



Cultural Underpinnings of Nanotechnology and Industrial Development Diffusion in the Fourth Industrial Revolution: The Context of Cultural Determinism in Accounting Innovation

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Abstract

The paper presents a fundamental analysis of how differential interpretations and uses of accounting innovations stimulate technological diffusion and industrial development in the argument of the relevance of accounting within the emergent technological milieu already threatening several professions. It identifies how the meanings and interpretations of accounting innovations contributed to the cultural determinants of various industrial epoch. Relying on the theory of cultural determinism in accounting and using Geert Hofstede 6D Model of National Culture to explain that the diffusion of technology and industrial development is also culturally dependent, the paper shows that the lack of the use of accounting innovation is implicated in the inability to translate technological advancements into industrial developments in parts of the world. The paper recommends that changes in the organizational structure, culture and strategy stimulated by accounting innovations be embraced to tilt the tide in favour of faster-paced transition of nanotechnology and other high-level technological advancements into industrial development in African and other developing economies.

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*Technological diffusion
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1. Introduction

Since human society evolved from the agrarian age, when the barter economy was characterized by the exchange of goods for goods, to the current knowledge economy when information is ubiquitous and knowledge is ever-expanding, accounting has evolved in tandem and supported this evolutionary process. However, as advancements in science and technology exploded since the first industrial revolution of the 17th and 18th century characterized by mechanization, to the second industrial revolution propelled by mass production (circa 1870-1914) and the third industrial revolution (1980s) marked by computer and automation there has been widening differences in adaption and application of these technologies for industrial developments across different countries around the world. The differences in technology and adaptation of technologies for industrial development may be as varied as the perceptions and interpretations of accounting theories and methods across countries. If that was not the case, then the explosion and convergence of information in the knowledge economy that characterized the fourth industrial revolution powered by advances in communication and connectivity should have resulted in the equalization or democratization of industrial developments. Even as the diversities in the application of technological advances such as

nanotechnologies for industrial development is emphasized by geography this paper departs with the notion that the implicit cultural determinism would require accounting innovation to elicit new and fundamentally different ways to bring about the required significant changes.

However, the persistence of low level of industrial development in Africa and notably in Ghana and Nigeria suggests that there are hiccups in the use of new knowledge, in the adaptation of existing knowledge or in the application of technological innovation to solve this development deficit. While accounting methods have been of general applicability and contributed to the various industrial development epochs, this paper makes the case for accounting innovation as a sine qua non for the translation of these techniques in “fundamentally different ways to bring about significant changes” in industrial development in developing countries. The potential of nanotechnology is too huge to be ignored. The project on emerging nanotechnologies listed over 800 manufacturing products as at 2008 and documents that the pace of growth is at the rate of 3 to 4 products per week (The Project on Emerging Nanotechnologies, 2008). Coupled with other emerging technologies in biotechnology, materials science, energy storage, quantum computing, artificial intelligence, internet of things and given the level of development in communications technology and the billions of connected people, the potential impact of nanotechnologies on industrial development is tremendous (Schwab, 2016).

This study is built on the foundational assumption that the adoption of nanotechnology will fast-track industrial development. Secondly that there is a positive relationship between the adoption of nanotechnologies and industrial development and finally that countries that adopt nanotechnologies tend to be developed and vice versa. The method of this paper is to deduce that high-level technological advancements such as nanotechnology and industrial development are cultural dependents using Geert Hofstede 6D Model of national culture. The paper invokes the theory of cultural determinism in accounting to show that the slow pace of industrial development is due to inability to apply accounting innovations capable of translating new knowledge or technological innovation into business opportunities and industrial development. Accounting innovation stimulates shifts in organizational structure, culture and strategy. This paper is significant as it presents a fundamental analysis that can form the basis of a future empirical assessment of how differential interpretations and uses of accounting innovations stimulate technological diffusion and industrial development. The emergent technological innovations in the fourth industrial revolution are already threatening the relevance of many professions including accounting. This paper contributes to the discussion on nanotechnology and industrial development as a strategy to market accounting techniques deliberately to gain prominence within emerging industries in response to the guidance of Loft (1994).

