



A Scientific Approach to Measure Shipbuilding Productivity

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This paper analyses the existing productivity measurement system for shipbuilding and brings out the gaps in the present system. In shipbuilding, often partial productivity is measured, due to the difficulties associated with calculating total productivity. Measurement of total productivity requires computation of multifactor efficiency and this can be evaluated using Data Envelopment Analysis (DEA), which is a mathematical linear programming technique. The need to measure multifactor efficiency for shipbuilding has been investigated in this paper. It is proposed that efficiency estimation using DEA by considering Compensated Gross Tonnage (CGT) of ships along with the shipbuilding effort using Work Breakdown Structure (WBS) would be a scientific method for measuring shipbuilding productivity.

Introduction

Profit-earning is one of the prime motives for any business venture. One way of achieving this is by obtaining more output for a given input. This ratio of output to input is known as productivity, which is basically a measure of effectiveness of

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production.¹ Productivity measurement is similar to efficiency measurement, the only difference being that the input and output have different units, and thus making the evaluation difficult. Defining productivity is easy, but measuring the same accurately is very difficult, as it involves different disciplines such as economics, management and accounting. In the case of productivity measurement for shipbuilding, it is more complex because of additional requirement of a fundamental knowledge in shipbuilding.² Literature indicates that measuring productivity in totality³ for any business venture is difficult and therefore suggests measurement of partial productivity.⁴ This paper aims to unravel a few of these difficulties and provide practical suggestions in measuring total productivity for shipbuilding.

In shipbuilding, partial productivity measurement is prevalent as shipyards find this convenient. This is measured both as output vs. input (steel tonne fabricated / man-hour) and input vs. output (man-hour per tonne of steel weight fabricated). However, the factors used as input and output are not standardised. Different factors such as steel tonne, man-days/hours, shop area, gross tonnage (GT),⁵ deadweight (DWT),⁶ compensated gross tonnage (CGT),⁷ *et al.* are used as input and/or output factors for productivity measurement. The different units of measures used by shipyards make it difficult to compare their productivity values.

In addition, the majority of the shipyards do not want to share their productivity values, for various reasons. This makes the comparison of performance between shipyards even more difficult. Literature⁸ indicates that only Japanese shipyards have a system of sharing productivity data amongst themselves regularly through their Shipbuilders Association (known as the Shipbuilders Association of Japan [SAJ]).⁹ They share their data so that information can be compiled for the complete country and this facilitates the shipyards to compete with each other in a healthy manner.

Various shipbuilding countries use different factors for measuring productivity. Japan and South Korea define their shipbuilding output mostly in terms of CGT, whereas China and India use DWT. The *Indian Maritime Agenda: 2010–2020*, indicates Indian shipbuilding capacity in terms of DWT.¹⁰ Within India, different shipyards use different factors to measure productivity and capacity. Shipyards under the Ministry of Surface Transport (MoST) use DWT, whereas shipyards under the Ministry of Defence (MoD) use ‘equivalent frigate unit’ (EFU) and ‘standard ship unit’ (SSU).¹¹ EFU is used by M/s MDL (Mazagon Dock Ltd) and it indicates the effort to build one 5000 tonne frigate, which is approximately equivalent to 21 lakh man-days.

The SSU used by M/s GRSE (Garden Reach Shipbuilders & Engineers Ltd) is 4.3 lakhs labour man-hours, where as one SSU used by M/s GSL (Goa Shipyard Ltd) is the effort required to build one fast patrol vessel. With different units of measure, it becomes quite difficult to compare the capacity or productivity of each shipyard. Non-availability of a standardised single unit for productivity and capacity assessment is a problem today. In the absence of a standard measuring unit, a calculated judgement cannot be made in assessing shipbuilding capacity. Therefore, the aim of this paper is to analyse the various methods/units used to measure productivity and propose a method, to calculate the productivity by considering all factors that influence shipbuilding.

