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Towards Industrialisation in Ghana: Defining Sustainable Manufacturing of Technology with Cultural Underpinning

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Abstract
A nation's grip on technology is a direct reflection of its industrial capabilities, hence, economic strength. Ghana, like many sub-Saharan Africa countries, aspired to develop its industrial base since inception as a nation. Such an aspiration was deemed by this study to require a concerted policy framework in technology creation/production/manufacturing intertwined with cultural underpinnings. The narrative being that; industry requires the use of technology and technology must necessarily be manufactured and done sustainably. However, the issue of technology has been problematic in the African regions. As such, to contribute towards the technology-development policy framework, this study sought to initiate the discussion to define technology and its manufacturing with cultural undertones. The study therefore adopted a multidisciplinary approach; theoretically exploring technology studies from varied schools of thought and interconnecting them with culturalisation, emphasising the critical role of institutionalisation with the aim to establish a common ground of understanding in the subject matter. This is to serve as a springboard for future work.
Keywords: *sustainable manufacturing, culture, technology, technology development, Ghana*

I. INTRODUCTION

The aspiration of the developing world, with Ghana inclusive, to industrialise its economy continues to elicit theold quest for technological breakthrough;the dilemma ofGhanasince inception as a nation. It is common knowledge that majority of African countries tend to register high levels of technological dependency on the advanced world for their technical solutions despite the huge amounts of seeming donor aids injection into the various African economies.

The technology development gap between the African States and the advanced worldkeeps increasing. It is a similar trend when compared with other developing Asian nations. This is despite the fact that these African nations and their Asian counterparts implemented similar growth policies at their inceptions. The outcome of these policies in Africa has not been very encouraging in producing the expected growth, thereby making Africa's case unique, of which Ghana is one.

Ghana's policies on industrialisation over the years leaves much to be desired.More answers are required to address its industrialisation aspiration, which still stands as a wish.

Africa's (Ghana) strategy of leapfrogging into industrial heights by taking advantage of the large exposure to widespread modern technological advances has yielded no measureable evidence of indigenous technical growth or change. The intention of leapfrogging into the fourth industrial revolution might remain a mirage if nothing is done differently to change the status quo.

As noted by a previous scholar, "majority of underdeveloped countries… have not established a basis of productive technologies related to scientific findings of their own" (Sagasti, 1979). The application of research in Ghana to lead to technical changeremains elusive(Nyasapoh, et al., 2022) as contrary to the advanced Communities.

In the history of industrial revolution, Africa is yet to make a mark at any stage of the revolutionary process as is the case with Ghana (Tanko, et al., 2023; Sewah, et al., 2023). The world industry is, at this period, experiencing the wave of the fourth industrial revolution, typically referred to as industry 4.0.This paper is not advocating forGhana to attempt leapfrogging into industry 4.0 without setting the base for a firm domestic technology footing.A clear and common understating of technology manufacturing in Ghana with a cultural grip is deemed necessary for that self-ownership and lasting technical changeto lead to the firm domestic technology base.

In view of Ghana's seeming inability to plug in, to establish the needed industrial growth, despite the numerous efforts, the authors of this study, perceive the seemingly absence of technology development scheme,

which is indigenously initiated and culturally embedded, as a major contributing factor to the setback. The very absence of technology to drive the industrial transformation should be seen as key obstacle to industrial reformation. The authors, therefore, considering the chronic stance of the technology lag situation, sought to define a manufacturing system, guided by the culture of the people. The approach employed was to first take a search into other fields of study that focus on technology discussions to gain better understating, hence, its multidisciplinary nature, and then further employ other possibilities.

That is to say simply, this paper emanating from a multidisciplinary perspective, theoretically examines the worldview of the growing body of knowledge towards technology, to find an approach of application skewed towards sustainable manufacturing of technology, which would be groundedina cultural base for acceptance and longevity. Theoretically exploring these fields would provide a multidisciplinary understanding of the role of culture in technology, hence, its manufacturing. By examining various perspectives, theories, and practices, the study seeks to define a worldview that appropriately defines culturally oriented sustainable manufacturing of technology for industry within a developing country context. Through this exploration, the research will identify key principles, methodologies, and lines of reasoning for integrating cultural values into the manufacturing process, ensuring that technological advancements are not only economically viable but also socially and environmentally sustainable.

Volumes of publications abound on the subject of sustainable manufacturing, as such, its discussions are not widely covered in this study.

The aim here is to contribute towards policy formulation inAfrica's industrialisation (focusing on manufacturing of technology) by initiating a discussion to define a culturally embedded sustainable manufacturing mechanism. The study draws mainly from the standpoint of other fields of study besides engineering.

Technology studies from economics, sociology, history and other related disciplines provide vast amount of details into the development, impact, growth and projections of technology. Predominantly among these is the social science concepts, like science and technology study (STS). STS,also commonly referred to as;science, technology, and society, is generally an interdisciplinary field that discusses the use of technology, its creation, development, analysis and consequences of science and technology in their historical, cultural, and social contexts (Neale, et al., 2023; Mansor, et al., 2009).

Moreover, this study will serve as a foundation for further and more elaborate research in this field. By highlighting the importance of cultural adoption in sustainable manufacturing practices, the research, for its contribution towards policy making, aims to encourage policymakers, industry leaders, and scholars to consider and implement strategies that would foster a symbiotic relationship between technology and culture. Ultimately, institutionalising the manufacturing of technology for industry in a culturally sensitive manner is hoped will pave the way for inclusive and holistic technological development, not only in Ghana but also in other developing countries facing similar challenges.

Exploring these various concepts is with the aim to better understand the mindset, arguments and debates surrounding technology discussions emanating from these different perspectives so as to position our definition within a broad contextual framework of knowledge. This is to serve as a means to stimulate thecreation and eventual development of technology for industry in Ghana and the developing world at large.