2. Theory of Cultural Determinism in Accounting

The theory of cultural determinism in accounting is hinged on the notion that there are factors inherent in different countries' cultures that affect the way accounting techniques are perceived and applied. Culture determines how a society perceives the world around them leading to non-rational but persistent ways and interpretations. Consequently, culture determines how existing knowledge is interpreted, how new knowledge is perceived and how technological innovations are applied. Within the knowledge economy of today, information is ubiquitous, yet while some societies are taking advantage of it to adopt relevant technologies such as nanotechnology to stimulate industrial development, others are not or at best, do so at a rather increasingly slower rate to the pace of advancements. This paper relies on this theory of cultural determinism to assert that the slow pace or lack of adoption of advancements in nanotechnology in Nigeria and the slow pace of industrial development is depended on the subsisting cultures that inhibit the application of new technologies towards solving persistent problems. Rather than use accounting knowledge and techniques to plan, budget, analyze, forecast, evaluate and determine the feasibility of new industrial projects, it appears that the persistent way accounting techniques have been applied is limited to the recording and presentation of historical financial information. Accounting is applied mainly towards stewardship reporting which depended on fidelity or honesty of individuals, and the maintenance of existing business enterprises rather than towards the development of new ones or even towards the technological adaptation. Infact, Osuala (2005) cited by Unegbu (2014) hold the view that every individual has a personal viewpoint, in varying degrees of adequacy and truth, from which different deductions in varying degrees of importance and accuracy are made. The attempt to postulate a unifying framework of accounting theories may therefore be dogged by the extent of individual and group differences in perception, postulates and assumptions that affect decision making. Consequently, the accounting interpretations of advances in the technological environment may have individual and group colorations that have implications for industrial development.

Tracing the empirical examination of cultural determinism in accounting, Belkaoui (1989) cited Acheson (1972) who carried out an anthropological study of how people in Cuanago (Mexico) viewed business opportunities based on the existing native system of accounting which consisted of a cash flow model. It was found that the system of accounting led to low perception of business opportunities and poor business decision culture. Invoking the views of ethno science that sees cultural orientation of people as deriving from a shared cognition, knowledge and belief, Belkaoui surmised that “cultural groups in accounting create different cognitions or systems of knowledge...” and went on to empirically show that accountants from different

cultural backgrounds have “different cognitions or systems for perceiving and organizing accounting knowledge.” [Belkaoui and Ronald \(1989\)](#) cited in [Belkaoui \(1989\)](#). The result of a study of three different cultural groups in Papua New Guinea conducted by [Ngangan, Shahrokh, and Frank \(2005\)](#) showed that there were differences in users’ perception of financial statement information thereby supporting the notion inherent in the theory of cultural determinism in accounting.

3. Accounting Innovations Central to the First to Third Industrial Revolutions

[Unegbu \(2014\)](#) traces the evolution of accounting from the agrarian era where accounting consisted of records of exchange of goods for goods to about 450BC in Mesopotamia, through 630BC when it was associated with the development of coins to replace the then barter economy. The period coincides with the Celtic and Greek technological revolution (700–200 BC) ([Šmihula, 2011](#)). Later in China, accounting was to evolve as a recording of transactions involving merchants, temples and estates. Thus, since earliest times accounting been associated with human economic activities in trade, commerce, estate investments and thereafter into a system that detects errors and frauds and much less for development of ideas for decision making. The associated pre-modern technological system of recording that was later to metamorphose into the double-entry system was a practice in Italy that was formally documented by Luca Pacioli in 1494. [Pyle, White, and Zin \(1980\)](#) observed that the changes from the agrarian economy to the industrial economy characterized by the rise in the building of factories and towns, emergence of capitalist business systems where ownership was separated from control was linked to the “emergence of large-scale industrial and commercial activities and accounting system in Europe, precisely in England”. The evolution of accounting has therefore been closely associated with the emergent economy of the first industrial revolution.

