

Aligning Health Supply Chain Maturity with Technology Transfer in Low-and-Middle-Income Countries

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Abstract

Background: Technological advancement has been very rapid in low-and-middle-income countries (LMICs), facilitating economic growth and removing structural challenges. However, there is still much to be achieved as the developing world is in the phase of adapting existing technologies, rather than pursuing innovations and creating new technology. In this context, many of the LMICs still lack social infrastructures like power and maintenance culture to help sustain the consistent and efficient use of these technologies. Technology affects public health supply chains (PHSC) mainly through automation, connectivity for last-mile delivery, and the level of innovation. Technologies like Logistic Management Information System (LMIS), RFID (radio-frequency identification), mobile phone technology, blockchain, etc have the potential to make existing PHSC more robust.

Purpose: This study aims to conceptually elucidate the constraints of the introduction of technology in PHSC of LMICs. Some of these countries do not recognize the absorptive capacity that must be in place to enable the diffusion of technology. In the absence of such capacity, major challenges can arise in a country after the technology transfer takes place. Therefore, to overcome this gap in the literature, we attempt to understand the role of technology transfer in PHSC of LMICs and focus on identifying the appropriate supply chain maturity stage that technology should be introduced to improve healthcare outcomes.

Methodology: We attempt to understand the appropriate stage for introducing technology in PHSC through the review of existing literature on broader themes. We searched the Google Scholar and Science Direct databases for studies that focussed on the right maturity stage of PHSCs for the transfer of technology. The review includes forty-seven studies encompassing four studies on health-care supply chains, seven on economic development, ten on technology transfers, six on innovation, five on how different models of technology transfer impact regional growth, and fifteen on the evolution and importance of maturity models in improving supply chain performance. Our detailed review supported our use of the Frontier Markets Supply Chain Maturity Model (MM), as proposed by the Bill and Melinda Gates Foundation, for further analysis, since it is based on the identification of the weakest links in LMIC supply chains and it is widely used in their context.

Finding: The frontier market maturity model is a reference framework that identifies dynamically shifting bottlenecks and helps supply chain teams know where to focus their improvement efforts for the maximum impact on supply chain performance. Our study elucidates how technology can be best used depending on the maturity stage of the health supply chains in LMICs. We identified leadership, collaboration, local capacity building, etc as some of the "key determinants for success" to enhance a country's absorptive capacity to strengthen the PHSC through technology. When the maturity model stages were mapped with the key determinants, we found that countries can use the technology differently depending on their capacity. At the canvas stage, the LMICs can absorb the technology and can optimally utilize it at the bronze stage. LMICs can exploit the imported technology at the silver stage leading to better integration at the gold stage. Finally, in the graduated stage, LMICs are more adept at realizing the full potential of technology and harnessing it for context-driven solutions.

Conclusion: An important consideration is that technology should be relevant to the country's capabilities and factor endowments. The introduction of technology does not necessarily bring immediate benefits. The benefits will depend on countless factors that vary across countries. If an LMIC uses technology for its development, it will have from the beginning human and capital resources for the new technologies, avoiding the problem of all the developed countries that must channelize more time and effort presently to reskill their workforces that have been trained on old technologies. The study underlines that key drivers like participation, benchmarking, developing capacity, and allocating financial resources judiciously will help in creating an enabling environment for better use of technology.

Keywords: LMICs; PHSC; RFID

Introduction

LMICs have experienced unprecedented growth in technology and its various applications in the past years. The technological achievement has been very rapid in the LMICs facilitating economic growth and removing structural challenges [1]. A vast literature in these countries identifies the characteristics of the population as rational, technologically adaptive, and brand-conscious [2,3]. However, there is still much to be achieved as the developing world is in the phase of adapting existing technologies, rather than pursuing innovations and creating new technology. At the core of innovation, technological expertise is an important attribute for all countries. This will help in embedding knowledge and creating the required capacity for nations to grow and prosper. Technological expertise is one of the ten attributes used in the 2019 Best Countries report¹. The top countries viewed to possess technological expertise include Japan, the United States, South Korea, China, Germany, United Kingdom, Singapore, Russia, Switzerland, and Sweden. The survey highlights the lagging behaviour of LMICs in technological expertise and signals to the real challenges in a development context.

Nonetheless, technology is being introduced into a different aspect of life including the health supply chain sector. However, the question of appropriateness has arisen many times and solutions on when the appropriate technology and time is to introduce them are being sourced [4]. More so, many of the LMICs still lack social infrastructures like power and maintenance culture to help sustain the consistent and efficient use of these technologies [5].

There is no doubt that the introduction of technology in PHSC will lead to better efficiencies and reduced costs (Polater and Demirdogen, 2018). There is more scope for improvements with the possibility of leading to better demand and supply of health commodities and services. It can also provide a means of establishing standards for quality and allow an LMIC to build credibility in the global market. However, studies have shown that not all technology introduction is appropriate and there should be a thorough assessment of appropriateness before the introduction of technology [6].