II. APPROACH TO THE STUDY

This study situates its approach from a non-engineering discussions, juxtaposing them with the fundamentals of engineering in manufacturing principles as would beinherently advanced in the field of *manufacturing/production and operations management* (M/POM).The study expands to incorporate the sustainability philosophy and cultural study. Here, the authors opine that technology creation and development would need to align with the sustainability principles for posterity and be culturally guided for user-societal acceptability and continuity.

In looking at technology from the analyses of these non-engineering subject areas, the paper attempts to reflect these discussions on the fields of engineering, industrial art and similar creative areas of study. The core of the discussion ispredominantly manufacturing engineering;for its role in manufacturing of artefacts.

The focus is however mainly on manufacturing engineering, because of its unique role in having all products to be manufactured. This is to identify its perceptions, analyses and discussions on the technologies it creates (manufactures), with a specific interest in highlighting issues of technology development for technologically deprived societies like the developing world, here, focusing on Ghana.

III. NOVELTY OF THE STUDY

Extensive search made by this study was unable to find new expansions (off-shoots) in manufacturing engineering directed at seeking technological solutions for technologically less endowed economies, like developing countries. However, volumes of such publications exist from different fields of study. Take for

example, manufacturing engineering, as expressed from the field of *manufacturing and production operations management* (MPOM),is concerned mainly with optimising shopfloor operations and improving on efficiencies by eliminating wastes, thus, leaving the discussions on the topic of technology to other disciplines. For example, Benjaafar& Hu, (2020) and Groover (2011) have shown that Operations Management and its associated fields of production systems have been concerned mainly with improving efficiency to enhance optimal production in manufacturing and its peripheries such as supply chain systems, financial function, transport, etc. MPOM has been able to achieve its efficiency and optimisation drive by developing a number of concepts and philosophies such as those found in management science (motion study, time study, etc.) (Pardos, et al., 2022), just-in-time production, lean production (Taghipour, et al., 2020; Hussein, &Zayed,2021), concurrent engineering philosophy (Asyraf, et al., 2022; Álvarez, &Roibás-Millán, 2021;Jo et al., 1991) and others. These MPOM concepts do not necessarily stand to address technology development issues facing the developing world. This study therefore calls for a broadening of MPOM's discussions into manufacturing of technologies for less developed countries, considering the unique role culture plays in development.

IV. CULTURAL ADOPTION OF SUSTAINABLE MANUFACTURING PRACTICES

Culture is a multifaceted and dynamic concept that encompasses the shared beliefs, values, norms, customs, behaviours, and symbols that define a particular group or society. It serves as a social blueprint, guiding individuals within a community in their interactions, decision-making, and understanding of the world around them.

Moreover, culture is not static; it evolves in response to historical, environmental, and social changes. It influences how individuals perceive themselves and relate with others; shaping their worldviews and attitudes, thus, impacting on society. Culture also impacts on communication, as language and non-verbal cues are deeply intertwined with cultural norms and meanings.

Furthermore, culture can have profound effects on various aspects of society, including art, politics, economics, and even technology. *It is culture that determines the acceptability or otherwise of the introduction of new technologies.*Understanding and appreciating the role of culture is essential for fostering cross-cultural understanding, promoting diversity and inclusion, and addressing complex societal challenges in an increasingly interconnected and globalised world.

In the pursuit of technological development and industrial growth, it is crucial to consider the cultural context within which these advancements take place. This section focuses on the sub-topic of cultural adoption of sustainable manufacturing practices.It highlights the significance of integrating cultural values and customs into the manufacturing processes.

While technology development is often perceived as detached from cultural and customary discussions, this research argues that a culturally inspired approach to manufacturing of technology for the industry can foster a sense of ownership and promote sustainable development.

In the case of Ghana, representing the broader context of sub-Saharan Africa, recognises the need to develop its industry and enhance its technological capabilities. To achieve this, it is essential to align technology manufacturing practices with the cultural values and aspirations of the Ghanaian society. By embracing cultural adoption of sustainable manufacturing practices and development (Zheng, et al., 2021), Ghana can establish a stronger sense of ownership and participation in technological advancements, which will contribute to the overall economic strength of the nation.

It is here worth noting that, within the context of this paper, all articles of culture, and indeed, all objects are technological artefacts, except if they occur naturally and remain in their natural state without any alteration for use of purpose. Thus, by this understanding, even an ordinary deliberately chipped stone for the purpose of cutting, or for any other purpose, is here considered to be transformed into an item of technology.

V. PERCEPTION OF CULTURALISATION: THE ROLE OF INSTITUTIONS

The concept of culturalisation in the context of technology manufacturing refers to the integration of cultural values, beliefs, and practices into the design, production, and implementation of technological solutions. This study as anotionemphasises the importance of cultural inspiration in the manufacturing of technology for the industry. However, understanding and effectively implementing culturalisation requires the active involvement of institutions (Rugkasa&Ylvisaker 2021).

Institutions play a crucial role in shaping and influencing the perception of culturalisation within the technological ecosystem (Masimba, et al., 2019). They provide the necessary framework and support to ensure that cultural values and customs are integrated into manufacturing practices. By fostering an environment that values and recognizes the significance of culturalisation, institutions can promote a sense of ownership and development within society (Allen, et al., 2021).

In the Ghanaian context, institutions such as government agencies, educational institutions, research centres, and industry associations play a vital role in facilitating the cultural adoption of sustainable

manufacturing practices. These institutions can act as catalysts by creating policies, providing funding and resources, and promoting collaboration among stakeholders. They can establish guidelines and standards that incorporate cultural elements into technology manufacturing processes, thereby fostering a sense of cultural ownership and identity.