Productivity in Shipbuilding

In shipbuilding, the term 'productivity' is used differently by various stakeholders, since there is no universally accepted standard unit. Ship owners, government officials and policymakers use productivity to compare the performance of two shipyards or shipbuilding countries. Shipyards use productivity values to assess the efficiency at which they are working. They benchmark themselves and subsequently attempt to improve their performance with respect to this benchmarked level. There are some usages of productivity which are as follows:

- Benchmark performance: the numerical value of productivity is used as a benchmark by a shipyard. The shipyard aims to improve its performance with respect to this benchmark level. For example, the value of CGT/employee-year for a particular Japanese shipyard is 175 (present benchmark value) and they are attempting to increase this to 205.
- Value for comparison: productivity value can be used to compare shipyards or shipbuilding countries. For example 'per-worker production' values for China, Japan and South Korea are \$9000, \$550,000 and \$480,000 respectively.¹² This clearly brings out that the value of production per Japanese worker is the highest amongst the three shipbuilding countries.
- Measurement of production capacity: the number of ships or DWT produced per year can be used as an index to measure the shipbuilding capacity of a yard or a nation. For example Indian shipbuilding output was 1.3 million DWT/year in 2007.¹³

- Resource utilisation: partial productivity values are used to measure the effectiveness of the various resources used in shipbuilding. Examples of this are “tonnes of steel fabricated/number of employee” or “annual CGT/shop area”. This gives an index of how resources such as employees and shop area are utilised by a shipyard.
- Measure profitability: profitability is a function of the production cost of a ship and the price at which it is sold. If the price is considered as output and the cost as input, then the ratio of output to input can be considered as a productivity unit. This unit of measure is not commonly used, because shipyards do not share cost data.

It can also be noted that there are different approaches to measure productivity, depending upon the purpose for which productivity value is being used in shipbuilding. Some of the measured productivity values for four leading shipbuilding nations are tabulated in Table 1. This table lists nine different productivity units measured for four major shipbuilding countries. The range of productivity value has been listed for these countries. It can be observed that in shipbuilding, productivity units measure output vs. input or vice versa. Multiple productivity units do not help a customer to compare and identify the best performer.

Difficulties with Productivity Measurement

Table 1 indicates the various units that are available to estimate different aspects of productivity. In addition to these, literature also indicates several other units of measurement such as DWT/employee, value of production/employee, etc. Having a plethora of measuring unit creates a problem for comparing performance. Different stakeholders in shipbuilding take the benefit of different productivity value and use them suitably. Some of the problems in working with the present productivity measurement system will be discussed in this section.

Accuracy of Data

The various productivity units have been evolved to estimate the performance of a shipyard. The calculation of these productivity units requires correct data, however in practice the data used by many shipyards is not accurate. Data is collected and

Table 1. Productivity units and values for major shipbuilding countries.

Sr No:	Productivity units	Europe	Japan	Korea	China
1	CGT/Employee-tear incl. SC*	25–140	125–205	95–121	22–39
2	Man hours/CGT incl. SC*	12–15	9–15	16–21	52–103
3	Steel tonnes/Worker tear incl. SC*	8–36	100–270	33–56	15.6–30
4	Steel tonnes/Shop area m ²	0.48–0.52	1.7–2.8	1.9–3	1
5	CGT/Shipyard total area m ²	0.28–0.78	0.3–0.8	0.4–1.25	0.18–0.5
6	Production workers incl. SC*/Total employees	0.7–0.79	0.72–0.83	0.7–0.9	0.83–0.93
7	Total employees/Total area m ²	0.003–0.011	0.001–0.003	0.0043–0.01	0.01–0.016
8	Annual CGT/Shop area m ²	1.12–2.04	3–6	3–8.5	0.5–1.41
9	CGT/Building berth area m ²	7–14	3–10.5	10.5–17.5	6.24–10.9

SC* = Subcontracting

Source: T. Lamb. “Worldwide Shipbuilding Productivity Status and Trends” (paper presented at Pan-American Conference on Naval Engineering, Maritime Transport and Port Engineering, Maritime Transport and Port Engineering, Michigan, USA, October 22–26, 2007).

adjusted to suit specific requirements, as there is no standard procedure to collect and verify data. A shipyard does not focus on accurate data collection, because collection of precise data is costly and requires both time and effort. For example, to calculate man-hours consumed for a job, the shipyard needs to install a system to collect data at the workshop. The collected data should be validated. This would be possible if there is a separate set of people/department who were working on this. All this involves time and effort and therefore shipyards tend to approximate these data, which could lead to an incorrect assessment of productivity.

