickshaws, 5) motorcycles, and 6) scooters. The production of automobile units in each of these categories was forecast using a VAR technique.

[9] Steel Scenario Yearbook - 2010

Table 10: Automobile VAR Estimates (units)

Year	Commercial Vehicles (CV)	Passenger Cars (PC)	Jeeps (JV)	Auto rickshaws (AR)	Motorcycles (MC)	Scooters (SC)
2010-11	711,526.7	2,465,030	482,197.7	735,141	9,975,379	2,687,804
2011-12	620,057	3,209,073	477,410	741,683	9,885,139	3,050,828
2012-13	664,148	4,230,439	504,204.4	772,955	10,101,656	3,541,613
2013-14	737,652	5,707,772	536,609	816,164	10,845,150	4,090,454
2014-15	779,217	7,863,533	569,261	863,196	11,687,243	4,698,302
2015-16	821,862	11,027,611	601,651	910,781	12,352,594	5,366,356

Figure 6: Production of Auto Rickshaws (units/month)

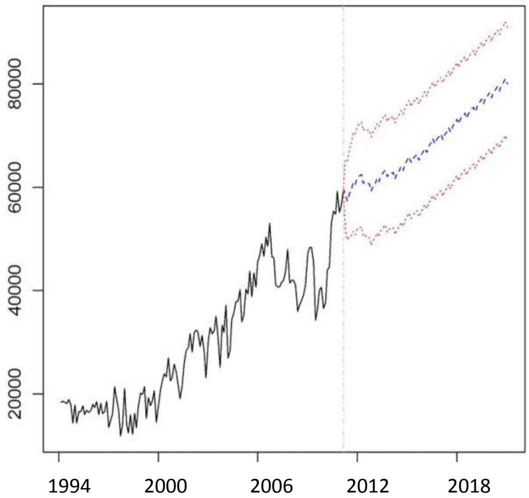


Figure 7: Production of Commercial Vehicles (units/month)

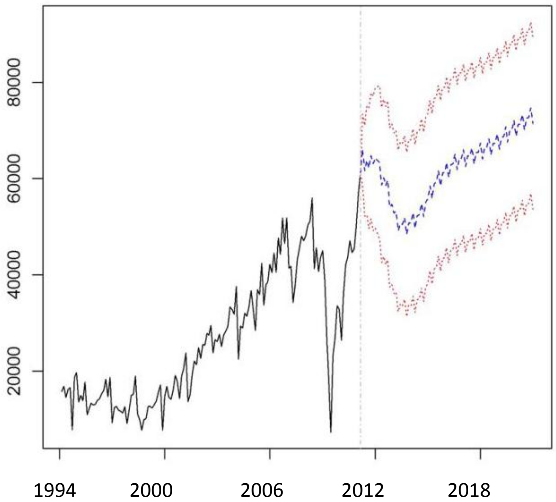


Figure 8: Production of Motorcycles (units/month)

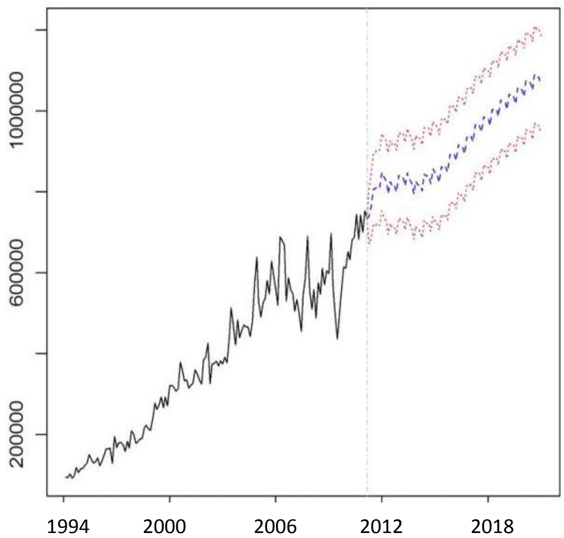


Figure 9: Production of Passenger Cars (units/month)

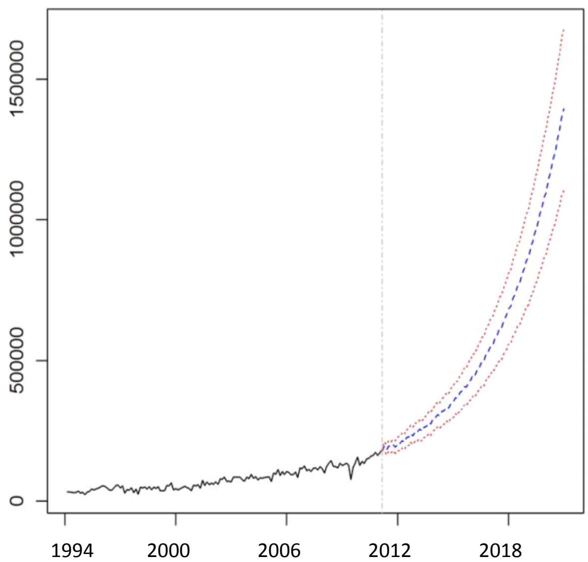


Figure 10: Production of Scooters ('000 units/month)