Moreover, institutions can also facilitate knowledge exchange and capacity-building initiatives to empower local communities and manufacturers to embrace culturalisation. By organising workshops, training programmes, and awareness campaigns, institutions can enhance the understanding and appreciation of cultural values in technology manufacturing. Through partnerships with cultural and heritage organisations, institutions can ensure that the knowledge and wisdom of indigenous communities are preserved and integrated into the manufacturing process, which is engineering and scientific in principles.

Recognising the role of institutions in promoting culturalisation is crucial for the successful implementation of sustainable manufacturing practices. By incorporating cultural elements into technology manufacturing, institutions can drive economic growth, social cohesion, and environmental sustainability. Additionally, their efforts in institutionalising the manufacturing of technology for the industry can serve as a model for other developing countries facing similar challenges.

VI. THE ROLE OF INSTITUTIONS IN TECHNOLOGY CREATION

Institutions are very important in delivering programmes of national agenda.

Considering harnessing cultural prowess to achieve an objective (here, sustainable manufacturing of technology), it is imperative to treat culture in an institutionalised order. The traditional setup, typically, embodies all aspects of culture and its interpretations.

The traditional setting in Ghana, in itself, presents a complex relationship comprising of varying cultures from different ethnic and historical backgrounds, with its institutional arrangements and structures (Appiah, 2020; Lin & Nugent, 1995). The traditional sector could possibly provide greater understanding to the quest for enhancing the productivecapacity, since it is native to the people.

Unfortunately, however, the traditional sector, to a very large extent, has not received the needed attention from national policies for involvement in this area of discussion. Subsequent government administrations have persistently modelled their system of governance to reflect the structure of the developed world (Gaskell, et al., 2020; Yagboyaju, &Akinola, 2019; Edgerton, 2008; Chevalier et al., 1992), hence, adopting their mode of institutional approach, without modifying them to local content. Indeed, according to Herbst (1997), the early African governments sought to flatten the traditional landscape. Developing countries like Ghana, seems to have directly adopted the foreign system of institutional arrangements and its overall structure as earlier suggested by Price (1975). This has led to a persistently bureaucratic system of inefficient, weak or inexistent institutional linkages (Johnson et al., 2003; Lin & Nugent, 1995; Price, 1975, Szogs et al., 2009) since they are alien to cultural systems. How these institutions can be structured in the context of the traditional sector to enhance its linkages for technology creation and development by itself is the overall challenge in this study as the traditional sector is noted for not consciously able to make improvements to its artefacts and processes for reason of cultural heritage and preservation.

VII. FORMAL AND INFORMAL SECTOR INSTITUTIONALISATION

Ghana, emerging from its traditional (informal system) ways of doing things, which is non-formal, non-universal and comparatively, less efficient, is confronted with the more structured but bureaucratic formal system (Appaih, 2020; Davidson, 1992) to work with. It is unable to compete effectively with the incoming bureaucratic system. The two systems seem to be in contention, as they are unable to merge even when they have duplicating roles (Englebert, 2002).

The realisation of the relevance of institution in economic development is actually a recent occurrence and has led to a new branch of economics referred to as New Institutional Economics (NIE) (Chang, 2003; Lin & Nugent, 1995). According to Lin and Nugent (1995), although NIE is essentially microeconomic in perspective, it also includes several distinctive approaches to the analysis on institutions, each with its own techniques, concepts, advantages and disadvantages.

The economic theories of NIE do not in themselves have any direct bearing on issues of technology or its creation, but, giving a broad understanding of the term and description of institution, its arrangements could be seen to, not only greatly influence, but also determine the position of technological growth and creation. For example, standard economic theories, like those shown in the works of Cohn &Hira, (2020),Oatley, (2022) and others, have not demonstrated evidence of economic theories leading to economic transformation and growth like the case of in Korea, because it did not anticipate the effect institutions had on the working environment, conditions and attitude of the people (Chang & Evans, 2000). Like all other industrialised (or, industrialising) nations, Korea's economic transformation is attributed to its technological achievements (Bowman, 2020), hence,its rapid technical growth (Lundvall&Borras, 2005). Institutions are therefore seen to play an

indispensable role in economic development, which, invariably is technology-creation dependent. This work, not being a study of economics may not delve into its extensive discussion, but would seek to underpin the relevance of the concept of institution on to technology creation and development, i.e., culturally sensitive institutions in "natural linkage" with existing cultural institutions. In doing so therefore, it would be helpful to lay out clearly, for common ground discussion, what is meant by institutions using the work of Lin and Nugent (1995).

According to the above mentioned authors, the term institution is used in a variety of ways, and may be defined as a set of humanly devised behavioural rules that govern and shape the interactions of human beings, in part by helping them to form expectations of what other people will do. The authors pointed out from the definition why institutions could consist of both formal entities on one side, like laws, constitutions, written contracts, market exchanges and organizational by-laws and the other side, informal counterparts, like shared values, norms, customs, ethics, and ideology. In short, all such institutions involve rules that can constrain behaviour over a certain domain and give rise to behavioural regularities.

Thisstudy therefore wishes to place emphasis here that institutions are people oriented. In other words, they are created by humans and for humans. They cannot function on their own, but need people's commitment for efficient functioning. By this therefore, it can be seen and said that human behaviour,when viewed under the scope of perception, attitude, etc., culture, is fundamental to their operation. This could be traditional (customary) institutional culture or formal institutional culture.

As mentioned earlier, members of an institution are governed by its rules (depending on the functions of such rules), which impact on their behaviours and attitudes and they in turn bring about institutional change as they likewise impact on the institutions, thus, creating a two-way system (Chang, 2003). This two-way system actually explains why and how institutions are formedwith new ones emerging, sometimes to compete (Chang & Evans, 2000) for dominance.

