Could open source ecology and open source appropriate technology be used as a roadmap from technology colony?

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Abstract: In the quest for sustainability, emerging economies can no longer rely on the vertical transference of foreign technologies. Therefore, the development of endogenous technologies as a driver of any sustainable national industrialisation efforts should be reoriented. Technological independence is profound in ensuring sustainability, which according to the research findings, is inhibited by the resilient status of a technology colony. A technology colony demonstrates interests in production and sales, than in idea generation, research and development (R&D), and industrialisation of new products or services. The aim of this article is to provide a brief explanation on what a technology colony is, and how it affects innovation and development. In a next step, the significance of open source ecology (OSE) and open source appropriate technology (OSAT) concepts as a roadmap to eliminate the effects of technology colonisation on the sustainable development of emerging economies are explored relying on a qualitative literature review.

Keywords: sustainable development; technology colony; openness; value creation; technology transfer.

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1 Introduction

Due to the deficient development of their national systems of innovation, industries in the technology colonies are more dependent on foreign technologies for the development and improvement of their products, services, and processes (De Wet, 1999; Buys, 2004, 2001). From this viewpoint, we affirm that most developing economies portray the traits of technology colonies, and can thus be referred to as technology colonies. Radosevic (1999) points out that "the wider the technological gap, the more reliant a country will be on the importation of foreign knowledge and technologies". With inadequate resources to engage in broad R&D activities, most developing countries are playing technological catch-up with the developed countries, through the acquisition and absorption of innovative technologies or by imitating foreign technologies (Glass and Saggi, 1998; Hobday, 2005), though this approach still represents a display of technology colonialism.

However, most scholarly articles have subjected the economic growth, technological advancement, and the sustainable development of resource rich developing countries to the acquisition of foreign technologies, with less attention given to the development of poignant endogenous technologies, which eventually results in the intended socially sustainable development of technologies, and hence the economy.

Buys (2004) outlined that due to the lack of endogenous technological efforts, the deficient technological base of scientists and research facilities, inadequate R&D budgets, and customers low disposable income, the innovative capabilities of developing economies are expected to be incomparably low to that of the developed countries. The verification of this statement can be vividly observed since the inception of the global innovative index (GII) report, with the growth of most developing countries dominant in the lowest part of the GII (2014) rankings.

Within this paper, we aim to propose the open source ecology (OSE) and open source appropriate technology (OSAT) as some of the viable means to initiate a transition from a

technology colony to a technology advanced state. OSE and OSAT are complementary strategies that rely on the concepts of openness, networking, decentralisation, collaboration-oriented development, thereby challenging existing predominant value creation paradigms. The introduction of these two initiatives has encouraged the development of intermediate and alternative technologies which was highlighted by Schumacher (1973) as an effective means developing countries could use to foster productivity by adopting and adapting advanced technologies to their unique needs.

Through structured literature review, the research aims to provide an outline of the technology colony concept, and to show the effects of technological colonialism on the growth of emerging economies. Furthermore, we aim to explore the potential contributions of OSE and OSAT in eliminating the effects of technology colonialism in emerging economies, but also outline the limitations of these concepts.

2 Literature review

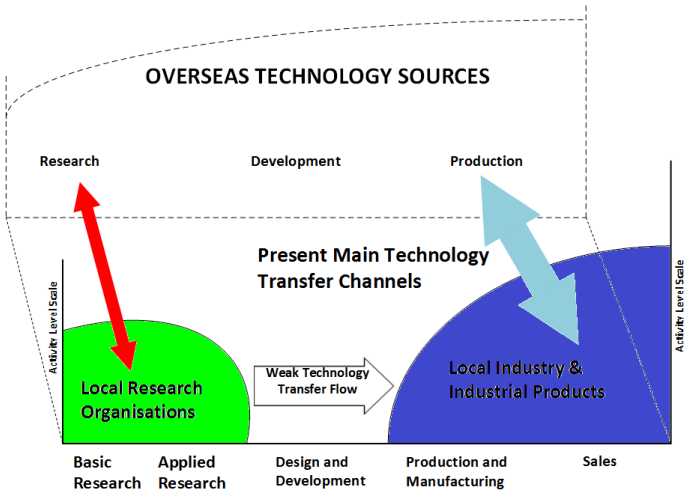
In the present technological era, the sustainable development and economic growth of both emerging and developed countries are highly attributed to their technological prowess and their level of industrialisation (De Wet, 1999; Buys, 2004; Kachieng'a, 2009). Various empirical studies were able to show that there is a massive technological gap between the technology frontiers of the colonies and their former colonial figures (developed countries). Though technology transfer has been purported to be one of the fundamental processes that influences the sustainable performance of an economy (Radosevic, 1999; Ramanathan, 2008), the inability of emerging economies to improve the quality of life of their citizens and the delays in economic developments are resultant effects of the technology colony (De Wet, 1999; Gardner and Lewis, 1996). The features of the technology colony are as follows (Figure 1):