Then entered the era of mass production and the controversies associated with scientific management which was characterized by the industrial tension between the industrialists and the labor unions. Accounting innovations for the determination of labor cost through the piece-rate wage system, determination of production cost through appropriate charging of cost of property, plant and equipment through depreciation gave meaning to and helped in the resolution of the disputes that facilitated the mass production system. [Loft \(1994\)](#) gave details of issues and events that indicated that when the exigencies of prosecuting the first world war meant that the time and cost for procurement of ammunition has to be minimized to the barest minimum, accounting innovation of standard costing was again to come to the fore. The cost accountant was the expert who provides the light that brings to the forefront the impediments to production efficiency. Loft concluded her expose of the role of accounting under the stress of the first world war by implying the importance of accounting to market its techniques as a means of gaining prominence within emerging industries.

The emergence of the third industrial revolution in the 1980s and 1990s heralded by new capabilities in computing and automation brought about increased industrial development through the application of information technology. Information technology enhanced efficiency, competitive impacts and the production of new products and services ([Laudon, 2009; Melville, Kraemer, & Gurbaxani, 2004](#)). The prominence of information technology was because it synchronized with the capabilities of other resources to bring about increased productivity. However, some researchers doubted whether the huge investment in IT portfolio is justified ([Barua, Kriebel, & Mukhopadhyay, 1995; Sambamurthy, Bharadwaj, & Grover, 2003](#)). Again, accounting innovation came to the rescue through the performance management technique of incremental accounting that helped to decompose the benefits associated with investments in information technology from the capabilities and other resources of the firm.

4. Accounting Innovation, Nanotechnology and Industrial Developments in the Fourth Industrial Revolution

The advent of the fourth industrial revolution announced by [Schwab \(2015\)](#) and elaborated by [Schwab \(2016; 2017\)](#) is characterized by unmatched technological advances in the “robotics, artificial intelligence, nanotechnology, quantum computing, biotechnology, the internet of things, decentralized consensus, 3D printing and autonomous vehicles” and expected to improve the quality of life, reduce inequality while raising income levels ([The Fourth Industrial Revolution, 2019](#)). In *Wikipedia* retrieved April 29, 2019). It represents an era for the democratization of opportunities as increased communication and connectivity offers changes to the way we live, work and relate to one another. One specialization that has contributed to these advancements is nanotechnology. Nanotechnology is the manipulation of matter for the fabrication of nanoscale products for medical, electronics, telecommunication and other industrial applications including the industrial production of consumer products. Because of the multiplicity of applications to a variety of other specializations, the potential of nanotechnology for industrial development is inherently limitless and therefore offers opportunities for developing countries like Ghana and Nigeria to catch up with the rest of the developed world. To do this, the impediments that have hampered the diffusion of technological innovations to the developing countries may need to be adjusted.

Innovation is the application of new ideas or the use of existing ideas in new ways to bring about major changes. Technological innovations are more prevalent in the advanced industrial economies and much less so in other countries. At the same time, some countries tend to embrace new technological innovations much

