



# The Seven Factors of Production

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## Author's contribution

This whole work was carried out by the author SOO.

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## ABSTRACT

The review of the Factors of Production is reported. The dynamics and response of globalization has rubbished the age long definition of factors of production. General management as entrenched in operations and production in the past centuries gave birth to non-responsive and dormant factors of production which dictated public service bureaucracy. Information and Time change were of no essence. Bureaucracy has been swept off the stage in the face of the emerging technology-driven global markets were competitiveness demands that the consumer/customer is king. In this era, Information and Time are considered of great essence to the success or failure of products/project delivery to the consumer. Consequent on the above, the review has revealed seven factors of Production which are relevant and sufficient to drive the global markets.

*Keywords: Productivity; production factors; machines; information; time.*

## 1. INTRODUCTION

The classical economists treated land as distinct from capital: "land, labour and capital" were the three basic "factors of production". They were

mutually exclusive. They were comprehensive, including all economic agents. Each was also "a constraint," meaning at least some quantity of each of the factors was needed for all economic activity. Neo-classical economists denied the

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distinction and undertook to purge land from economics. Many of them, following John B. Clark and Frank Knight, still deny the distinction. Many treat the matter by seizing on and stressing all similarities of land and capital, while ignoring all differences. Some invent gray areas that seem to fuse land and capital, present them as typical, and quickly move on. Many more simply ignore. The market exchange of capital for land causes an elementary failure in the minds of many. Land and capital each have their prices and may be bought and sold for money [1]. Each alike is part of an individual's assets, colloquially called his "capital". Each is a store of value to the individual. What is true of each individual must be true for all together, is the thinking: it is the "fallacy of composition." Production economics deals with the optimal combination of inputs in production, and how this relates to their relative costs. That should lead right into factor distribution, but this aspect is softpedaled or omitted entirely. This omission alone is a fatal fault, considering that the forces determining land rents vary inversely with those determining rates of return on capital. Within production economics, "variable proportions" with "factor symmetry" replaces diminishing returns [1]. The parcel of land disappears as a unit of analysis, replaced by "the firm," a disembodied spirit that combines resources optimally, treating all alike as variable "in the long run." In the "short run," land is subsumed in "fixed costs"; rising demand that raises rents is just "imputed away" silently and lumped with other elements of "fixed cost. Time is also referred to under "history of economic thought," as an obsession of some 19th century Austrians who wrote quaintly of "roundabout" (time-using) methods of production. Relations of sequence are found in macro, but not firmly integrated with micro theory, which is the enduring core of the discipline. Micro theory still deals with relations of coexistence in time, and space as well. The life of capital, like that of people, is marked by major sacraments of birth, growth, aging and death - all missing from micro theory. Micro deals mainly with how existing resources are allocated at a moment in time, not how they originate, grow, flourish, reproduce, age, die, and decompose [1]. Capital occupies space; land is space. In common micro theory, resources and markets come together at a point not just in time but in space. Again, it excludes from its purview one of the prime qualities of land. For the reasons given, alone, land and capital are mutually exclusive. Land as "site" (location plus extension) does not normally wear out, depreciate, spoil, obsolesce, nor get used up

by human activities incident to occupancy and production. In contrast, capital depreciates from time and use, routinely and by nature. After being formed, it must be conserved from entropy by continual maintenance, repair, remodelling, safeguarding against theft and fire et cetera. Like our own bodies, it returns to dust; land is the dust to which it returns. Inventories are depleted; moving parts wear out; fixed capital depreciates with use and time. Land normally does not depreciate as a function of time. Most attributes of land also withstand use and abuse. Most land is, rather, expected to appreciate in real value in the long run. Values go in cycles, but the secular history is upwards as population, capital, and demands all grow while land remains fixed. Capital has a period of formation during which it creates value by storing up other inputs and changing physical form, but that is a phase. Once formed, almost all capital fails with time. Perhaps the most durable capital is intellectual, like the writings of Plato [1]. "Land" in economics means all natural resources and agents, with their sites (locations and extensions in space). Land is not just the matter occupying space: it is space. It includes many things not colloquially called land, such as water and the beds under it, the radio spectrum, docks, rights of way, take-off/landing time slots for aircraft, aquifers, ambient air (the right to breathe it and the license to pollute), "air rights" to strata in the third dimension of cities, falling water, wild fish, game, and vegetation, natural scenery, weather, the environment, the ecology, the natural gene pool, etc [1]. The basis of agricultural production and the most important production factor for the farmers is land. By means of it, they can use their labour (and capital) in order to earn their livelihood. In traditional agriculture, more land also means more income and a better life, and increasing the size of the faun was a simpler way of improving the living conditions than farming the existing land more intensively. This was the source of the inclination to buy land that is still found in agrarian societies [2]. The possibilities of increasing the area of land are, however, limited. Land cannot be enlarged or increased beyond that which it is, and when all of the land has been put under cultivation, growing populations lead to continually smaller farms. This is why land has the reputation of being a scarce production factor [2]. If the system of land management is improved, the scarcity of land is reduced by more intensive cultivation. An improvement in the agrarian structure creates the precondition for appropriate management and land use systems, a purposeful integration of animal husbandry and

much more. The farmer's major instrument for achieving a good output is labour. Labour has a direct effect if by means of investing a greater amount of it the output is increased. Indirectly, labour can have an effect on the production via capital formation [2]. In densely populated agrarian societies, labour is an abundant production factor, especially in relation to land and capital. This results, in extreme cases, in land being substituted for by labour [2]. The productivity of the labour would be raised if the agrarian structure could develop a more balanced ratio between labour and land. The precondition for this could be to raise the abilities of those cultivating the soil to a higher level [2].