The emergence of institutional competition signifies the variances in human behaviours. However, when talking about formalising traditional institutional systems, some pertinent questions come to mind. For example, in the Ghanaian traditional sector or system, what constitutes its version of an educational setup as an institution? How does one formalise the educational system of the traditional institution (when there is none, if there is none)? For a common ground discussion; if education is considered, for example, as a structured system for the acquisition of knowledge, then could oral tradition, from the traditional sector (Gyekye, 2003), be thus defined and formally institutionalised? This contention comes up since Africa's system of knowledge, as in oral tradition and training are neither structured nor synchronised with the formal educational structure, hence giving rise to dispersed institutions. Indeed, oral tradition (informal) is not recognised in the mainstream educational system in Ghana (World-Data-on-Education, 2010/11).

Similarly, the chieftaincy institution has remained isolated from the formal sector and relegated to customary interpretations (Beall&Ngonyama 2009; Davidson, 1969;Englebert, 2002), even though in Ghana, there is an attempt to formalise its recognition in the governance structure (Fuseini, 2021). These can go a long way to signify the non-existent institutional linkage between the formal and the informal(traditional) sectors. This institutional scenario applies to other settings of both the traditional and formal sectors as their institutions often do not interact, thus, posing significant challenge to overall development agenda. Such conspicuous problems make the study of the formation and development ofthe traditional institutions relevant in the creation and development of technology in the society. This takes to cognisance the significance of the traditional sector as constituting a component of originality in the Ghanaian demography and societal structure.

The Role of Institutions is needed in the technology creation exercise for Socioeconomic Development.

Existing literatures, have so far, shown how developing countries (with focus on Ghana) could be characterised as having little or no domestic technology base, and as such, are heavily reliant on the industrialised world for their technological solutions. Their situation has received extensive analyses from economists, sociologists and historians alike, with the economists' analyses advancing from NIE and eventually leading to the emergence of the National Innovation Systems (NIS), and others, by extension, to modern approach of sustainable development goals (SDG) (Bowman, 2020).

It may at this stage be helpful to look at technology discussion from otherfields of study.

VIII. TECHNOLOGY DISCUSSIONS IN VARIED FIELDS:

- **ECONOMICS**

Technology manufacturing, essentially, an engineering exercise, is seen as relevant to industry, hence, national economy. However, theseimpactful technologiescreated from manufacturingprocesses and theireffectson human life and businesses have generated interestsin other fields of study, leading to extensive discussions and analyses spanning beyond the boundaries of engineering. This has brought about changes to traditional subject areas like classical economics, which treats technology as exogenous in its theorems.

Different traditions in the theories of economics nevertheless, oppose each other disagreeing in contents and principles as new theories evolve. It is however argued that economists actually do not disagree on the fundamental principles of economic theories. Where contentions arise is when applying the details, in other words, when trying to focus the larger picture onto the smaller screen (Weintraub, 1985). Some of the controversies in approaches put forward for economic development by the progenitors of classical economics (Marx & Engels, 2013) were, for example, earlier highlighted by the developers of marginal economics such as the work of Irving Fisher (Fisher, 1906) and others.

This branch of economics claimed that classical economic theories did not reflect the `value' of the price people would pay for a commodity, but was based on the balance of its demand and supply till saturation occurred (Weintraub, 1985). The saturation theories of marginal economics eventually evolved into neoclassical economics, which works with, `economic agents' which could be households or firms. These agents are conceptualised as `relational actors' modelled for optimisation'. The theory asserts the essence of technology and science in economic development (ibid), but does not explicitly lay out its new approach until development economics (Schumpeter &Swedberg, 2021) emerged broadening the scope of `economic agents' as institutions, hence, the concept of institutional economics and national innovation systems (Lin and Nugent, 1995, Lundvall, 2010;Lundvall et al., 2001;Szogs et al., 2009). This is subsequent to the intermediate technology approach, which randomly became referred to as the appropriate technology movement (Schumacher, 1974).

This new approach to the evolving development economics is perceived by modern economists to be most beneficial to developing countries as it takes into cognisance the value and influence of social capital, such as *custom, tradition and culture*. These are seen to characterise the African economic outlook (Long, & Ascent 2020; Lin & Nugent, 1995). It may be argued that these economic development approaches have not been able to translate into economic growth for Africa. They also neither explain the low or absence of growth that characterise the African States (Nunn, 2020; Aryeetey&Fosu, 2008; Frazer, 2005; Teal, 1998) in relation to the presence or absence of a technology development interface/system. In view of such problems, Sachs' (1992) description, looking at a UN record, sums it up as" ...a problem compounded by cyclical factors, borne most heavily by the third world" (Sachs, 1992). A proposed solution put forward by Sachs to the disappointing outcome of relying on `monodisciplinary approaches' in development economics was that; "A restructuring of the development paradigm is called for, debunking the conventional development economics and transcending the mystifying distinction between economic and non-economic factors introduced in a simplified, if not caricatureal, way into formal deductive models". Thus, taking the position of the author to debunk conventional development economics, this study therefore seeks a pragmatic approach to creating technology, which incorporates the concerns of socio-cultural-techno-economic development.

Building the engineering position may require further perspectives of other fields of study besides the efforts from economics.