- business activities in the technology colony are predominantly at the production and sales or 'trade-in-final-products' end of the product life cycle (De Wet, 1999; Kachieng'a, 2009)
- research and development (R&D) represents a small group of activities on the product life cycle, with more focus given to incremental innovation (De Wet, 1999; Kachieng'a, 2009)
- in-flow of technologies in the technology colonies are predominantly based on the horizontal technology transfer from the developed countries (De Wet, 1999; Glass and Saggi, 1998; Kachieng'a, 2009)
- lastly, the vertical transference of technologies within the product life cycle in the technology colony are trivial (De Wet, 1999; Kachieng'a, 2009).

Nepelski and De Prato (2015) speculated that developing countries will become important producers of technologies demanded by other countries. However, the validity of this statement depends on the perpetual focus in creating a vertical transference of technology during the entire product life cycle, rather than their focus on production and sales. Therefore, in the quest for global sustainability, emerging economies can no longer rely solely on the acquisition of foreign technologies and R&D (Kim and Jung, 1998; Desai et al., 2002), they also need to focus on the development of endogenous

technologies as in the cases of South Korea, India and China (Nepelski and De Prato, 2015; Kim and Jung, 1998; Desai et al., 2002). Hence, a stringent focus should be given to the development of endogenous alternative technologies as a major capital that drives any sustainable, national industrialisation endeavours.

Figure 1 Technology transfer channels in the technology colony (see online version for colours)



Source: De Wet (1999)

Therefore, facilitating an effective transition from a technology colony to a technology decolonised state means creating adequate coopetitive (i.e. competitive and collaborative) presence in the global market. This can be accomplished through education, development of human capital skills as well as through the creation of attractive business environments (De Wet, 1999; Kachieng'a, 2009) that foster the integration into global value creation processes that are directed towards a collaboration-oriented rather than an export-oriented industrialisation (bottom-up economics), self-organisation, and openness (Sikka, 1996; Redlich et al., 2014).

2.1 The technology colony as a barrier to development

De Wet (1999) further outlined that the developmental activities in technology colonies were solely designed around the subsistence of their natural resources, which serves as the major determinant of the infrastructural developments. This poses as a barrier due to the equivocal focus on production and trade of mineral resources in raw forms, rather than development of exemplary endogenous technologies to efficiently manage the production and distribution of the resources. Thus, they are denying themselves the economic value adding opportunity of beneficiation (Figure 1).

Secondly, De Wet (1999) highlighted that technology colonies are technically dependent on their former colonial leaders for industrial and economical support, which becomes visible in the predominant engagement of nationals of the former colonial leaders in the financial and industrial affairs of the colonies. Unarguably, this serves as a barrier for the development of human capital in the technology colonies, and limits the opportunity for natives in the colonies to gain experiential training in research, design and

development environments, in order to boost their entrepreneurial flairs to co-create local technology-based enterprises that effectively manage their resources (De Wet, 1999).

Lastly, in the technology colonies, secondary industries developed to purvey consumer goods either emancipated as subsidiaries of foreign organisations or as independent local enterprises with a preponderance of ownership and technological support from foreign companies (former colonial leaders) (De Wet, 1999; Kachieng'a, 2009).

From these physiognomies, it is evident that the value creation processes in technology colonies are predominantly based on an asymmetrical top-down economics approach, which gives little attention to the creation of real value needed by the natives (bottom-up economics) of the colonies. Therefore, it is pertinent that the technological colonial status is detrimental to the sustainable growth and industrial development of a developing country, with its net effect recorded in the perpetuation of technological supports from the former colonial masters (Kachieng'a, 2009).

Having stated the features of the technology colony, the basic factors required in traversing to a decolonised economy, and the inhibiting effects of the technology colonial status, the following paragraph gives a detailed description of OSE and OSAT and their potentials in fostering an adequate technological value creation process.