Measurement of Output

The output delivered by a shipyard is a ship. However, measuring productivity in terms of the number of ships delivered per year (as done in the automobile industry) is not done in shipbuilding as ships are not produced in standard sizes which can be compared. Traditionally, the output measure used in shipbuilding is tonne of steel

produced in a given time duration and the productivity unit used is “man-hour per tonne of steel fabricated”. The limitation with this approach is that it does not consider the size and type of cargo carrying capacity of the ship. To overcome this limitation DWT or GT was formulated as an output factor and productivity units such as man-hour per DWT and/or man-hour per GT was used.

Though DWT or GT are able to quantify the size of the ship, they are not able to quantify the effort required to build and outfit the ship during its construction. Generally, in commercial shipbuilding, the steel fabrication work accounts for 30% to 45% of time and effort, whereas around 35% to 50% of time and effort goes into outfitting the ship, depending on the type and complexity of the ship. Consequently, the unit of output measure is gradually changing from steel weight to DWT to CGT in majority of the leading shipbuilding nations.

The CGT system was developed in the 1960s by the Organisation for Economic Co-operation and Development (OECD) in cooperation with the Association of West European Shipbuilders (AWES) and the Shipbuilders Association of Japan (SAJ). This system was needed because GT alone was considered to be an inadequate indicator of work content or capacity in shipbuilding. The work content in shipbuilding was observed to vary with the size and type of ship. For example, one GT of a passenger ship, with its sophisticated accommodation and public spaces, contains a significantly greater level of work content when compared with one GT of a bulk carrier ship, which is quite similar to a large steel box with an engine. One CGT of either ship on the other hand would contain roughly equivalent work content. This system has been now highly developed and is fundamental to the analysis of shipbuilding activity. In November 2006, the OECD published a new set of rules for computing CGT, which were brought into effect from January 1, 2007. The formula is: $CGT = A * GT^B$, where A represents the influence of ship type, B represent the influence of ship size, and GT is the gross tonnage of the ship. The values of A and B have been given by OECD as per their study.

The list of these values is tabulated in Table 2. CGT has been calculated for all these ships for an assumed GT value of 1000 T. It can be noted that for the same GT value, the highest CGT value corresponds to a passenger vessel and therefore this type of vessel has been assigned a complexity rank of 1. The complexity ranking of all types of ships has been computed and listed in the last column of Table 2.

Table 2. Data for calculation of CGT and sample calculation.

Calculation of CGT = A * GT ^B						
Sr No:	Type	A	B	GT	CGT	Complexity rank
1	Oil tankers	48	0.57	1000	2462	10
2	Chemical tankers	84	0.55	1000	3752	2
3	Bulk carriers	29	0.61	1000	1961	13
4	Combined carriers	33	0.62	1000	2391	11
5	General cargo ships	27	0.64	1000	2246	12
6	Reefers	27	0.68	1000	2960	7
7	Full containerships	10	0.68	1000	1096	15
8	RoRo vessels	32	0.63	1000	2484	9
9	Car carriers	15	0.7	1000	1888	14
10	LPG carriers	62	0.57	1000	3180	6
11	LNG carriers	32	0.68	1000	3509	3
12	Ferries	20	0.71	1000	2698	8
13	Passenger ships	49	0.67	1000	5014	1
14	Fishing vessels	24	0.71	1000	3238	5
15	Non-cargo carrying vessels	46	0.62	1000	3332	4

Source: For CGT formula and value of A and B: OECD Directorate for Science, Technology and Industry, "Compensated Gross Ton system", Council Working Party on Shipbuilding, 2007.

Globally, the majority of the shipyards building commercial ships are gradually changing their unit of output measure to CGT and calculate the productivity in terms of "man-hour per CGT (mh/CGT)". However, the CGT measurement using the OECD index has two limitations. Firstly, the values of A and B have been computed only for 15 types of ships. There are ships such as ocean-going tugs, ropax, heavy lift ships, etc., which are not in this list, for which the calculation of CGT becomes difficult and certain approximations in the values of A and B are unavoidable. Secondly, for warships the values of A and B have not been promulgated by OECD. Literature suggests that research is underway for the calculation of CGT of warships.¹⁴ The standardisation of these CGT coefficients by all the warship building shipyards and their respective countries will be essential to facilitate productivity measurement as well as the comparison of efficiencies.

Indian shipbuilders are still using DWT as a measure of shipbuilding order and capacity. All Indian government records and data still reflect productivity/capacity measurement in terms of DWT, which needs to be changed to CGT in lines with global shipbuilders. In the warship-building industry, all the defence Public Sector Undertaking (PSU) shipyards and other private shipyards need to modify their measures in line with the global trend, so that a realistic capacity assessment and efficiency measurement can be undertaken.