Vegetables are not only beneficial for their contribution to the share of agriculture in the economy of Swaziland, but also have a significant probability to compete where there are fewer government regulations and restrictions in the economy. Currently, the local demand for vegetables is higher than local production and hence the gap is filled by imports from South Africa. The results of an investigation showed that the factors that significantly affected productivity of vegetable farmers were access to credit, selling price, fertiliser quantity, distance to market and gender of the farmer [3].

The starting point of agricultural production is land resources. Large land resources are available in Australia, North America and New Zealand (respectively 671, 155 and 69 ha per person employed in agriculture). In Western Europe the corresponding figure is less than 12 hectares. Among developing countries, no region has the land resources such as North America and Australia. Only in Latin America that a relatively high rate of agricultural land of 13.8 ha per person exist. In developing countries as a whole, one villager has only 2.2 hectares; the world average stands at 3.7 hectares of agricultural land per person. No less important is the amount of cultivated land (arable land). In recent decades, it is consistent with population growth in the world and remained at a level of 0.24 hectares per capita. But in poor countries in Asia, Africa and Latin America the usage of agricultural land has been reduced. Under these conditions, an increase in production is ensured through the intensification of production: chemical application, agricultural irrigation and scientific breeding [4]. Reliability of food supplies globally has been threatened by four major hazards in this century:

- 1) Deterioration in climatic conditions,
- 2) Depletion of water and fossil energy resources
- 3) Soil degradation,
- 4) Economic liberalism [4].

All economists give the factors of production as three -- land, labour and capital. And without exception that I know of, they name them in this order. This, indeed, is the natural order; the order of their appearance. The world, so far as political economy takes cognizance of it, began with land. Reason tells us that land, with all its powers and potentialities, including even all vegetable and animal life, existed before man was, and must have existed before he could be. But whether still "formless and void," or already instinct with the lower forms of life, so long as there was in the world only the economic element land, production in the economic sense could not be, and there was no wealth. When man appeared, and the economic element labour was united to the economic element land, production began, and its product, wealth, resulted. At length (for in the myths and poems in which mankind have expressed all the wisest could tell of our far beginnings they have always loved to picture a golden age devoid of care), or more probably almost immediately (for the very first of our race must have possessed that reason which is the distinguishing quality of man), the greater power that could be gained by using wealth in aid of labour was seen, and a third factor of production, capital, appeared [5]. But between this third factor and the two factors which precede it, a difference in nature and importance is to be noted. Land and labour are original and necessary factors. They cannot be resolved into each other, and they are indispensable to production, being necessary to production in all its modes. But capital is not an original factor. It is a compound or derivative factor, resulting from the union of the two original factors, land and labour. Capital is not indispensable to production, being necessary, not in all modes of production, but only in some modes. Nevertheless, the part that it bears in production is so separable, and the convenience that is served by distinguishing it from the original factors is so great, that it has been properly recognized by the earliest and by all subsequent writers in political economy as a separate factor; and the three elements by whose union wealth is produced in the civilized state are given by the names and in the order of (1) land, (2) labour, and (3) capital [5]. A factor of production may be defined as that good or

service which is required for production. A factor of production is indispensable for production because without it no production is possible. It is customary to attribute the process of production to three factors, land, labour and capital, to which we add organisation [6]. In economics, land as a factor of production does not refer only to the surface of land but to all gifts of nature, such as rivers, oceans, climate, mountains, fisheries, mines, forests, etc. In the words of Dr Marshall, by land is meant.....materials and forces which nature gives freely for man's aid, in land, water, in air, light and heat. Land is, thus, an important factor of production which helps in the production of goods and services in one way or the other [6]. Labour refers to all mental and physical work undertaken for some monetary reward. It includes the services of a factory worker, a doctor, a teacher, a lawyer, an engineer, an officer, etc. But labour does not include any work done for leisure or which does not carry any monetary reward. A person painting for leisure, singing a song to entertain his friends, or attending to his garden would not be considered to have done any labour in the sense of economics. On the other hand, if a person sells his paintings, a singer sings a song for a fee and a gardener looks after a garden in payment for money, their services are regarded as labour. Thus labour is essential for production [6]. Capital means all man-made resources. It comprises all wealth other than land which is used for further production of wealth. It includes tools, implements, machinery, seeds, raw materials and means of transport such as roads, railways, canals, etc. In modern usage, capital not only refers to physical capital but also to human capital which is the process of increasing knowledge, the skills and capacities of all people of the country. It is this human capital which is regarded more important than physical capital in production these days. As pointed out by Professor Galbraith, We now get the larger part of our industrial growth not from more capital investment but from investment in men and improvements brought about by improved men [6].

Land, labour and capital are respectively natural, human and material means of production. No production is possible without bringing together these three factors of production and employing them in right proportions. So there must be somebody to hire them from their owners by paying rent, wages

and interest, and to decide the quantities of each needed for production. This is known as organisation. Organisation refers to the services of an entrepreneur who controls, organises and manages the policy of a firm, innovates and undertakes all risks [6].

Benham has objected to the wider meaning of land as a factor of production. According to him, it is more convenient to consider only the land which can be bought and sold as a factor of production, rather than such elements as sunshine, climate, etc. which do not enter directly into costs. Similarly, it is wrong to group together the services of an unskilled worker with that of an engineer, or of an engine driver with that of a waterman in the railway. Again, there is little point in grouping together as capital, as diverse as canals, diesel, seeds and machinery. It would, therefore, be more accurate to lump together all homogeneous units, whether hectares of land, workers, or capital goods, and to consider each group as a separate factor of production. This method gives us a large number of factors of production and each group is regarded as a separate factor [6].