faster than others. The adoption of technological innovation is therefore much driven by some rational and non-rational factors. Among the rational factors is included the utilitarian value of the innovation and the ease of usage. For instance, advancements in mobile communication was easily diffused for these reasons. Some non-rational factors may be inherent in the culture of the individual and society. Residents in the Brazilian Amazon forest may be resistant to mobile communication devices to avoid intrusion to their ways of life. Despite enormous advantages in nanotechnologies, the less industrialized countries are yet to embrace it as a strategy for industrial development. What factors then inform the diffusion of innovations? It was argued by [Askarany \(2005\)](#) that the diffusion of innovation is influenced by both the attributes inherent in the innovation on the one hand and the attributes of the adopters of the innovation on the other hand. Drawing from [Rogers \(2003\)](#) he enumerated the attributes of innovation to include relative advantage, trialability, compatibility, complexity, and observability while the attributes of adopters comprise organizational structure, culture and strategy ([Brooks & Bate, 1994](#); [Gosselin, 1997](#)). The translation of nanotechnology into industrial development would, therefore, require a fit of the right organizational structure, culture and strategy to the needs, values, complexities and other advantages associated with the emerging technology. Consequently, the organizational structure, culture and strategy including the accounting organization, must be adaptive to new ideas, embrace complexities and recognize the relative advantages of developing the new technologies into industrial systems. This means that the new technological process and products must be translated into cost and pricing structures to enable appropriate resource allocation decisions to be made. But rather than merely providing information for decision making, [Swieringa and Weick \(1987\)](#) see accounting information of this sought not only as action generating, but one that instigates and compels action. Information about the prospect of nanotechnology when presented in terms of future profitability and return on investment can more quickly lead to investment decisions and industrial development. [Askarany \(2005\)](#) also identified the moderating factors between the technological innovation and the adopters as the social environment and the level of development of the society suggesting that some socio-cultural environment support the diffusion of innovation much more than others. Consequently, the cultural values of those societies that embrace new technological innovations are different from those that do so at a slower pace. [Geert Hofstede 6D Model of National Culture \(2019\)](#) formulated and mapped different countries into six dimensions for measuring cultural values namely: individualism–collectivism; power distance, uncertainty avoidance; masculinity–femininity, long-term orientation and indulgence. Individualism is the extent to which people feel independent rather than interdependent on one another and Power distance is the degree to which less powerful members of organizations and society accept and expect that power would be distributed unequally. Uncertainty avoidance is the extent to which the society tolerates risk, uncertainty and ambiguity and masculinity is the degree to which the use of force is socially endorsed. Below in [Table 1](#) is the summary of mappings of cultural dimensions of two sample countries each in North America, Europe and Africa. The scale of measurement allocates the numbers 2, 4 and 6 for ratings of low, average and high respectively in each of the six cultural dimensions. The average of the total score is then derived and used as a basis for the overall assessment of the country or region. A critical observation of the maps (ratings) shows that most of the sample countries in Western Europe and North America scored high on Individualism and indulgence while the sampled countries in Africa scored low on individualism but high on indulgence. Another marked observation is that while the sampled countries in Africa (Ghana and Nigeria) scored high both on power distance and short term orientation, the sampled countries in North America and Western Europe scored low on power distance and tended towards long term orientation but on average. Overall, the analysis above shows that the advanced industrial economies in North America and Western Europe are more culturally flexible with average scores of between 3 and 4.7 while the less developed countries in Africa were more culturally rigid with an average score of 6. This shows that industrial development is culturally dependent on the degree of flexibility, with the more flexible being the more developed industrially than those that are less so. A similar relationship of the degree of cultural flexibility in the adoption of nanotechnologies is assumed.

Accounting has the peculiar role of translating physical flows in organizations and society into financial flows ([Miller, 1994](#)) usually for the purposes of stewardship reporting, a view that sees accounting as “a functional and neutral response to organizational imperatives”. And I dare add it is equally the job of accounting to translate financial flows into physical flows in a reverse feedback communication that lead to the creation of new products, new firms and the transformation of society. Such a view of accounting stemming from the political economy frame of reference proposes that accounting be concerned with social welfare and distribution ([Cooper & Hopper, 1987](#); [Cooper & Sherer, 1984](#)). Therefore, accounting can play a critical role in transforming the determinants of the diffusion of nanotechnologies into financial flows to form the bedrock for industrial development and economic growth by playing active roles in translating technical and market imperatives into cost and pricing structures, financial forecasts and viability analysis which are necessary for allocation of resources to new products and new industries.

Table-1. Summary of mappings of cultural dimensions of sample countries in North America, Europe and Africa.