As stated in the introductory section, the OSE and OSAT are complementary platforms based on the concept of openness or open innovation and the bottom-up economics approach that rely on interaction and collaboration between all actors in the value creation process at eye level. Recent publications in the field of innovation, production engineering and technology management have largely attributed the concept of openness and co-creation paradigms as the viable means to advance the value creation process, and to enact the development of a sustainable society (Sikka, 1996; Redlich et al., 2014; Basmer et al., 2015; Chesbrough, 2006; Heyer et al., 2014; Sargsyan et al., 2009; Osunyomi, 2015; Buxbaum-Conradi et al., 2014; Laursen and Salter, 2006). We aim to shed more light on these concepts in the following sections.

3 OSE and OSAT

3.1 Open source ecology

The OSE is a movement framed on a paradigm that surmises that the development of an open source economy is an avenue to develop a harmonious and prosperous community through the democratisation of technology development and the realisation of distributive enterprises that are replicable and create sustainable circular systems (Thomson and Jakubowski, 2012). Open source economy is assumed to be an economic approach that is profoundly efficient in promoting sustainability. The efficiency of the open source economy is measured on the maximum impact of the innovative capacity and level of interactive opportunities created for manufacturers with minimal capital (Thomson and Jakubowski, 2012). The OSE consists of various enthusiasts with keen interest in the concept of openness, networking, collaboration-oriented developments, and sustainability. This includes entrepreneurs, producers, engineers, makers, and tinkerers globally.

From a recent survey, Ludwig et al. (2015) discovered that consumers from various countries globally spend significant portions of their time and income to create and

modify products for their personal use. Therefore, open sourced technologies are of great significance in enabling consumers to manufacture needed products.

The backbone of OSE lies in its openness to economically-significant information such as product designs, techniques, and rapid learning materials. Therefore, OSE is a platform for creating distributive enterprise, and it lowers the entry barriers through global collaboration and opens up economic development to open product and process design. Moreover, the OSE has the potential to raise the bar on the quality of products in the productive economy (Thomson and Jakubowski, 2012; Jakubowski, 2015b).

Furthermore, Jakubowski (2015b) speculated that the OSE has the capability to aid the effective appropriation of strategic resources through the principle of substitutability (i.e. increasing the level of productivity and appropriate technologies by creating qualitative, available and affordable developmental substitutions for strained strategic materials), thereby addressing the conflicts evident as a result of the misappropriation of natural resources especially in the developing economies.

Up to date, the OSE claim to have 67 global village construction set (GVCS) open prototypes and 16 unique prototypes in five countries within the five years of its existence (Jakubowski, 2015a), which includes devices like tractors, digital fabrication devices (such as 3D printers, 3D scanners, laser cutters, and milling machine), soil pulveriser, cement mixer etc.

These GVCS technological devices can be used to enable developmental programs to provide both the materials and the required training that will lead developing economies in maximising their resources and accomplishing self-sufficiency and sustainability. Which culminates into a technological decolonised state.

3.2 Open source appropriate technology

In an attempt to proactively mitigate the incessant socio-environmental, socio-technical, and socioeconomic issues, the United Nations (UN) developed the millennium development goals (MDGs), which has seven strategic objectives (WHO, 2008), these are:

- to eradicate extreme poverty and hunger
- to achieve universal primary education
- to promote gender equality and empower women
- to reduce child mortality
- to improve maternal health
- to combat HIV/AIDS, malaria and other diseases
- to ensure environmental sustainability.

Moreover, in recent years the MDGs have been extended to include an additional global objective (UNDP, 2015), which is:

- to develop a global partnership for development.

Various scholarly articles have poised that these insistent issues could be monitored and controlled with the development of appropriate technologies (Willoughby, 1990; Pearce, 2012; Bowonder, 1979; Wicklein, 1998; Pattnaik and Dhal, 2015).

Furthermore, the bid to facilitate sustainable economies and to solve the disparaging human developmental issues in developing countries gave rise to the emergence of concepts such as appropriate, intermediate, and alternative technologies. An appropriate technology (AT) is defined as a *technology tailored to fit the psychosocial and biophysical context prevailing in a particular location and period* (Willoughby, 1990). Moreover, AT is concerned with directing technological research, development and dissemination facilities towards raising the internal and external efficiency of technologies.

The AT concept aims to proffer solutions that dispel social developmental issues such as unemployment, poverty, pollution and other societal degradation constraints by harnessing the intervening measures of technologies, and advocate for the development and distribution of small scale technologies (Kachieng'a, 2009; Willoughby, 1990; Pearce, 2012). Some of the criteria for the selection of AT are: availability of raw materials, ecological stability, cost-effectiveness, import substitution, rural orientation, durability, learnability, waste recycling, small-scale amenability etc. (Bowonder, 1979; Wicklein, 1998).