Again, the distinction between land, labour and capital is not clear. To take land and capital, it is said that land is a gift of nature "whose supply cannot be increased while capital is man-made whose supply is changeable. This is not correct because the supply of land can also be increased by clearing it, draining and irrigating it and fertilising it by the efforts of man and capital. The "supply of land" does not refer to its area alone, but to its productivity [6].

Further, we find that land, labour and capital often get intermixed into one another and it is difficult to specify the contribution of each separately. For instance, when land is cleared, canals are dug and fences are erected, the productivity of land increases. But all these improvements on land are possible by making capital investments and through labour. In such a situation, it is not possible to specify the contribution of land, labour and capital in increasing productivity [6]. Similarly, the amount of money spent on educating and training workers is included under capital. So, when such workers produce goods by operating machines in a factory, they put in their labour as well as skills (acquired through capital investments on them) by using raw materials which are also the product of labour and machines used on land. Thus it is difficult to

disentangle the contribution of land, labour and capital in such cases [6]. It is customary not to treat organisation as distinct from labour. This is misleading and underestimates the role of the entrepreneur as a factor of production. As a matter of fact, labour and entrepreneur are quite distinct from each other. An entrepreneur is a man of special managerial ability who controls, organises and manages the entire business of a firm [6]. The concept of the factor of production is of great importance in modern economic analysis. It is used in the theory of production in which the various combinations of factors of production help in producing output when a firm operates under increasing or decreasing costs in the short run, and when the returns to scale increase or decrease in the long run. Further we can also know, how the least cost combination of factors be obtained by a firm.

The theory of cost of production also depends upon the combinations of factors employed in business and the prices that are paid to them. From the point of view of the theory of costs of production, factors of production are divided as fixed factors and variable factors. Fixed factors are those whose costs do not change with the change in output, such as machinery, tube-well, etc. Variable factors are those whose quantities and costs change with the change in output [6].

Factors of production are also divided into divisible and indivisible factors. Factors are divisible when their inputs can be adjusted to the output. Labour is said to be divisible when the number of labourers may be reduced in keeping with the output of the firm. Divisible factors lead to the economies of scale for a firm by adjusting the number of factors to the output of the firm. Indivisible factors are those which are available in minimum sizes, and are lumpy, such as machines, entrepreneur, et cetera. They also lead to economies of scale, but at a faster pace. A firm's expansion occasions proportionate increase in its return to scale. This increase is due to the fact that the indivisible factors are employed to their maximum capacity. More output can be had by using the existing machines up to their full productive capacity [6].

Productivity analysis of cassava-based production systems gave birth to four factors that can be hypothesized as the determinants of Total Factor Productivity (TFP) on cassava based farms [7]. These factors are farm size in hectares ( $T_1$ ), labour in man-days ( $T_2$ ), educational status of farm household head ( $T_3$ ) in years of schooling

and fertilizer input in kilogramme ( $T_4$ ). To examine the influence of these factors on TFP, the linear function of the determinants is specified as in equation (1).

$$TFP = b_0 + b_i T_i + E_i \quad (1)$$

All the hypothesized factors were therefore incorporated into the regression equation. The data collated on these factors were fitted by the ordinary linear simultaneous equation (OLSE) method using diverse econometric specifications, namely, the Cobb-Douglas, semi-log, quadratic and the exponential functional forms. The model that gave the best fit was selected as the best equation. The partial productivity estimates are the Marginal Products (MP) given as in Eq. 2 [7].

$$MP = \frac{TFP}{T} \quad (2)$$

$$Gross\ Margin\ (GM) = TVP - TVC;$$

Where,

TVP = Total Value of Production  
TVC = Total Variable Cost and  
TFC = Total Fixed Cost  
Total Factor Productivity =  $Y/TVC$

Where

Y = Quantity of output in Kilogramme  
Or  $TFP = Y/(\sum P_i X_i)$

Where

$P_i$  = Unit Price of the  $i$ th variable and  
 $X_i$  = Quantity of  $i$ th variable input

From cost theory  $AVC = TVC/Y$ ,

Where,

AVC = average variable cost in Naira..

$$Therefore, TFP = \frac{Y}{TVC} = 1/AVC.$$

$TFP = Inverse\ of\ the\ AVC$  [7].

In a similar vein, Factors of production include Land and other natural resources, Labour, Factory, Building, Machinery, Tools, Raw Materials and Enterprise [8].

Imbalance in the use of factors of production has been identified as a major reason for the sub-

optimal coffee yield in Uganda [9]. The desired elasticity of response indicated that land and capital were the most limiting factors in cloned coffee production for poor farmers. Land and labour were identified as the most limiting factors for rich cloned coffee farmers. Overall land and labour were found to be most limiting [9].