Cultural Dimension	Definition of Cultural Dimension	North America		Europe		Africa	
		USA	Canada	UK	Germany	Ghana	Nigeria
Individualism-Collectivism	The extent to which people feel independent rather than interdependent on one another	High	High	High	High	Low	Low
Masculinity-Femininity	The degree to which the use of force is socially endorsed	Average	Average	High	Average	Average	Average
Uncertainty avoidance	The extent to which uncertainty is avoided in preference for certainty.	Low	Low	Low	High	Average	Average
Power distance	The degree to which less powerful members of organizations and society accept and expect that power would be distributed unequally	Low	Low	Low	High	High	High
Short term orientation -Long-term orientation	The extent to which the people prepare short term as opposed to long term events	Average	Average	Average	Average	High	High
Indulgence-Restrained	The extent to which the people enjoy the good things of life.	High	High	High	Low	High	High
Total Score		24	24	26	28	30	30
Average Score		3	3	4.3	4.7	6	6

Scale of measurement:

Low = 2; Average = 4; High = 6

Source: Extracted from Geert Hofstede 6D Model of National Culture (2019) Dimension maps of the world showing the 6-D model of national culture.

The propagation of nanotechnologies and industrial development in Nigeria will be entrenched if accounting innovation helps to reduce uncertainty by providing relevant information to initiate or instigate future action, help organizations to focus on the long term through viability analysis, promote economic prosperity and maximum social welfare. Accounting innovation hence contributes to the government of the economic life of the individual and the society.

The government of the economic life of individuals and society in culturally specific ways was the concern of Peter Miller and O'Leary (1987); Miller and O'Leary (1994). They implied that this can be done by accounting guiding the changing vocabularies and discursive fields (rationalities) that define the objects (purpose or goals) and objectives of government. They further posited that accounting can also help in governing the economic life of individuals and societies through offering appropriate technologies and techniques by which the new vocabularies can be made operable and went further to state that the penchant to improve productivity, reduce costs and enhance competitiveness are the result of specific elements of particular mode of governing the economic life instigated by accounting innovations. They cited standard costing and budgeting as the technologies advanced by accounting to "render visible the inefficiencies of individuals within the enterprise..." hereby making efficiency "to be an individual as well as a collective phenomenon". By emphasizing and propagating standard costing techniques, the culture of improved productivity is promoted while inefficiency and waste is discouraged. Standard costing has helped to reduce uncertainty and promote individual efficiency (individualism) and fostered the "calculated management of life" (long-term Orientation). This way standard costing has been applied in new ways to bring about major changes. Power distance can also be altered by accounting innovation as "standard costing has helped to bring about a significant shift in the mode of exercise of power in advanced industrial societies." (Miller & O'Leary, 1994). It means that when such techniques can alter organizational structures, culture and strategies in the less industrial economies in Africa and elsewhere, industrial developments might once again stimulate economic development. It requires innovations to bring about the diffusion of technological innovations.

Another significant role of accounting innovation is in translating plans into budgets and committing events into historical records and subjecting them to analysis and finally enabling variance analysis, monitoring and evaluation. The accounting innovation of return on investment is seen as an action generating technique rather than merely a tool for rational decision making.

5. Conclusion and Recommendations

This paper presents snapshots of the symbiosis between accounting innovations and technological developments throughout history and advocates that nanotechnology and industrial development can be diffused if accounting innovations that promote efficiency lead to cultural shifts in the structure and strategy of organizations and the society. The culture of improved productivity promoted by standard costing and budgeting techniques are some of the accounting innovations that promotes accountability and responsibility while discouraging inefficiency and waste. The paper advocates these accounting innovations that influence and promote individuality, long-term orientation, and lower power distance when embraced as a strategy for influencing the cultural shift in the organizational structure can tilt the tide in favor of faster-paced adoption of nanotechnology and other high-level technological advancements to bring about industrial development in less industrialized countries in Africa and elsewhere.

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