- **SOCIOLOGICAL PERSPECTIVES TO TECHNOLOGY**

Looking at technology as being relevant to a national economy alone could be perceived as underestimating the extent of its influence and the relationship it creates between humans and artefacts in society. Such consideration has been broadly expanded by the actor-network theory (Prout, 1996) popular among sociologists, especially those of the science and technology studies (STS) cohort. Human history is often seen to be intertwined with the evolution of technology (Khalil, 2000) so much so that existence of civilisation without technical change could not be conceived (Rip 2020; MacKenzie&Wajcman, 1999). As such; technology is sometimes viewed as a separate entity outside of society with which to interact, i.e. an object that society is dependent on and must adapt to. Sociologists have however been able to put forward explanations from arguments and counter arguments, challenging such narrow [parochial] perception and broadening the scope to defining technology as being a constituent of society, influencing it and it being influenced by society in turn. This line of reasoning sets the ground for the Social Shaping of Technology (SST) (Howcroft, & Taylor, 2022; Hughes, 1987, MacKenzie&Wajcman, 1999, Williams and Edge, 1996). Pantzar (2010) sees the work of SST as a non-deterministic model of technology change. Indeed, MacKenzie&Wajcman's (1999) work must have set the ball rolling in this position, pointing out that technology determinism (Țicau, &Hadad, 2021; Ogburn, 1938), which in effect asserts that technology accounts for the development of a society, is an oversimplified representation of the overall picture. In the determinist's view, according to the authors, technological change is perceived as an independent factor impacting on society from outside of society. SST therefore claims to provide a holistic approach of looking at technology which is actually shaped by a range of social and economic factors, including technological factors, as in, technology shaping of technology (MacKenzie&Wajcman, 1999, Williams and Edge, 1996).

In the discourse of this study, trying to understand technology as a construct of human society, as put forward by SST, raises the question of where to place the limits of society. That is to say, when the question is viewed against the backdrop of technological development, how far does social determinism define the bounds

and limits of technology advancement, deployment and acceptability? In other words, is it economy or technology embedded in society or vice versa that plays the leading role? In fact, this argument seems limited to technologies where society is the user. The rule does not appear applicable to the use of technology at firm [industry] level. More so could it not be argued that technology sometimes develops outside the purview of society before it is later recognised and accepted (or rejected as the case may be)? For example, history of the automobile has it that its emergence faced serious opposition and competition, suggestion an initial rejected by society, but has now become an invaluable part of family life, hence, society at large as in vintage cars (Clarke, 2020). These and other technological artefacts have invariably determined the picture of modern society in support of technology determinism. Probably, owing to such obvious presence of technology, SST recognises technology as an active shaping force in its development (Howcroft, & Taylor, 2022;MacKenzie&Wajcman, 1999). This position by the authors whose work supports social determinism as opposed to technology determinism looks more like coming to a compromise with technology determinism, at least in this area by stating that `there is no single dominantshaping force'. By such statement, the authors are invariably agreeing with technology determinism as an inevitable contributor to the theory of social determinism (i.e. SST), as the politics of artefacts (Winner, 1980) could actually be a complex network.

SST in its build up could however be seen as providing a perspective for alternative analysis and discussion of technological change, but as it logically reverts to the prominence of technology as the force to reckon with, this discussion will place more emphasis on the pursuit of technology. Thus, technology could be described as exhibiting `power' over society, and, society impacting its influence in determining its acceptance or rejection.

These non-engineering contributions evolving into concepts and theories raise the question of what concept or approach is `engineering' putting forward to address the question of technology drawback in developing countries. This study further emphasises that environmental, economic, social and cultural sustainability should be the hallmark of any approach that may be developed from the engineering perspective.

- **TECHNOLOGY DISCUSSIONS IN MANUFACTURING ENGINEERING**

As we have seen so far, discussion of technology, spans the fields of Sociology, Development Economics, Political Economics, History of Technology (Edgerton, 2008, Singer and Williams, 1954, Austin &Headrick, 1983), Geography of Industrial Practice (Gertler, 2004), and others not explored in this study.

Technology discussion is however not visible in the extended fields of Manufacturing Engineering such as; Manufacturing and production Operations Management (Hill & Hill, 2012), Operations Research (OR) which, evolved from Management Science (Hillier & Lieberman, 2001, Winston, 1994). These could be described as offshoots of manufacturing engineering during the boom of factory productions (ibid), most notably during the Second World War (Edgerton, 2008). To advance the discourse, a common ground of understanding of technology is needed, thus, an attempt to define manufacturing.

IX. DEFINING MANUFACTURING AND ITS ECONOMIC RELEVANCE

The term manufacturing is so variedly used that it means different things to different people. This sub-subsection will attempt to construct a common understanding of the subject for this discussion.

When speaking on the subject of manufacturing, in most cases, the first things that come to mind as examples of manufacturedproducts are cars, computers, mobile phones, etc. These are clearly good examples of manufactured goods, but in principle, taking a broader perspective, the term "manufacturing" is not limited to these goods alone. Literally speaking, every object that forms part of the human material world is obtained through manufacturing, except for naturally occurring events which remain unaltered and in their natural state of condition. Thus a term broadly used by different fields of study, manufacturing lends itself to differing interpretations. The engineering perspective of manufacturing becomes of interest here dressed up with a cultural underpinnings and intent. To proceed with the discussion, it would be helpful to see previous scholars' opinion.

According to Groover (2011), the word "manufacture", is derived from two Latin words; *manus*, meaning hand, and *factus*, which means to make. In other words, to manufacture simply means to make [something] by hand. This original meaning of the word is shared by a number of authors, one of which is Lu, et al. (2020).

This meaning fits every society and culture, as peoples everywhere need to make the things they need to survive on, e.g. baskets, canoe, chisel and hammer, etc. through to more sophisticated products like combined harvesters, ships, computers, cars and so on.

Furthermore, this study claims the position that manufacturing technology impacts on other professions directly or indirectly as their means to getting their tools and equipment to carry out their professional tasks. This can range from the office pin to the most sophisticated medical or scientific instrument. See Figure 1

below. There, it attempts to show how manufacturing technology relates to providing the products required in human society cutting across other fields of profession.
It could be described as being central to all other professions and trades (see Fig. 1) as they all rely on the use of equipment, which must necessarily be manufactured.