In the year 2003, the Vice-President of Federation of Malaysian Manufacturers, Raja Abdul Aziz Raja Musa, stated that Malaysian Manufacturing Sector was experiencing a significant gap between the information system and overall resources, therefore causing more delays in the overall processes on manufacturing management [10]. He added that the manufacturing Sector in Malaysia had a problem in maintaining its competitiveness, quality and just-in-time delivery. Some manufacturers outsourced their production in order to maintain competitiveness. According to the Federation of Malaysian Manufacturers in 2003, most people in the Malaysia's Manufacturing Sector were yet to master the Information and Communication Technology for the purpose of business and manufacturing as some of these companies were still working with the conventional manufacturing processes.<sup>[10]</sup> A study to ascertain whether there was any correlation between Organizational factors and quality of production in Malaysia's Manufacturing companies was done. A theoretical model of the relationships among the constructs of Organizational factors that consist of Organizational Resources, Rewards and Recognition Structure, Information System and Quality of production were proposed and tested using multi- Regression analysis. The results showed positive relationship between Organizational factors and quality of production in Malaysia's manufacturing industry, except for one which is related to Rewards and Recognition Structure. Information System had a dominant effect on competitive advantage in either cost or differentiation [10]. Methodology of research applied:

- i) 7-point Likert scale Questionnaire as the Research instrument;
- ii) Check for multi-co-linearity or correlation among items;
- iii) Varimax rotation to reduce number of variables to smaller numbers;
- iv) Computation of eigenvalues and
- v) Computation of the Kaiser-Meyer-Okin value [10].

The factor analysis entails:

- i) Preparing a table for Reliability Analysis on variables;
- ii) Preparing a table for mean and Standard Deviation of measures;
- iii) Preparing a table for Correlation Matrix among constructs and preparing a table for Multiple Regression Analysis of Organizational Factors with Quality of production [10].

The economics of fish production in Kaduna State of Nigeria was investigated and the Resources, Costs, Returns and other factors affecting fish production were examined. The analysis revealed that Land, water, labour and capital were the main resources employed in fish production. With this high level of profitability in fish farming, it is recommended that this information should be disseminated to all the farmers in these and other surrounding communities [11].

The analytical equations used are:

$$NFI = GR - TC \quad (3)$$

$$TC = (TVC + TFC) = P_x \cdot X \quad (4)$$

$$GR = P_y \cdot Y \quad (5)$$

Where

NFI = Net Farm Income  
 TC = Total Cost (N)  
 GR = Gross Revenue (Gross Return Period)  
 $P_y$  = Unit Price of Output  
 Y = Quantity of Output  
 $P_x$  = Unit Price of Input  
 X = Quantity of Input  
 TFC = Total Fixed Cost (N) and  
 TVC = Total Variable Cost (N) [11].

On the other hand, the inclusion of land-use activities in Life Cycle Assessment (LCA) has been subject of much debate in the LCA community. Despite the recent methodological developments in this area, the impacts of land occupation and transformation on its long-term ability to produce biomass (referred to here as biotic production potential (BPP)) - an important endpoint for the area of protection (AOP) Natural Resources - have been largely excluded from LCAs partly due to the lack of life cycle impact assessment methods. The characterization factors developed suggest that

the proposed approach to characterize land use impacts on BPP, despite its limitations, is both possible and robust [12].

Classical economic theory describes three primary factors, or inputs to the production of any good or service: land, labour, and capital. These factors facilitate production, but do not become part of the end product (as a raw material would). While these three factors have been much discussed and extended at different points in economic evolution, I believe that they, in any of the advanced economies of the world today, are vastly antiquated. Sometime even prior to this new millennium, the primary factors of production have now assuredly become: Time, Information and Capital. I submit that the primary relevance of land and labour has diminished, not completely but measurably, from their prominence during agrarian and industrial economic times. In a sense, owning land and employing lots of people no longer highly correlate to a valuable and successful enterprise [13].

Although in certain industries these two factors will remain prominent (think mining and energy production, for example). By and large, land and labour have yielded two more important factors – time and information. The third factor, capital, has been and will continue to be of primary importance in any Western-style, capitalistic economy. Or perhaps more to the point, an enterprise's ability to raise and efficiently deploy capital will continue in its historic prominence [13].

Competing based upon speed and time delivers a primary marketplace advantage. Understanding and translating customer needs swiftly from concept to practice, in many ways, determines the success rate of an enterprise. In part, the pace of technology innovation itself has set a blistering schedule for the rest of the business world. And in turn, technology innovation enables all organizations to compete on the basis of time (and speed). Many timelines describe technology advancements that have accelerated markedly and consistently, quickening even more so during the past 40 years. Now, the "Internet of things," hastened by cloud computing and network ubiquity, unprecedented gains in microprocessor performance, rapidly declining memory prices (while capacities have skyrocketed), and the more efficient use of computing power and energy (virtualization of

most every computing resources) provide new possibilities for dramatically reducing the time to learn innovate, and execute on a business plan [13]. Speed in project and product development also enables fast failure, which is actually a good thing [13] Toyota offers a great example of using "Time" for competitive advantage, which absolutely relies on putting more data and information to work [13]. Much research has chronicled the onslaught of data and its growth, especially during the past decade. A recent study by IDC (and sponsored by EMC) predicts that the amount of digital information created annually will grow by a factor of 44 from 2009 to 2020, as all major forms of media – voice, TV, radio, print – complete the journey from analogue to digital. Speaking at a technical industry conference in the summer of 2010, Google's Eric Schmidt warned about both the opportunity and the responsibility this much information represents. "People aren't ready for the technology revolution that's going to happen to them," said Schmidt. Indeed, Google and countless other companies are thriving at the epicentre of this data explosion, both enabling and taking advantage of it. In many ways, they represent models for any organization to more effectively use information to its own advantage [13]. To this end, harnessing information as a primary factor of production will mean recognizing and effectively planning for the four "V's" of data: volume, velocity, variety and veracity.