Just like the OSE, OSAT are technological advancements based on the concept of openness and collaboration between different actors. These are made up of technologies built with affordable, appropriable and readily available resources in local communities, which enable preventative mechanisms in combating most of the environmental, cultural, economic, educational, and resource constraint issues, thereby providing sustainable development (Pattnaik and Dhal, 2015).

These alternative technologies select and develop methods, which are compatible to local economies, and their sophistication level placed between simple and complex technologies (Pattnaik and Dhal, 2015). To substantiate the importance of the vertical transference of technology from the initial phase of the product life cycle to the final phase, further literature review highlighted that technology frontiers between countries are not uniform, that is, all existing technologies are not suited for all economies (Jerzmanowski, 2007; Basu and Weil, 1998).

Jerzmanowski (2007) outlined that the technology development processes in industrialised nations are based on their factor mix, while the same is different in a technology colony. Moreover, the ad hoc focus on technology acquisitions only provides symptomatic solutions, while a simultaneous focus on internal technology development and acquisition strategies provides an adequate technique to facilitate the sustainable development and technological independence needed by the technology colonies. Examples of some basic AT are: the appropriate renewable energy technologies, the pot-in-pot refrigerator, bicycle powered water pump, Hippo water roller, and the rocket stove, etc.

Basu and Weil (1998) argued that developing a model with appropriate technology and technology diffusion is more engaging and has more pragmatic predictions for long-term growth and convergence, than the simple endogenous growth and the neoclassical models. Therefore, the OSE and OSAT can be dubbed as '*open*' reverse and frugal innovation artefacts that aim to build local-to-global technologies (i.e. new technologies developed locally, with the potential of being exported back to the developed countries) rather than the existing '*glocalisation*' concept (i.e. *global products amended for local use*) (Govindarajan and Trimble, 2013), which is an ardent reflection of technology transfer in the technology colony. The following section aims to explore the significance of OSE and OSAT in a technology colony.

4 Significance of the open value creation paradigm in transforming the technology colony

In a recently concluded survey on the impact of digital fabrication, we discovered that developing countries tend to benefit a lot from the introduction of social digital fabrication initiatives such as *fabrication laboratory* (FabLab), *Hackerspaces* and the *OpenLab* micro-factories (Osunyomi et al., 2015, 2016). These social initiatives are incubators of both incremental and radical innovations, alternative and appropriate technologies, and also a viable means that fosters hands-on learning and commensurate human developmental capabilities, which were identified by Kachieng'a (2009) as the major transitive measures that facilitate technology decolonisation.

Moreover, these digital fabrication platforms embody a value creation system that is based on concepts such as: openness, self-organisation and collaboration-oriented paradigms (Redlich et al., 2014). Therefore, ensuring the sustainable development of an economy requires the development and implementation of alternative value creation mechanisms (Redlich et al., 2014; Ueda et al., 2009). It also requires definite actions and major alterations on technologies, coupled with the development of economic strategies from the local, national, and international levels (Altieri and Masera, 1993). The following subsections highlight the significance of OSE and OSAT as a vehicle for sustainable bottom-up development.

4.1 OSE and OSAT as bottom-up economics platforms

Altieri and Masera (1993), Fraser et al. (2006), and Sas (2011) discovered that the conventional 'top-down' development strategies are fundamentally limited in their ability to promote equitable and environmentally sustainable development. Sas (2011) further highlighted that the top-down approach is based on the theories of modernisation, which implies the classic transfer of technology from the developed countries to the so-called 'third world' and dismisses the importance of local indigenous knowledge, thereby creating a rent economy that further increases the level of dependency between 'recipient' and 'donor' countries. In respect of this, we look at the significance of OSE and OSAT as a bottom-up economics platform.

The bottom-up economics approach embodies the fusion of production and consumption. It is further characterised by distributed structures and processes otherwise known as collaborative-oriented industrialisation (Redlich et al., 2014; Basmer et al., 2015). In this sense, the *collaboration-oriented development* facilitates and strengthens participation between consumers and producers (Redlich et al., 2014; Ueda et al., 2009). The relationship between consumers and producers can be considered as a highly asymmetric one within traditional value creation paradigms. It is synonymously reflected on a macro level in the relation between technology colonies and technologically advanced nations. The information and power asymmetries (demarcating the boundaries between consumers and producers) are, however, drastically decreasing in open source collaboration-oriented approaches. Also, in collaboration and value co-creation, labour and production are more location-independent (Basmer et al., 2015; Bhalla, 2010). This signifies that technology transfer to technology colonies should be tangible and intangible in nature. While tangible technologies can be used to aid the development of explicit and tacit knowledge (intangible).