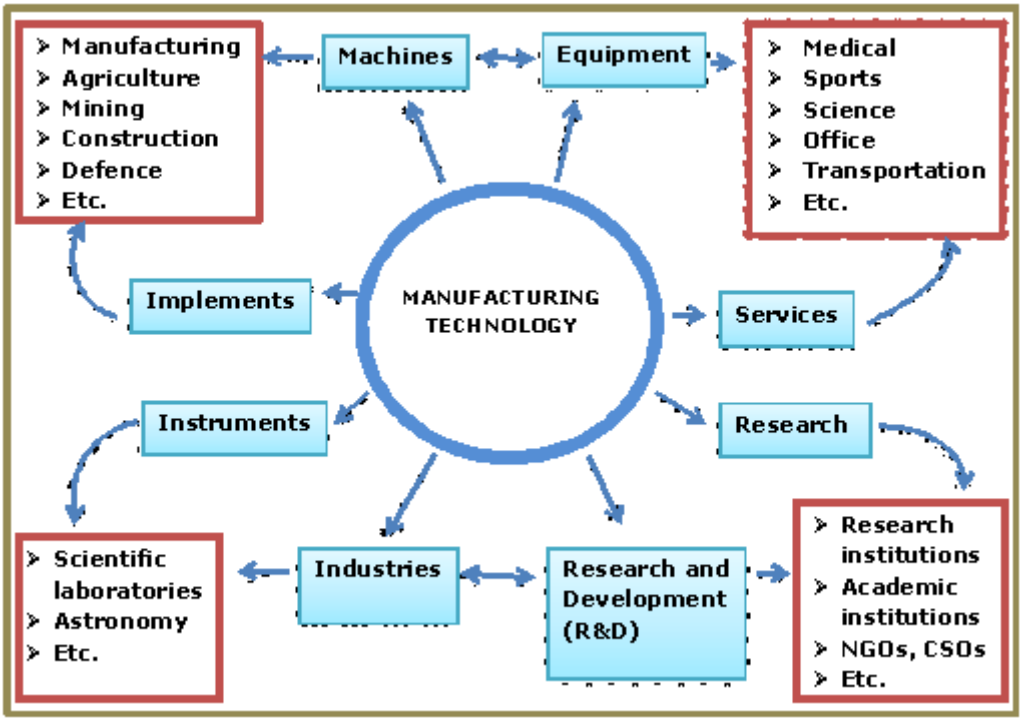

Fig. 1. Centrality of manufacturing technology

Manufacturing today is however, no longer limited to making things with the hands. Haven moved on from the "making" of things by hand, now tools and other machines (systems) are used in manufacturing.Technologies have been developed (manufactured), with varying levels of sophistication and used in many areas of production to convert raw materials into finished products (Chryssolouris, 2006; Creese, 1999;Kaebernick et al., 2003b). These systems (the technologies e.g. machines, robotics, etc.) employed in the manufacturing process will be referred to, in this study, as *manufacturing technology* (i.e. the technology used in manufacturing). Groover (2011) has elaborated upon the technological and economic perspectives of manufacturing by denoting the technological perspective as the application of physical and chemical processes to alter the geometry, properties, and/or appearance of a given starting material. The economists' perspective was the *adding of value* to a material by changing its shape or properties. This was previously expanded by Freeman (2006), who views manufacturing as a wealth-producing sector of an economy.

From the above discussions, the picture being painted here to define manufacturing, sees manufacturing essential as *using technology to alter a material into a value-added finished product to suit the need of society*. This may be the market, industry, individual or the firm. The use of the term society in studyincludes all humans and their activities in the world of materiality.

In summary, the engineering perspective ofmanufacturing is concerned with the transformative processes involved in meeting physical needs, while the economist's perspective is focused on the commercial value to be gained. The economists' stance detaches from how the product is made, while the engineers' concern is how to make the product efficiently and economically. Let the reader recall that, the end-product could itself be a technology to be used for the manufacturing of other products, that is, manufacturing technology.

- **MANUFACTURING OF TECHNOLOGY**

It may be noted here that the manufacturing of technology, which is the focus of this study, is not limited to the term, manufacturing technology. In essence, manufacturing technology is a noun and encompasses the tools, knowledge and techniques by which all manufacturing and productions are made possible (AMT, 2013; Khalil, 2000). Manufacturing of technology on the other hand, is the process (the verb) of making (manufacturing) the technology and it is mainly concerned with using these tools, knowledge and techniques (i.e. using the manufacturing technologies, which is the noun) to manufacture all the needed technologies,

including the technologies used for manufacturing, i.e. the manufacturing technologies. Thus the terms; manufacturing of technology and manufacturing technology which recur in this study, should be considered as distinct terms.

Sustainable manufacturing on the other hand looks atsources of raw materials, the amount of energy required for processing, and so on (Machado, et al., 2020).

- **DIFFERENTIATING BETWEEN MANUFACTURING AND PRODUCTION**

The terms manufacturing and production are very similar in meaning, and are often used interchangeably, though they differ in meaning and application. Groover (2011) for example sees production as having a broader application than manufacturing in the sense that one could say, `the production of crude oil', but would be incorrect to say; `the manufacture ofcrude oil'. It is however accurate to say; `the production of a car' and `the manufacture of a car'. These examples however do not provide detailed explanation as to the difference in their meaning and usage. In the opinion of Creese (1999) and Kaebernick et al. (2003) the difference in both terms has to do with geographical location, thus manufacturing engineering is used by the Americans, while production engineering is the preferred choice for Europeans and Japanese. This line of differentiation is too simplified and cannot be used to explain Groover's examples; neither did Groover give any further explanation to differentiate both terms beyond the example presented. An attempt to clarify the difference between manufacturing and production is made here:

Note that manufacturing does not occur freely in nature, i.e. everything around us, which is not a naturally occurring event, is manufactured. Hence, using Groover's example as a point of departure; crude oil is a naturally occurring material; hence, it cannot be manufactured.