Measurement of Input

The various input factors that a shipyard employs for constructing a ship are: employees (measured in term of labour man-hours/man-days man-month/man-year), ship launching area, shop floor area, total shipyard area, etc. Labour is considered as one of the important inputs that contributes shipbuilding and therefore “labour productivity” is the most common productivity unit, which is calculated in terms of “man-hours per CGT”. Generally all shipyards only account for man-hours consumed for shipbuilding activity and exclude the man-hours contributed by the supporting staff. This productivity measurement also does not differentiate the work output produced by a shipyard during normal working hours and during overtime working hours. Similarly, the work output produced by the subcontracted workers is not accounted for by the majority of shipyards while calculating labour productivity.

Productivity study in terms of only labour gives skewed information, as this does not consider the infrastructure available with the shipyard that assists the labour in production. A shipyard which employs state-of-the-art technology such as plate cutting, bending, welding machines and jigs, along with modern material handling tools/devices such as cranes, modular trailer, etc., will be able to produce more compared to a traditional old shipyard which uses more of manual labour to produce ships. Therefore, the efficiency with which labour works is a function of the tools and the system in which they are working. These factors do not get accounted for in the present system of productivity measurement.

The productivity measured in terms of average DWT/man for Korea, Japan, China and India is 320, 290, 56 and 50 respectively. This does not mean that the Chinese or Indian labour is inferior to the Korean or Japanese labour. This data should probably be interpreted as the working system and infrastructure in Korean and Japanese shipyards are superior to that at Chinese and Indian shipyards. If such

are the labour productivity figures, the question that arises is: how is the Chinese shipbuilding industry growing at a faster rate? (China has acquired number one position and has become the global leader, in terms of new order book value¹⁵ by displacing South Korea. China has around 61.6% of the global new order¹⁶ in terms of DWT.) The second question is: if the labour productivity of India and China is comparable, then does the Indian shipyard produce the same number of ships as China? The answer to these questions can be understood if productivity is assessed in terms of profitability known as economic efficiency (EE).

Measurement of Non-Measurable Intangible Input Factors

A shipyard's performance also depends on several input factors which cannot be numerically measured, such as the reliability of the vendor to deliver raw material and equipment on time, the working of sub-contractors, the decision-making process in the shipyard management, the efficiency of the supply chain management, the knowledge management system employed in the shipyard, the working culture of the shipyard, etc. All these factors play a major role in contributing to the efficiency with which a shipyard performs, but unfortunately these are not considered while estimating the productivity. If these factors are not included, the productivity measurement becomes absolutely incorrect.

New Approach to Productivity Measurement

The majority of the shipbuilding productivity units which are in vogue are known to measure only partial productivity. All the factors which influence shipbuilding are not being considered and total productivity is not being measured. Therefore, a new approach that can incorporate multiple factors for productivity measurement needs to be adopted in shipbuilding. Calculating efficiency considering multiple input and/or output factors is known as multifactor productivity and this measure is also referred to as total factor productivity.¹⁷ It has been acknowledged that the multifactor productivity measurement is a better indicator of efficiency compared to the partial productivity measurement. Multifactor efficiency can be calculated using Data Envelopment Analysis (DEA), which is a linear programming technique. This technique has been used to measure efficiency of several engineering and R&D

organisations¹⁸ and it is proposed to use this technique in the shipbuilding industry for the measurement of productivity.

DEA can be used when several factors (any number of input and output factors) are to be considered to measure relative efficiency.¹⁹ The limitation being, the number of shipyards [known as a decision-making unit (DMU) in DEA terminology] that are analysed should be three times more than the sum total of input and output factors being considered. Another limitation in using DEA is it provides the relative efficiency of one DMU with respect to the other DMUs being analysed. However, these limitations should not bound the usage of DEA for calculating the total productivity in shipbuilding, as the DEA efficiency value provides relative grading of shipyards and identifies the weakness factor which should be improved upon (this is known as slack analysis in DEA terminology) by the shipyard.

DEA can also use abstract parameters for calculating efficiency. This abstract parameter is known as “attitudes” in the field of management. These attitudes for shipbuilding could be level of technical knowledge possessed, the effectiveness of team work, the speed and accuracy of the decision-making process, the communication system existing in the organisation, certain hygiene factors such as the motivational level of the employees, etc. Gauging these abstract parameters into measurable numerical values is called as “scaling of attitudes”. The three most commonly used scales for gauging these abstract parameters are the nominal scale²⁰, the ordinal scale²¹ and interval scale.²² The interval scale is very popularly used by DEA to calculate efficiency, as it is more amenable for statistical operations.