OSE and OSAT are termed as iconoclastic innovation because of their focus on creating pragmatic solutions to local problems in its root, rather than providing a symptomatic solution (Jakubowski, 2015b). Hence, the design and development of alternative bottom-up strategies helps to define priorities and problems, and develop specific intervening measures (Altieri and Masera, 1993; Fraser et al., 2006). Moreover, the bottom-up alternative approach develops flexible and adaptable technologies that can be easily modified according to specific circumstances and problems in their various localities (Altieri and Masera, 1993).

Though most AT are beneficial projects from technologically advanced countries, however, the benefits of involving the natives of the developing countries (technology colonies) during developmental processes and the localisation of materials, encourages creative thinking towards the development of endogenous appropriate technologies. From this context, OSE and OSAT can be concluded as a potential platform that promotes the bottom-up economic approach and also as one of the adequate means to ensure technological decolonisation.

4.2 OSE and OSAT as the basic structure of the value creation system in technology colonies

Due to their flexibility (i.e. their appropriability and adaptability to changing circumstances), the significance of openness in OSE and OSAT in aiding the decolonisation of the technology colony is evident through collaboration, interaction, and sharing of knowledge between two or more actors in the value creation system. The benefits of open sourcing in a technology colony's value creation system are as follows:

- open sourcing facilitates rapid development of effective AT (Pearce and Mushtaq, 2009)
- it provides the acceleration of AT innovation (Pearce and Mushtaq, 2009; Jakubowski, 2015a, 2015b)
- it provides adequate access to relevant AT (Pearce and Mushtaq, 2009)
- it allows marginalised communities to have say and ownership over their technology exploitation and development activities (Buitenhuis et al., 2010).

Redlich et al. (2014) iterated that in considering the openness of the value creation structure, it is pertinent to examine the relationship of the system with its environment, and also investigate the internal structure of the system in conformance with the specifications of openness. Relating these considerations to this research focus, it can be concluded based on their flexibility, that the OSE and OSAT provides a permeable structure for technology colony to interact in the global space, to internalise foreign knowledge, inspire local knowledge, and to accelerate the vertical transference of technology in its product development life cycle.

4.3 OSE and OSAT as architecture of the value creation artefact in technology colony

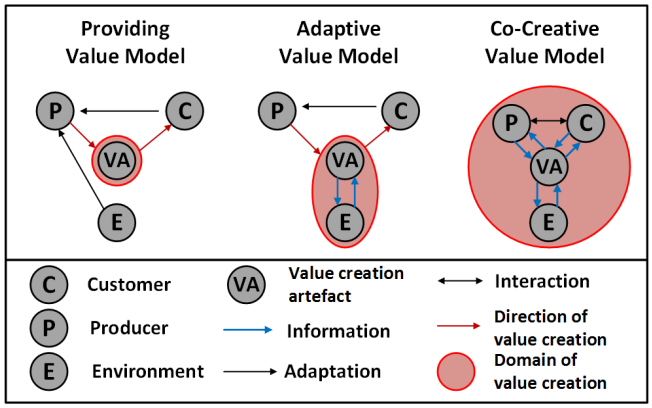
To furnish the viability of the value creation structure, Redlich et al. (2014) further outlined that developing value creation artefacts with the openness concept is potentially sociable. In addition, value creation artefacts are artificial systems created for a specific purpose, hence a product of tangible and intangible constituents (Redlich et al. 2014), whose value is articulated by its functionality, economic significance, and network externalities (Ueda et al., 2009). Ueda et al. (2009) indicated that the acquisition of comprehensible knowledge precedes the creation of any valuable artefacts. Moreover, the relativity of openness to the physical structure of the artefacts are consequential to the properties of granularity, modularity, and complexity (Wulfsberg et al., 2011). The sustainable development of value creation artefacts lies not only in the acquisition of knowledge, but in the synthetic engagement in developing knowledge.

However, for an artefact to create value, it must be in conformance to the environmental (i.e. social and natural) and human values (Ueda et al., 2009). In light of this, we conclude that OSE and OSAT are social technology artefacts with an avid focus on the concept of openness. These concepts possess the potential to portray the granularity, modularity, and complexity properties in their simplest form. In accordance with the overall findings of Ueda et al. (2009), OSE and OSAT has the potential to ensure the sustainable development of valuable artefacts, thereby assisting in the technological decolonisation process. It is worth noting that by sustainable development, we mean creation of artefacts that are ecological, economic, social, environmental, and humanly viable.