### 1.1 Volume

The sheer amount of data being digitized, maintained, secured, and then used. Knowing the organization's current needs and having a plan for its growth is fundamental.

### 1.2 Velocity

The speed at which data must be moved, stored, transformed, managed, analyzed or reported on in order to maintain competitiveness. This will vary by organization and application or usage.

### 1.3 Variety

The different types of data, from source (origin) to storage and usage, must be well understood because competitiveness requires access to the right types of data more than ever. From aged flat files to spatial and unstructured data, a plan must be in place.

## 1.4 Veracity

The truthfulness or quality of data can either lead to poor understanding and decisions that belie progress or deliver a powerful jolt of reality that fuels new insight and ideas. Ultimately, data quality may be the most important frontier [13].

For the first time, causality between data-driven decisions making organizational success has been proven in a study published in 2011 by Massachusetts Institute of Technology (MIT) and University of Pennsylvania researchers in which their reporting began thus:

*"Today, organizational judgment is in the midst of a fundamental change – from a reliance on a leader's "gut instinct" to increasingly data-based analytics. At the same time, we have been witnessing a data revolution; firms gather extremely detailed data and propagate knowledge from their consumers, suppliers, alliance partners, and competitors. In particular, since 1993, most large companies have invested in large enterprise resource planning (ERP), Supply Chain Management (SCM), Customer Relationship Management (CRM) and similar enterprise information technology [13]."*

Success in the new economic battleground is based on our differential use of time and information, the two new factors of production. Because we can have no more of the former and an unlimited amount of the latter, our need for efficiency is never-ending. Harnessing information in ways that creates new insight and ideas will increasingly come from data-driven applications. The analytic views provided by these hard-working applications are fuelled by the volume, velocity, variety and veracity of data available to an organization – which provides big incentive to understand and maximize these dynamic data characteristics. Embracing the new factors of production is now required. Nothing more than ultimate economic competitiveness is at stake [13].

New data on IT investment and productivity for 41 countries from 1985-2004 were analyzed and compared the results from 1994-2004 with the years 1985-1993 covered in earlier research by Dewan and Min in 1997, it is found that for developing countries, there was no significant effect for IT capital for the 1985-1993 sample, but the relationship is positive and significant for the 1994-2004 sample. on the other hand, for developed countries, IT capital is significant

across all time periods [14]. In order to take into account the improvement of product quality caused by information technology investment, a hedonic price index is used to deflate the information technology variable. beside the general specifications of Cobb-Douglas production function, this paper considers the impact of information technology on total factor productivity (TFP), capital and labour productivity, through substitution by applying a non-neutral production function. The study reveals that IT investment provides a significant contribution to productivity. The study also finds that IT capital is a complement for TFP and a substitute for non-IT capital [15]. Several firm-level empirical studies have found positive and excess returns to investments in information technology (IT) capital. Using a production function framework that typically include such inputs as IT capital, non-IT capital and labour, these studies estimate the return on investment in IT. Taken together, this body of research provides evidence of a payoff to investment in IT contrary to the often-cited productivity paradox [16]. In reporting the results of a survey on the experiences of CFOs of the top 800 Australian companies with Enterprise Resource Planning (ERP)-systems and alternative systems integration concepts, the most important conclusion drawn is that the quality of an information system is a function of the achieved level of integration and not of the integration concept used (for example, ERP) [17]. Also ICTs enable management to perform new business functions like computer-aided design, ability to work out of the firm site, co-ordinating team work between distantly located parties et cetera [18]. In other hand, information technologies (IT) may substitute for routine/manual tasks and complement complex problem-solving tasks, which can induce bias towards greater demand for skilled labour. This phenomenon of "skilled biased technical change" has important implications for the impact of IT on factor substitution within a firm's production process. Using firm level panel data from California Hospitals from 2002-2006, a translog production function estimated elasticities of substitutions between IT spending and skilled versus unskilled labour were specified. It was found that IT is a substitute for capital and low-skilled labour, but a complement for high skilled labour [19]. In another development, a standard Cobb-Douglas production function was used to model the production process, considering ICT as a factor of production. With this analysis, the impact of these technologies on company efficiency and

productivity was assessed. However, moving beyond the productivity paradox, there is growing evidence that ICT generates large positive returns that are even in excess of the returns from other types of investments [20]. In reporting the impact of ICT output of scientists in two Nigerian Research Institutes (namely: The Nigerian Institute for Oil Palm Research and Rubber Research Institute in Edo state of Nigeria), study show that usage of computer, television, Global System of Mobile Telephones (GSM), internet and printer ranked highest among the ICT tools in the Institute which contributed to productivity [21]. In reporting the new trends in global manufacturing systems and the impact of information technology on the formation of agile virtual enterprises, the widely spread, efficiently proved information technologies such as the internet are currently being used in their continuous pursuit of new cutting edge development as well as for winning new markets and sustaining growth [22]. The research describing mass customization and provision of a framework to understand the relationships among time-based manufacturing practices, mass customization and value to the customer is reported. The outcome of the study indicates that firms with high levels of time-based manufacturing practices have high levels of mass customization and value to the customer [23]. On a similar vein, part of a research programme being undertaken in Italy on the applicability of the just-in-time (JIT) approach is reported. The programme includes both the development of methodological concepts to evaluate JIT applicability and an extensive survey of the value of JIT implementation as seen by the Italian industry. Two levels of performance are identified: first, the various performances at system level (critical manufacturing tasks); second, operating conditions being the variables describing the characteristics of single production factors and their interconnections (such as efficiencies, capability, process flexibility and lead times). A paradigm of JIT approach results, which explains the changes in the traditional trade-off within overall performance [24]. Results of a survey on the application of the just-in-time (JIT) approach in Italy based on a sample of 173 industrial companies is reported. Major benefits in production system performance are achieved in terms of mixed flexibility, working capital productivity and productivity both direct and