The process of its extraction (production) however requires the use of technology and technology generally has to be manufactured. So, manufacturing creates (makes, produces) the technology and the technology is used in the production (extraction) of the crude oil. In other words, one can also say, technology is produced through manufacturing, but not vice versa, i.e. it may be incorrect to say, technology is manufactured through production. That is to say; we manufacture `something', say a machine, and use it to produce things (replicate or produce products). Expounding further on the example, it could be said that in the modern manufacturing process of an automobile (or the production of an automobile), the various components that make up the automobile will need to be manufactured (or produced) individually using its specialised and dedicated manufacturing technology. Recall that this manufacturing technology (which could be a mould, a press, robot, machine, etc.) will be used to produce the various components. This can then be [re]produced in large quantities (for interchangeability). That is to say, due to the requirement for large quantities of standardised parts, manufacturing these components individually will not make the car production cost effective. As such, a technological piece of equipment (the technology) is manufactured (or produced through manufacturing) and used to produce (to reproduce, to replicate) the specific part or a range of parts in large quantity (mass production) based on the principle of interchangeability (i.e. producing identical parts with exact dimensions and features). These mass produced interchangeable parts will be assembled together (assembly line production) to build the required automobile to specification.

Put in a different form, as understood from the Association for Manufacturing Technology (AMT, 2013); manufacturing creates the means for production to take place, whereas production is the churning out of the manufactured product or system using a technology designed and manufactured for that task. An illustration of this is: A mould is manufactured and then used to produce engine block by the process of casting. That is to say, the mould is manufactured or made to be used to produce engine blocks by casting, hence, the production of engine blocks (not manufacturing) is done by using the mould, but the mould must necessarily need to be manufactured. Using production therefore, any quantity of equal dimensioned engine blocks could be produced (interchangeability) using that mould.

So, in as much as the two terms are similar in meaning, hence, used interchangeably, they actually carry their specific identity in meaning and application. Setting out the difference is imperative to this study, as the aim of the study may not be achieved if the term, manufacturing is misconstrued to simply mean production. The above explanation, as understood from literature and scholars in manufacturing, is an attempt to present manufacturing as responsible for bringing a product into real world existence from concept. That is, brining it from the abstract world of design, conceptualisation or imagination into the world of reality. Manufacturing can therefore be seen to predate production, whereas production, on the other hand, comes in after the product has been manufactured, tested and approved for replication (Creese, 1999;Groover, 2011).

Manufacturing of products in this modern era does not come about as a single occurrence. It involves certain activities even in its simplest form like being `made by hand'. The practise of manufacturing has not remained in its simplest form. As deduced from literature, its advances and complexities have meant that it is now carried out involving different stages of activities. Different authors identify these activities differently though with a common convergence. In conformity with the objective of this study and in commonality with

manufacturing processes, the manufacturing activities identified are listed, as shown in Fig 2. They are here considered to include, but not limited to the following: planning, design, supply chain (materials), setup, manufacturing-production-craftsmanship, marketing and research. In addition to these is the product end life, what to do with it; recycle or dispose. It is the duty of manufacturing, for sustainability reasons, to provide a clear guideline of its intention for the product's life span. These activities need to be carried out under the consideration of the concept of the sustainability philosophy.