4.4 Value creation process of OSE and OSAT in technology colony

The degree of openness (*i.e. width and depth of co-activity*) in the value creation process is determined by the value creation strategies and activities of the actors (Redlich et al., 2014). Openness in the context of value creation strategies aims at exploiting synergies and cooperation between all the actors in the value creation process. While co-activity shapes the openness of the value creation process and includes all collaborative efforts between actors directed at maximising value creation (Redlich et al., 2014).

Figure 2 Value creation model according to Ueda et al. (2009) (see online version for colours)



From the above illustration (Figure 2), the state of technology transfer to the technology colony is evident in the 'providing value model'. In this model, the values of artefacts are derived independently by the producer (former colonial leaders) and the consumer (technology colonies), while the interaction with the environment can be specified in advance (Ueda et al., 2009; Wulfsberg et al., 2011). The providing value model typifies the dogmatic closed systems, which can be transferred to mass production and provision of routine services (Wulfsberg et al., 2011).

While the value for customer and producer can be specified in the adaptive model, the model is limited by the unpredictability of the environment (Ueda et al., 2009; Wulfsberg et al., 2011). This results in the formation of a partially open system, which can be likened to the existing 'glocalisation' concepts highlighted by Govindarajan and Trimble (2013) as an ineffective solution to the sustainability issues in developing economies. Nonetheless, in the co-creative value model, the values of the artefacts are jointly determined by the actors during the value creation process (Ueda et al., 2009; Wulfsberg et al., 2011). This exemplifies an effective measure to aid the sustainable development of an economy especially in a technology colony (Redlich et al., 2014; Basmer et al., 2015; Osunyomi et al., 2015, 2016; Buxbaum-Conradi et al., 2014; Ueda et al., 2009; Bhalla, 2010).

Therefore, we hypothesise that the augmentation of both OSE and OSAT in a technology colony can facilitate co-creativity within the global value creation space, as well as the provision of pragmatic solutions to global issues from the source.

4.5 Benefits of OSE and OSAT

In addition to some benefits stated in earlier sections, the OSE and OSAT devices also have the following benefits some of which includes:

- economic significance through encouragement of entrepreneurial activities (Jakubowski, 2015a, 2015b; Pearce, 2012; Buitenhuis et al., 2010; Dorf, 2001)
- simplicity and low cost of production compared to the retail price of the on-shelf version (Jakubowski, 2015b; Dorf, 2001)
- development of technological self-reliance (Jakubowski, 2015a, 2015b; Pearce, 2012)
- effective utilisation of limited financial resources, through the minimisation of R&D costs (Jakubowski, 2015b; Pearce, 2012)
- expedited production cycle through access to technological development blueprints and elimination of the inhibitions caused by the intellectual property rights (IPRs) (Thomson and Jakubowski, 2012)
- minimisation of wastes, overheads, and bureaucracy (Jakubowski, 2015a, 2015b; Pearce, 2012; Buitenhuis et al., 2010)
- localisation of material sourcing and of production (Jakubowski, 2015a, 2015b; Pearce, 2012; Buitenhuis et al., 2010)
- replicability, maintainability, and flexibility (Jakubowski, 2015a, 2015b; Pearce, 2012; Buitenhuis et al., 2010; Dorf, 2001)

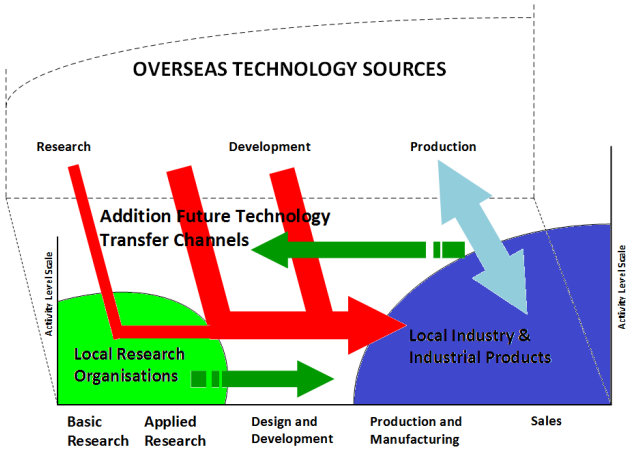
- technology recursion, scalability and fractality (Jakubowski, 2015b)
- resilience and robustness (Jakubowski, 2015b)
- iconoclastic innovations and transformation by providing solutions that attend to local problems or problems in general at their root (Jakubowski, 2015b; Buitenhuis et al., 2010).
- best practices and eco-friendly (Jakubowski, 2015b; Buitenhuis et al., 2010; Dorf, 2001).