clerical labour [25]. In another development, the effect of various treatments, viz, (i) soaking in plain water and sodium bicarbonate solution, (ii) cooking of soaked seeds, (iii) autoclaving of soaked seeds, (iv) germination and (v) frying of germinated seeds was studied by measuring the oligosaccharide contents of five commonly grown legumes, namely: Rajmah (*Phaseolus vulgaris*), Bengal gram (*Cicer arietinum*), Black gram (phaseolus mungo), Red gram (*Cajanus cajan*) and Broad bean (*Vicia faba*). The contents of sucrose, raffinose [26].

For many businesses, the key success factor is delivering the right product to market before competitors and even the development cost is secondary to product timeliness [27]. It is to be noted also that the project management information involves costs (budget), schedule (time) and quality of work, and all are attached to the same deliverable structure [27].

## 2. MATHEMATICAL FORMULATIONS AND CASE STUDY

### 2.1 Mathematical Formulation

From the foregoing, deduced factors of production are ; Materials ( $M_1$ ), Money ( $M_2$ ), Machines ( $M_3$ ), Manpower ( $M_4$ ), Management ( $M_5$ ), Information (I) and Time (T). These factors of production will be commonly referred to as 5 Ms, I and T. Equation (1) above could be expanded to accommodate the seven factors of production, that is:

$$\text{If Productivity, } P = f(M_1, M_2, M_3, M_4, M_5, I, T) \quad (6)$$

$$\text{Or } P = KM_1^a M_2^b M_3^c M_4^d M_5^e I^f T^g U^h \quad (7)$$

Where,  $M_1$ ,  $M_2$ ,  $M_3$ ,  $M_4$ ,  $M_5$ , I and T are the explanatory variables which try to in appropriate combination define the value for productivity. On the other hand U is the disturbance term and tries to account for the unexplained part of the productivity. The value of U is dictated by the circumstances of losses due to errors of omission, commission and force majeure. This expression is a non – linear regression equation. In order to bring the expression into the linear form, logarithm of both sides is taken to base 10 and we get:

$$\log_{10} P = \log_{10} K + a \log_{10} M_1 + b \log_{10} M_2 + c \log_{10} M_3 + d \log_{10} M_4 + e \log_{10} M_5 + f \log_{10} I + g \log_{10} T + h \log_{10} U \quad (8)$$

If we put

$$\log_{10} P = Y; \log_{10} M_1 = X_1; \log_{10} M_2 = X_2; \log_{10} M_3 = X_3; \log_{10} M_4 = X_4; \log_{10} M_5 = X_5; \log_{10} I = X_6; \log_{10} T = X_7; \log_{10} U = X_8; \log_{10} K = \beta$$

We get,

$$Y = \beta + aX_1 + bX_2 + cX_3 + dX_4 + eX_5 + fX_6 + gX_7 + hX_8. \tag{9}$$

This is a linear multiple regression equation.

Let  $w_y$  be the uncertainty in the result and  $w_1, w_2, \dots, w_7$  be the uncertainties in the independent variables. If the uncertainties in the independent variables are given with the same odds, then the uncertainty [28] in the results having these odds is given by:

$$w_y = \sqrt{[\left(\frac{\partial y}{\partial x_1} w_1\right)^2 + \left(\frac{\partial y}{\partial x_2} w_2\right)^2 + \dots + \left(\frac{\partial y}{\partial x_7} w_7\right)^2]} \tag{10}$$

### 3. CASE STUDY

Consider the missing Malaysian Plane (Flight MH370) [29] with brief details in the Appendix. Consider the 4-factor and 7-factor of production scenarios using 6-point Likert evaluation instrument on the basis of information contained in the Appendix, the tables below are derived.

In the Likert scale, 0 = the resource do not exist; 1 = poor value of resource; 2 = fair value of resource; 3 = good value of resource; 4 = very good value of resource and 5 = excellent value of resource.

Recall equation (7) above, that is  $= K M_1^a M_2^b M_3^c M_4^d M_5^e I^f T^g U^h$ .

Substituting the values of  $M_1, M_2, M_3, M_4, M_5, I$  and  $T$  that is the 7-factors of Table 1 into this equation, we get:

$P_7 = K 5^a 5^b 5^c 5^d 5^e 0^f 2^g U^h$ . For a non-zero  $f$ , the value of  $P_7$  will be equal to zero. The search for the missing Malaysian plane is a project. Every project executed has a potential to yield results, that is, some productive level. In this search, not even some pieces of the plane (debris) have been found; not a corpse of a passenger or crew has been seen. Hence for now the search productivity is equal to zero. This has been confirmed by the value obtained for  $P_7$ .