One of the major hurdles in calculating EE is the reluctance of shipyards to share data on their costs. Hence this DEA formulation cannot be used to compare the productivity of different shipyards. However, this approach can be used by shipyards internally to measure the efficiency with which profit has been generated for each ship built and delivered by them. Shipyards can benchmark this efficiency value and attempt to improve upon them for their subsequent shipbuilding project. DEA also identifies the input or output factor that can be corrected (slack analysis), so that the total efficiency can be improved.

A prerequisite of using DEA for computation of efficiency is the identification of various input and output factors. These factors will depend on the subject that is to be analysed. Towards estimation of total shipbuilding productivity, it is essential to analyse all the activities that have an impact on shipbuilding. The construction

of a ship goes through various activities such as the procurement of material, fabricating the hull, launching, outfitting, trials and delivery. The effort required to accomplish each of these activities is different. The right way to study the consolidated effort to build a ship is to split the effort required for each activity through the work breakdown structure (WBS).

Difficulties in measuring the efforts required for outfitting, utilisation of infrastructure and supply-chain management for procurement of raw materials can be addressed in WBS. All these efforts can be incorporated as input factors and the multifactor efficiency can be estimated using DEA. Towards this it would be desirable to work out the various factors of WBS jointly by all shipyards, along with an international productivity measuring organisation such as the OECD. It is also imperative that the measurement procedure be standardised. Post finalisation of procedure and the factors that are to be considered for productivity measurement, all shipyards would need to collect data in a systematic manner to estimate multifactor productivity value. This will help in measuring productivity accurately. Thereafter, this productivity value can be used to benchmark the performance of shipyards and also analyse and compare them country-wise.

Conclusions

Productivity is a measure of output for a unit input from a production process. This is also a measure of effectiveness of production and is primarily used to calculate the efficiency of operation. If the productivity of all shipyards/shipbuilding in a country is to be compared, then a uniform measuring scale is essential. However, it is observed that there are several productivity measures being used in shipbuilding, thereby making comparison of shipyard performance difficult. Therefore, standardising the productivity unit is essential and this can be best done through a joint effort by all the shipyards from the major shipbuilding countries. In addition to standardising the productivity unit, collating the correct data used for productivity measurement is also important. Hence, a system to capture accurate data should be standardised amongst all the shipyards.

Compensated gross tonnage (CGT) as formulated by the OECD is one of the best approaches to measure the “output” in shipbuilding, as it incorporates the effort required to outfit the ship. However, the CGT coefficient is not available for all types

of commercial ships and warships, which makes relative comparison difficult. As it is important to have a uniform measuring scale, it is essential for some international organisation such as the OECD evolve the CGT coefficients for all types of ships.

Towards measuring the “inputs” that go into shipbuilding, it can be observed that there is not a single factor which can comprehensively encompass all the efforts that go into shipbuilding. The cost of production can be considered as a single factor which will include all efforts, but it may not be possible to get data related to the cost of shipbuilding, as shipyards might not like to share their costing data. Therefore, it is essential to estimate shipbuilding effort using the work breakdown structure (WBS) and define the input factors based on this.

Most of the existing shipbuilding productivity units measure only partial productivity, whereas it is essential to measure total productivity. Total productivity can be measured in shipbuilding only if multiple inputs and outputs are considered, whereby all the influencing factors (measurable and non-measurable) are evaluated together. Multiple input and output factors can be considered in calculating efficiency using Data Envelopment Analysis (DEA). DEA is a potential and flexible tool as it can also incorporate abstract factors such as decision-making capability, supply-chain management, etc., which are very important in shipbuilding. Several authors have used DEA in shipbuilding to measure relative efficiency of shipbuilding asset, infrastructure, performance target and management efficiency. This author has also used DEA to measure efficiency in the ship design industry and for measuring profitability of shipbuilding using a unit called the economic efficiency of shipbuilding.

It is recommended that the CGT along with shipyards’ efforts in building a ship using WBS be used to estimate realistic total productivity using the DEA technique. The same can be also used for the capacity assessment of shipyards.