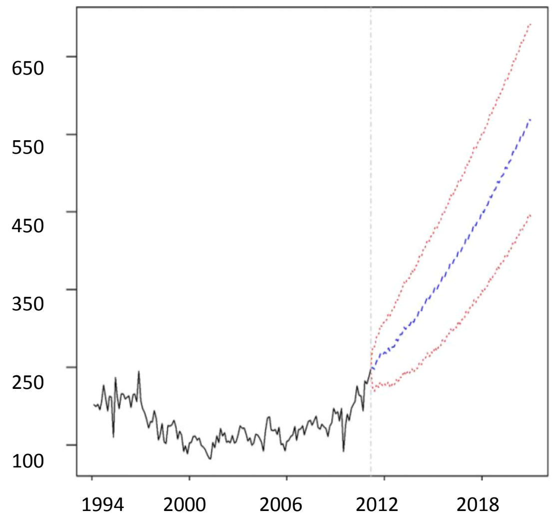
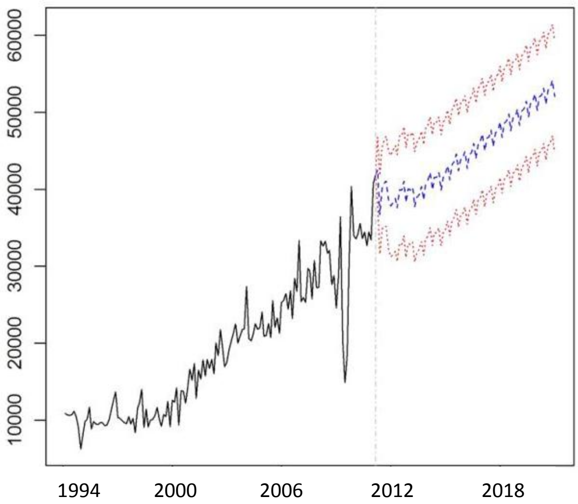


Figure11: Production of Jeeps (units/month)



The steel weight of each component was derived from various experts and the steel weight of the total number of units produced was estimated for each category. The average steel weight in each category of automobile gave us the average steel consumed to produce one unit. This was then multiplied by the number of units to be produced to arrive at the total steel consumption of various segments in the industry.

Shipbuilding and Containers

With the opening up of trade in India, the shipping sector is assuming renewed significance in the transport industry of the Indian economy. India has one of the largest merchant shipping fleets among developing countries and approximately 95 per cent of the country's export-import merchandise trade by volume (70 per cent in terms of value) is transported by sea. Given the aforementioned context, the role of the shipbuilding sector in the future of the Indian economy seems very bright.

Method

In order to calculate the total consumption of steel by the shipbuilding sector, the major types and number of ships currently being built in India (based on tonnage and DwT) was compiled from the order books of all the major shipbuilding yards. These ships were then categorised into four weight groups namely small (<1,000 tonnes), medium (1,000-40,000 tonnes), large (40,000-100,000 tonnes) and ultra large (>100,000 tonnes). A review of naval literature and expert opinions from naval architects were used to identify the self-weight of ships (weight of an empty ship) and the time taken to complete building ships in each of these categories.

Table 11: **Details of Shipping Industry**

Type of ship	Deadweight Tonne (DwT)	Self Weight as a percentage of DwT	Project Completion Time (Minimum)
Small	<1,000 T	35%	6 months
Medium	1,000-40,000 T	25%	6 months -1 year
Large	40,000-100,000 T	15%	2 years
Ultra Large	>100,000 T	12-15%	>3 years

Source: **Athena Infonomics**

Problems of heterogeneity in the customer base of the shipbuilding yards, differing delivery timelines and a poor track record of delivery on time makes the estimation of annual consumption of steel very vague and ambiguous. Thus, the shipbuilding sector suffers from an obvious time error. It is thus at this stage quite difficult to establish time series data on steel consumption in shipbuilding. However, assuming that the current pattern in the order book will be sustained, an average of 0.46 million tonnes will be consumed by the shipping sector in 2015-16. Further, in order to account for the steel consumed in ship repair and maintenance, a margin of 10 per cent of total steel used in shipbuilding was added.

In addition to shipbuilding, container manufacturing is another large steel consuming sector. The total number of containers being manufactured in the country was compiled from the Annual Survey of Industries data. The ARIMA technique was applied to forecast output. The total output in tonnes was considered a proxy for steel consumption. Total consumption of steel by the container industry is estimated to be around 1.16 million tonnes.

IV. EVALUATION OF THE MODEL

In order to test the validity of our model and the degree of inclusiveness of our forecast, we applied our demand estimation methodology to the year 2009-10. The actual demand for the year is stated to be 60 million tonnes. The demand for steel as estimated by our methodology for 2009-10 was estimated at 56.42 million tonnes. The sectoral divisions are given in the table below.