On the other hand for the 4 Factors of production, reducing equation 7 to 4 factors of

Land, manpower, Capital and Entrepreneur, the productivity  $P_4$  is given by:

$$P_4 = \text{Land}^h \text{Manpower}^i \text{Capital}^j \text{Entrepreneur}^k$$

Substituting the values of Table 2 into this equation, we get;  $P_4 = 5^i 5^j 5^k 5^l$

**Table 1. Seven factors of production**

Factors	Factor status on Likert scale
Materials( $M_1$ )	5
Money( $M_2$ )	5
Machines( $M_3$ )	5
Manpower( $M_4$ )	5
Management( $M_5$ )	5
Information(I)	0
Time(T)	2

Source: Evaluation of data in appendix using 6-Point Likert Scale

**Table 2. Four factors of production**

Factors	Factor status on Likert scale
Land	5
Manpower	5
Capital	5
Entrepreneur	5

Source: Evaluation of data at appendix using 6-point Likert Scale

A critical look at the values of  $P_7$  and  $P_4$  reveals that  $P_4$  appear greater than  $P_7$  giving a false impression of higher productivity. This value of  $P_4$  do not represent the reality on ground so much as the 4 factor theory failed to embrace the dynamics of time as constrained by the preset 30 days designed specification of the bleeping of the Black Box on one hand and the dynamics of the information on the location of the missing plane on the other. Part of the mind set for the search for Malaysia MH370 was that the plane crashed into the ocean. Now the body of water in the ocean is in motion and hence the debris of such a plane could be swept along with the currents. The implication of this scenario is that the corresponding information in tracking the missing

plane has to be dynamic and hence become the most important factor in this instance. The gap or shortage of the two factors, namely, Time and Information as a consequence limited the search success for the missing Malaysian MH370 Plane. The key to success in locating the missing plane therefore rest squarely on the acquisition of quality and accurate information.

#### **4. DISCUSSION**

In defining Factors of Production, several of the cited authors defined Land as including everything in the universe not created by man, and some of the authors actually referred to this conglomerate of items (land inclusive) as materials. Consequent on this definition, Materials ( $M_1$ ) could be loosely upheld as a factor of production representing an array of non-man-made items. In a similar vein many of the authors used Money interchangeably for Capital as factor of production. Hence non-controversially, Money ( $M_2$ ) is also recognized as a factor of production. Some of the authors equally recognized some of the man-made resources such as Machines and Equipment which were hitherto classified as part of capital but should now stand on their own as separate factor of production. This development is based on the importance and intricacy of machines and equipment to productivity. Hence Machines ( $M_3$ ) represent factor of production. Most of the cited authors in this work recognize Manpower as a factor of production. A couple of authors prefer to use the word Human Capital in place of Manpower in order to erode gender chauvinism. In the usage here, manpower is seen as a collective noun for the total work force consisting of men and women. Hence with due respect to the female workforce we uphold the word Manpower ( $M_4$ ) as factor of production. Unequivocally, Entrepreneur, Enterprise and Management were interchangeably used by various authors as cited in the introduction. It is a factual statement that Management is the known face of the Entrepreneur or Enterprise. Consequent on this, Management is seen or heard of or felt by the environment or society in statutory, legal, social/community responsibilities. Hence Management ( $M_5$ ) can be substituted for Entrepreneur as a factor of production without loss of meaning and value. In a similar vein, information has become a very important component of productivity, manufacturing, maintenance and operations. Many organizations do market research with the view of understanding consumer needs so as to produce

to the specifications of customers. The world has become a global village and producers of goods and services are facing competitive market scenarios. In the light of this market dynamics, only producers of goods and services with up-to-date and accurate market forecasts thrive in the global market. A celebrated case study to buttress this claim is the Malaysian Plane, Flight MH 370 that disappeared in flight on the 8 March 2014. Due to shortage of accurate information the search and rescue operation for the plane has continued up to today without fruitful results. So many nations have contributed search and rescue equipment into the search effort to no avail. The cost of the search for Flight 370 has passed the \$billion Dollar mark. In the military parlance, a ragtag army in possession of information and time advantage can defeat and create an upset for a formidable and well equipped army. Many organisations today have come to recognize the importance and role of information that the departments of Information and Communication Technology (ICT) have been setup and heavily funded. Many organizations in attempt to track their competitors' progress even do industrial espionage. Various countries get involved in international espionage in order to regulate and maintain the status quo in world order. These espionage and information gathering apparatus is maintained at a colossal cost/budget which in a way shapes the overall cost of the goods and services/benefits derived from the operations of such organizations. From the fore going therefore, the impact of information on productivity is too high to be discarded from the list of factors of production. In this light therefore, Information (I) is hereby prescribed as a factor of production. Time is simply defined as duration of consciousness. Time has impact on all the six factors of production so discussed above. Materials usage and degradation is tied to passage of time. Discounting of money and its value is also tied to time. The depreciation and salvage values of machines are tied to time. Manpower evaluation is done on the basis of energy expended per unit time. Managements' programmes are charted out on a schedule (which is time driven activities). Consequent on the above, time is of great essence. Project managers realize that time lost cannot be recouped. When project time is lost, some of the project activities are left undone. Hence to recover lost activities, such project activities must be crashed at a cost. As we can see, all the six factors of production are time based. Man-hours of an organization are derived from the stipulated working hours of the

workforce or manpower. That the six factors of production, namely, materials, money, machines, manpower, management and information are procured into place do not translate to organizational success. For many businesses, the key success factor is delivering the right product to market before competitors and even the development cost is secondary to product timeliness [14]. In order for many organizations to track their time effectively, time clocking machines have been employed. Time-based materials management, maintenance, operations, project management have been adopted by various organizations. Matrix-driven project management considers Schedule (Time) as one of its critical success factors in project delivery. Consequent on the foregoing Time (T) is hereby adopted as the seventh basic factor of production. Hence the value/importance/role of information and time as factors of production cannot be overemphasized. These seven factors of production can be represented by the acronym  $M^5I^1T^1$ .