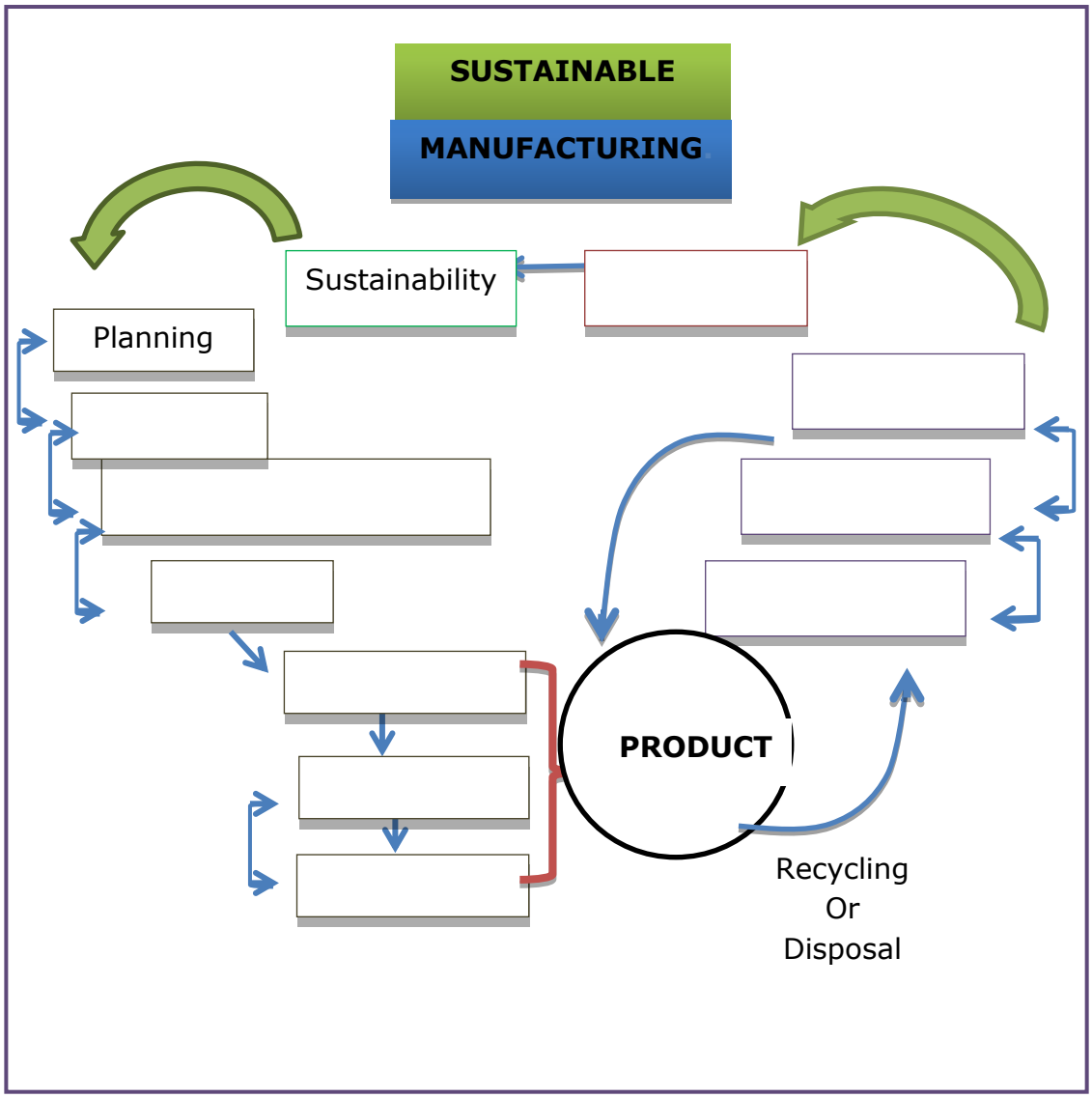

Fig. 2Sustainable manufacturing activities

As can be seen from Figure 3below, manufacturing technology (MT), going through a manufacturing activity, is used to manufacture products both for the provision of services or as consumer goods. It can be seen from the bottom-left of the figure, how the service sector, like banking, health, etc., rely on the use of technological artefacts (machines, instruments, computers, etc.), as pointed by the arrow to the right box, to carry out their work. This emphasises the point that without these manufactured "instruments" and others, the profession and the service sector may not be able to adequately dispense its duties.

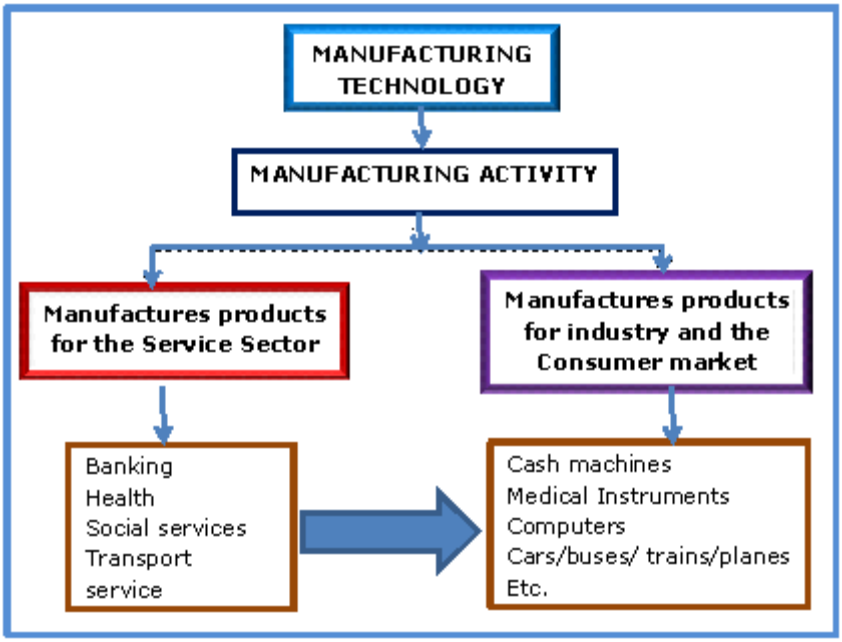

Fig. 3Model of showing manufacturing technology

Similarly, Figure 3 above, attempts to depict the centralisation of the (MT) in all industries. For example, taking looking at the contents of the four boxes at the four corners in the Figure, the central manufacturing technology is used to manufacture all the machines, tools, equipment, etc. for the various industries, including the manufacturing industry, agriculture industry, mining, medical and all the other industries.

X. CONCLUSION

This research paper attempted to undertake a comprehensive exploration of technology study from a multidisciplinary perspective, with a particular focus on its application in sustainable manufacturing of technology for Ghana's industrial development, driven by cultural undertones. By delving into various fields of study, including economics, sociology, history, and social science concepts like science and technology studies (STS), the paper has laid the foundation for a holistic understanding of technology's role in advancing the productive sector of the economy and the role of institutions.

The study's primary objective has been to contribute to the formulation of effective policies that can enhance Ghana's industrial growth. By bridging the gap between technology and culture, the research emphasises the importance of culturally acceptable manufacturing and production systems, which are essential for gaining societal acceptance and fostering a sense of ownership and commitment toward technological advancements.

Through this theoretical examination, the paper has highlighted the significance of integrating indigenous knowledge and practices with modern technological approaches. This cultural adoption of sustainable manufacturing practices can lead to environmentally friendly and economically viable solutions, aligned with the needs and aspirations of local communities.

The integration of insights from various disciplines has facilitated a broader understanding of technology's impact on society and the economy, opening avenues for more informed decision-making in policy formulation. By recognizing that technology is not developed in isolation from cultural contexts, but rather co-evolves with societal norms, this study underscores the importance of incorporating cultural inspiration and the involvement of diverse stakeholders in the technology development process.

This research contributes to the academic discourse on technology and cultural adoption in sustainable manufacturing practices, particularly in the context of Ghana's industrial growth. It serves as a stepping stone for further research and provides a solid framework for policymakers and stakeholders to develop strategies that promote inclusive and culturally relevant technology manufacturing, thereby fostering sustainable and equitable economic development.

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