In conclusion, reviewing the benefits of the OSE and OSAT affirms that these two paradigms possess the potency to facilitate the vital developmental processes needed by technology colonies to effectively harness and manage their resources to transcend beyond the constraints imposed by their technology colony status, and strive for sustainable growth and economic development, hence, contributing to the global sustainability. The next section provides a detailed analysis of the backward integration in respect of OSE and OSAT.

5 OSE and OSAT in backward integration of technology flow

With backward integration, technology colonies can set up their local development facilities to ensure a more reliable and effective flow of inputs. De Wet (1999) indicated that technology colonies can create a value addition strategy focused on adding value from the earlier stages of the product life cycle, and to gain ownership of intellectual properties (IPs), which in turn leads to the development of competitive advantages (Figure 3). However, in lieu of the IP and IPRs, this research proposes the use of the openness concept as a viable alternative for developing economies to gain the technological independence, which in turn leads to technological decolonisation and advancements.

Figure 3 The effect on technology flows resulting from backward integration (see online version for colours)



Source: De Wet (1999)

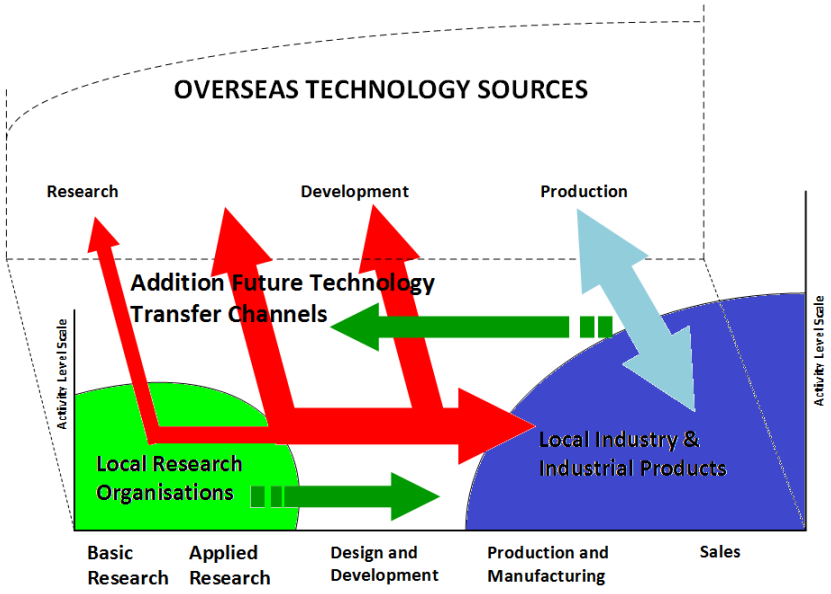
Figure 3 indicates that technology transfer at the production and sales end of the product life cycle should be relatively reduced, so as to afford the vertical transference of technology from the initial stages of the life cycle (i.e. from basic research capability) (De Wet, 1999; Kachieng'a, 2009). However, the backward integration strategy highlighted above is preconceived on the notion of closed system concept, which provides a symptomatic solution by focusing on promoting competitiveness, capturing value, and its prior focus on technology transfer from former colonial imperials, with inadequate representation of the technology development process in the technology colonies. Moreover, Buys (2001) identified a five-stage process of industrialisation of backwards integration in the technology colony, these are:

- Stage I: Local distribution, marketing, sales and after sales services of foreign products and services, and technologies. In the first phase of industrialisation, the imperials aims to gain access to the local market by establishing local distribution, marketing, sales and support of their products and services within the technology colony. Although in some sectors, most countries have transcended beyond Stage I. However, in terms of technological developments, most are still stuck in Stage I.
- Stage II: Local production and manufacturing of foreign products and services. Stage II emerges as most imperials aim to utilise cheaper local labour and raw materials, likewise to substitute imports. In terms of technological development, most technology colonies are yet to progress to this stage.
- Stage III: Local improvement of foreign products and processes. This stage starts with the internalisation of foreign technologies and proceeds to 'glocalisation' concept, that is, the local adaptation and modification of foreign products and services to suite local conditions. During this stage, the technology colony is still mainly dependent on foreign technologies for its product development and improvement processes.
- Stage IV: Local development of new products and processes. This stage aims at developing new products by imitating foreign technologies and competing within the local and export markets. This can be purported as the development of frugal and reverse innovation activities. The case of China, South Korea and some of their Asian pacific counterparts perfectly depict this stage and the succeeding stage.
- Stage V: Local technology development. In Stage V, the chasm between the research sub-systems and the development sub-systems of the life cycle in the technology colony has been bridged by local technology development. Though the transcendence to Stage V is elusive to most technology colonies, we postulate that augmenting OSE and OSAT is a feasible alternative to accomplish technological independence.