## 5. CONCLUSION

Factors of Production have been re-classified into Seven groups, thus: Materials( $M_1$ ), Money( $M_2$ ), Machines( $M_3$ ), Manpower( $M_4$ ), Management( $M_5$ ), Information(I) and Time(T). The seven factors of production can be represented by the acronym  $M^5I^1T^1$ . The contributory role of machines, information and time to productivity is too great consequentially to be left behind the main stage of the burner in a globalized economy, where the emphasis is to do it right the first time, that is just in time (JIT). The simple but important Case Study of the missing Malaysian plane (Flight MH370) has demonstrated the weakness and threats of the 4 factors of production and has highlighted the strength and windows of opportunity of the 7-factors of production. These seven factors of production therefore challenge the twenty-first century matrix project-driven economy. The old school of thought of factors of production which is static and none responsive to the dynamics of information and time must be made vibrant by embracing the dynamics of reality in Information and Time.

## COMPETING INTERESTS

Author has declared that no competing interests exist.

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## APPENDIX

### CASE STUDY ON THE IMPACT OF SEVEN FACTORS OF PRODUCTION VERSUS FOUR FACTORS ON THE SEARCH AND RESCUE OF MISSING MALAYSIAN PLANE (FLIGHT MH370)

The search for Malaysia Airlines Flight 370, the longest civil aircraft disappearance in modern history, has unearthed more questions than answers, as the mystery surrounding the fate of the missing jetliner continues to intensify with each passing day [16].

#### Malaysia Airlines Flight MH370: Missing Plane Search Timeline Live Updates [16]

Published time: March 19, 2014 01:35

Tuesday, April 1

01:56 GMT:

Malaysian authorities now say the final words from the cockpit of missing Flight MH370 were, in fact, "Good night Malaysian three seven zero," and not "All right, good night," as was reported weeks ago.

*"We would like to confirm that the last conversation in the transcript between the air traffic controller and the cockpit is at 0119 (Malaysian Time) and is "Good night Malaysian three seven zero,"* the Malaysian Department of Civil Aviation said in a statement released late Monday.

Wednesday, April 2

03:01 GMT:

The probe into the missing flight has been classified as a criminal investigation, Malaysia's police chief said, according to The Wall Street Journal. More people are scheduled to be interviewed. Meanwhile, the investigation into the pilot's flight simulator remains inconclusive.

03:01 GMT:

The search area, which has repeatedly shifted as experts analyze radar and satellite data, is currently focused on a 98,000-square mile area off Perth, Australia.

Lack of coordination between nations assisting with the search for missing flight MH370 has delayed the efforts, as the targeted area was 1,000 miles away from where the aircraft is believed to have crashed, sources familiar with the matter told The Wall Street Journal.

19:59 GMT:

Malaysian police say they have excluded the possibility that any of the passengers of the flight could have organized a hijacking, Xinhua news agency reported, citing Malaysian media.

Malaysian investigators excluded three more possibilities, in which the main suspects were passengers of the plane. The police said they were referring to sabotage by passengers with psychological disorders or personal problems. *"Suspicions according to four [possibilities] have been lifted from them (passengers),"* said Khalid Abu Bakar, inspector general of Malaysia's police, adding that the crew members, including both pilots, remain under suspicion in these four possibilities.

Friday, April 4

11:56 GMT:

A US Navy "black box" detector made has been deployed in the search for missing Malaysian Airline's flight 370. The Australian naval vessel Ocean Shield arrived with a *"towed pinger locator"*, which is capable of homing in on signals from the black box, AFP reports.

However, Angus Houston, Australia's former military chief and now coordinator of the eight-nation search, said *"we're now getting pretty close to the time when [the black box signal] might expire."*

Black boxes typically release a ping for 30 days. MH370 disappeared March 8, leaving rescue workers several days at most before its battery dies.

Saturday, April 5

12:43 GMT:

A black box detector on a Chinese patrol searching for missing Malaysia Airlines Flight MH370 has detected a pulse signal in the South

Indian Ocean, state media reported. It has not yet been established whether the signal picked up by the Haixun 01 vessel is in fact linked to the missing jetliner, China's official Xinhua news agency reported.

Sources in the Malaysian government later confirmed that the Chinese vessel had detected a signal though there is no confirmation on its origin.

The announcement came as international crews search the Indian Ocean for the flight's lost black boxes before the devices stop emitting locator 'pings'. Black boxes typically release a ping for 30 days. MH370 disappeared March 8, leaving rescue workers several days at most before its battery dies.

**15:35 GMT:**

The pulse picked up by a Chinese ship searching the southern Indian Ocean for the missing Malaysian airliner does not belong to the black boxes of Flight MH370, the China Maritime Safety Administration says.

The signal picked up by the Chinese vessel's black box detector had a frequency of 37.5kHz per second, the official Xinhua news agency said - identical to the beacon signal emitted by flight recorders.

Following a preliminary analysis, the agency now believes it is not connected to the jetliner.

**23:56 GMT:**

Chinese pilots involved in the search operations found white objects floating in the Indian Ocean, about 2,700 kilometres off the coast of Australia, Xinhua news agency reported.

**Sunday, April 6**

**18:09 GMT:**

UK naval ship HMS Echo has arrived in the area where the missing Malaysian plane is being searched for. It will conduct underwater searches after preliminary environmental tests. The ship was dispatched after a Chinese vessel detected a pulse signal in the vast search area on two occasions. Whether or not they are being emitted from the flight recorders of MH370 is still to be confirmed.

Edited time: April 06, 2014 18:19

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