Notes

1. S. Navaneetha Krishnan, I.S. Makkar, and H. Ravimohan, *Measuring Effectiveness of Technology and Infrastructure in Shipbuilding Projects using Data Envelopment Analysis Technique ICSOT: Technological Innovation in Shipbuilding*, 8–9 December 2011, Kharagpur, India (Royal Institute of Naval Architecture, London, UK, 2011), pp. 185–194.

2. T. Lamb. "Worldwide Shipbuilding Productivity Status and Trends" (paper presented at Pan-American Conference on Naval Engineering, Maritime Transport and Port Engineering, Maritime Transport and Port Engineering, Michigan, USA, October 22–26, 2007).
3. Seppo Saari, "Productivity Theory and Measurement in Business" (paper presented at the European Productivity Conference, Espoo, Finland, August 30–September 1, 2006).
4. Some of the partial productivity measures are single-factor productivity, value-added productivity, unit cost accounting, efficiency ratios and managerial control ratio systems.
5. GT is the fundamental measurement of the physical size of a ship. It refers to the volume enclosed by the ship's hull and superstructures in hundreds of cubic feet (figured at 1 tonne per 100 cubic feet). All registered ships will be assessed for their GT and this is the parameter normally referred to when the size of a merchant ship is quoted in tonnes. The gross tonnage (GT) is determined by the following formula: $GT = 0.2 + 0.02 \log_{10} V$, where V = total volume of all enclosed spaces in cubic meters.
6. Dead weight (DWT) is a measure of the total weight of cargo, stores, etc., that can be carried by a ship. Tankers and bulk cargo ships are generally measured in deadweight tonnage. The dead weight of the ship is indicated in metric tonnes.
7. CGT is a measure of the complexity of a ship which is to be built. It refers to the comparative work content inherent in building a ship.
8. Lamb, "Worldwide Shipbuilding Productivity Status and Trends."
9. The Shipbuilders Association of Japan, *Shipbuilding Statistics* (monthly report), September 2009.
10. Ministry of Shipping, *Maritime Agenda: 2010–2020* (Government of India, Ministry of Shipping, New Delhi, India, January 2011), p. 383.
11. Ravi Vohra, "Warship-Building: Demand and Capacity" in, *Shipbuilding in India: Challenges and Strategies*, ed. Ravi Vohra and T.S.V. Ramana (New Delhi: National Maritime Foundation, 2009), p. 11.
12. Gabriel Collins and Michael C. Grubb, "A Comprehensive Survey of China's Dynamic Shipbuilding Industry," *US Naval War College, China Maritime Studies*, no. 1 (2008): 1.
13. Ministry of Shipping, *Maritime Agenda: 2010–2020*, p. 384.
14. Richard Lee Storch, John Clark, and Thomas Lamb, "Technology Survey of US Shipyards – 1994" (Paper presented at 1995 Ship Production Symposium sponsored by Society of Naval Architect and Mechanical Engineers, Seattle, WA, USA, January 25–27, 1995), pp. 1–7.
15. 'New order' is an indicator for the expected long-term output. These figures reflect the actual situation in the market including speculative movements and could be used to analyse shifts in market shares.
16. Research In China, "China Shipbuilding Industry Report, 2009–2010," <http://www.researchinchina.com/Htmls/Report/2010/5848.html> (accessed July 1, 2011).

17. Saari, "Productivity Theory and Measurement in Business."
18. S. Navaneetha Krishnan, *Study of Indian Commercial Ship Design Industry and Suggest Improvements* (MBA diss., Indira Gandhi National Open University, 2009), pp. 12–18.
19. Harinder Singh, Jaideep Motwani, and Ashok Kumar, "A Review and Analysis of the State-of-the-Art Research on Productivity Measurement," *Industrial Management and Data Systems*, 100, no. 5 (2000): 234–241.
20. The nominal scale allows measuring of the attitude into a number of mutually exclusive categories. The typical application of nominal scale is in classifying the response as "yes" or "no", "like" or "dislike", etc.
21. The ordinal scale measures the attitude by way of ranking the alternatives. For example, ranking in terms of 1, 2, 3, . . . the performance of the outsourced vendor on the basis of job quality.
22. The interval scale of measuring an attitude is to assign a numerical value for a particular parameter on a numerical scale ranging between a minimum to maximum number such as 1 to 10. For example, the decision-taking skill of all the departments in a shipyard is assigned a value from 1 to 10.