Table 12: **Sectoral Steel Consumption (2009-10)**

Sector	Demand (MT)
Real estate	**25.4**
Infra	**6.8**
Machinery	**13.4**
Fasteners	**0.69**
Consumer durables	**0.7**
Auto	**4.83**
Power	**1.4**
Railways	**2.1**
Containers	**1.1**
TOTAL	**56.42**

This gives us a forecast error of 6 per cent. The sectors that have been considered under the current model are only 94 per cent inclusive. Thus, an additional 6 per cent margin has been added to the 2015-16 estimates in order to make our demand estimation model more inclusive.

V. OBSERVATIONS

While this approach continues to be fraught with forecast errors and general approximations, the merits of such a 'bottom-up' approach far outweighs its disadvantages. The use of macro-economic parameters to estimate the consumption of steel has a tendency to exaggerate the demand for steel. Similarly, the use of apparent steel consumption (production+imports-exports) as a proxy for steel demand is inadequate as the formula used to calculate apparent steel consumption excludes change in stock (ΔS).

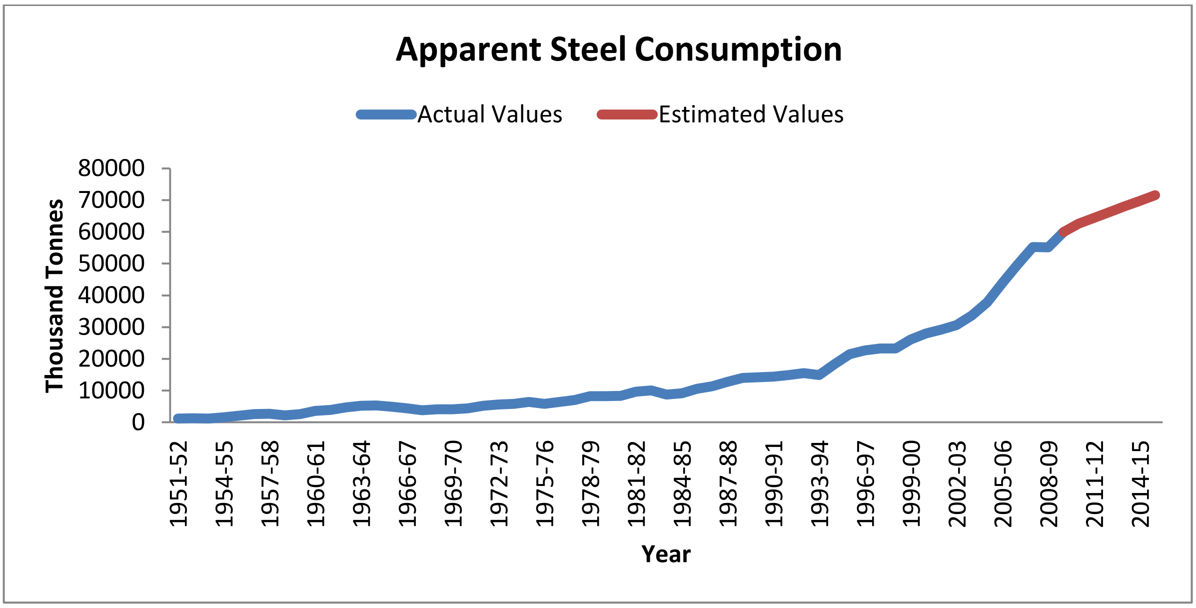
In order to test the validity of using apparent steel consumption as a proxy for demand we forecast future apparent steel consumption and compared the estimates thus derived with the estimates that were obtained from the end-use estimation method used in this study.

On running an ARIMA on apparent steel consumption we obtained the following estimates.

Table 13: **ARIMA Estimates**

Year	**Estimated Values**	**SE**	**+SE**	**-SE**	+2SE	-2SE
2010-11	62,550.343	886.628	63,436.97	61,663.72	64,323.6	60,777.09
2011-12	64,405.817	997.4792	65,403.3	63,408.34	66,400.78	62,410.86
2012-13	66,229.022	1,009.182	67,238.2	65,219.84	68,247.39	64,210.66
2013-14	68,021.071	1,019.971	69,041.04	67,001.1	70,061.01	65,981.13
2014-15	69,783.04	1,029.926	70,812.97	68,753.11	71,842.89	67,723.19
2015-16	71,515.967	1,039.12	72,555.09	70,476.85	73,594.21	69,437.73

Figure 12: **Apparent Steel Consumption**



Source: **Steel Scenario Yearbook, 2010 and Athena Infonomics.**

The apparent consumption of steel hovers around 71 million tonnes while the steel demand as estimated by the 'bottom-up' approach is close to 111 million tonnes of steel. This is a fairly large margin of error as it does not take into account the growth of various sectors and the consequent rise in steel consumption.

Alternatively the Bayesian vector autoregression equation can be used, in which certain proxy variables are introduced as an endogenous variable along with apparent steel consumption to capture the growth of independent sectors on total steel consumption. Again, we discovered this model was less efficient than methods used above on account of the poor quality of the proxies used to represent the different sectors.

In a world with the infinity of time, nothing is ever complete.[10] Thus any attempt to forecast market demand for steel in India is a continuous and dynamic process that will have to evolve with the industry.

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10 Prof. Shackle, *Epistemics & Economics*, Cambridge University Press, (1972) pp. 25-27.