With the proposed backward integration based on the concept of openness, technology transfer is based on the establishment of a bidirectional relationship between the phases of the product life cycle in the technology colonies and their former colonial leaders, this in turn represents both reverse and frugal innovation strategies embedded with openness, which emanates to the creation of adequate values and maintenance of a coopetitive advantage.

From Figure 4, the benefits accrued to the development and utilisation of this concept not only reduces the cost of engaging in R&D from both sides, it can also provide adequate and affordable designs that lead to the local production of foreign products and services, local development of new products and processes, and local technology development. Hence, it facilitates the global maximum effect in production and sales.

Figure 4 The effect on technology flows resulting from backward integration based on openness (see online version for colours)



6 Limitations of OSE and OSAT

Despite the enormous potentials of OSE and OSAT, they are not without limitations. The major limitation to these concepts is that the widespread awareness, contributions to, and use of OSEs and OSATs has not yet occurred, partly due to the factors given below:

- Communication and information specific barriers (Zelenika and Pearce, 2011): despite the surge in the Internet access, there is still a huge digital divide between the impact zone (emerging economies) and developed communities. This inadvertently connotes that the technology transfer process between the technology colony and advanced economies has to be in tangible form, which reduces the rate of development and strains the limited financial resources (Buitenhuis et al., 2010; Zelenika and Pearce, 2011).
- The distance and time barriers: the barriers of distance and time between the buffer zone and the impact zone makes it difficult to tackle issues from their source (Zelenika and Pearce, 2011).
- Language and culture barrier (Buitenhuis et al., 2010; Zelenika and Pearce, 2011).

- Educational and technical skills barrier: the academic inequity between the natives of the developed economies and the technology colonies further constrains the artefacts development efforts (Buitenhuis et al., 2010).
- Inadequate funding for basic implementation and further research (Buitenhuis et al., 2010).
- Lack of institutional support (Zelenika and Pearce, 2011).
- Inferiority stigma attached to AT as poor people's technology (Zelenika and Pearce, 2011).

7 Conclusions and recommendations

As indicated in earlier sections, the OSE and OSAT concept aim to create a platform, where appropriable technological information and knowledge can be distributed. This information includes access to technology blueprints, access to external participation in development, and also access to enterprise blueprints. However, the implementation rate of the platforms are still novel or unidentified. Therefore, further development and empirical testing will be needed to uncover the societal impact of the platforms, particularly through the conduction of adaptive field studies.

In this research study we identified that the considerations of OSE and OSAT do have some potentials for developing countries, especially countries formerly under colonial authorities, to traverse the technology colony status to a technology independent and advanced state. Therefore, we recommend a systematic study, development, and implementation of the impact of the concepts in enhancing the sustainable development of an emerging economy.

Also, future work should focus on obtaining requirements and feedback from communities employing the technologies so as to gather adequate information about the viability of the technologies in meeting their needs, and obtain further insights on the barriers encountered during the development and utilisation processes.

Finally, according to the concluding remark by De Wet (1999), "being a technology colony is not a disaster neither is it something to be ashamed of. However, remaining a technology colony should not be a fate to be suffered, but an opportunity to be managed". Furthermore, traversing the technology colonial status means emerging economies need to reorient their technology acquisition strategy, to also include internal or vertical transference of technology from their basic research facilities through the product life cycle. So that adequate value for in-house developed resources can be captured.

In addition, emerging economies should effectively harness the potentials of the open innovation and development approach, to strategically effectuate the value co-creation strategies in its product life cycle and innovation cycle. While developing applicable AT that attends to the social needs of its populace.

Therefore, we believe that this research provides new insights to the significance of open sourcing in OSE and OSAT as value creation patterns that ensure the most economically sustainable development. To answer the initial question posed by the research topic, we conclude that, if effectively harnessed, OSE and OSAT could be used as a roadmap by technology colonies to aid their transition into a technology decolonised states.

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