Literature Review

Channels of technology impacts on PHSC

Technology affects PHSC mainly through automation, connectivity for last-mile delivery, and the level of innovation. These can change the cost of labor versus capital, the cost of transacting, the economies of scale and the market competition. Together this will determine how and where essential health commodities are produced, procured and made available to the rural and urban population of an LMIC.

- **Automation:** This will help in increasing the speed and scale of PHSC activities. But unlike advanced countries, LMICs will adopt more slowly to digital technologies. Although this can lead to improved productivity, it can create polarization of different sectors creating inequality [7].
- **Connectivity:** This can change the cost of transactions and improve access to markets and resources. For example, mobile phones helping farmers access market information - Hello Tractors in Nigeria [8]. Yet, these technologies create oligopolies that are dominated by a few firms. Given that most of the platforms are developed in high-or-middle income countries, LMICs could potentially face the risk of becoming increasingly subject to the market power of foreign companies (Henisz and Zelter, 2010).
- **Innovation:** Technology has helped and changed the way we produce, connect and create new ideas, reducing the costs of risks and innovations. Innovations do take place in LMICs, but these are measured using conventional indicators and as such, it remains under the radar in these countries [9].

Types of technologies in PHSC

In response to PHSC needs and challenges, studies have recognized that information sharing is crucial, and that the key to this is harnessing different types of available technology [10]. The most commonly used technologies in this sector are the Logistic Management Information System (LMIS) to target freight-forwarding operations, financial information management systems used globally to oversee government contracts and ensure compliance; and integrated e-commerce platforms [11]. RFID (radio-frequency identification) is next and it has the potential of reducing inventory losses and increase the efficiency of supply chain processes [12]. Mobile phones are another inexpensive technology and make communication between participants in the health supply chain far easier, particularly in rural locations [13]. Another way in which technology has been championed as a potential solution to health supply chain problems and inefficiencies is through its capacity to virtually centralize the supply chain [12]. Blockchain technology has likewise been highlighted as a means of improving last-mile operations in LMICs [14].

Maturity models for measuring supply chain performances

The origins of maturity models can be traced back to the 1970s, when a quality maturity grid was developed to monitor the organisational progress through the five stages of uncertainty, awakening, enlightenment, wisdom, and certainty [15]. The next major leap in this area was the development of the Capability Maturity

¹The survey is based on a study that surveyed more than 20,000 global citizens from four regions to assess perceptions of 80 countries on 75 different metrics

Model by the United States of America Defence Software Engineering Institute in the late 1980s. This framework provided a continuous improvement path for process capabilities in software activities [16]. It consists of five evolutionary levels: initial, repeatable, defined, managed, and optimising.

It is well recognised that, nowadays, the competition in many industries is between supply chains rather than companies [17]. Therefore, it is necessary to understand how individual firms are performing in supply chain progression and stakeholder requirements [18]. Maturity models contribute to continuous learning and use supply chains to identify good practice and transfer the required knowledge [19]. Therefore, maturity, in a supply-chain context, indicates extensive collaboration across a wide array of partners, whereas immaturity indicates low levels of collaboration. However, it can be challenging to verify that, since inter-firm relationships can vary according to sector and industry [20].

In recent years, there has been a slowly growing interest in investigating maturity model development for the healthcare supply chains, because it is a method to define, measure, manage, and control business processes. It attracts academics, researchers, and business users [21]. Although its origins are not linked to logistics, these models are used to understand key performance indicators and improve logistical performance [22]. The models are expected to aid businesses in understanding the dynamics of supply chain cycles and their overall impact on revenues and costs [23]. Below are some examples:

- The SCOR (Supply Chain Operation Reference Model), introduced by the Supply Chain Council (SCC) in 1996, acts as the starting point of reference for understanding, comparing, and benchmarking supply chain activities across different industries. It provides a unique framework that links business processes, metrics, best practice and technology to guide the business through challenges and support decision making [24].
- The Framework, developed by the Computer Sciences Corporation (CSC) and first tested in 2003, aims to understand the logistics function's development stage in the surveyed companies, considering their level of performance and supply chain maturity stage [25]. The model identifies five levels of maturity. At the first level the company prioritises improvements to functional areas, at the second level logistics gains are given more attention, strategic redesigning takes place at the third level, and in the fourth level the company takes collaborative initiatives. The fifth level is described as the most difficult to achieve and consists of integration throughout the supply chain.
- The business process orientation maturity model suggests that businesses can improve their performance by adopting

a strategic view of their processes [26]. This model uses the SCOR to identify the maturity levels of performances and the five stages show the steady progress of supply chain activities with time. Each of the five levels, namely: ad hoc, define, linked, integrated and extended, is determined by predictability, capability, control, effectiveness, and efficiency.

Nevertheless, the public health context in an LMIC can render these models inefficient. Yet, their health supply chains can, while moving through similar maturity pathways, adapt customised strategies and strengthen the healthcare impact. The maturity model in public health as proposed by USAID consists of four key stages namely ad hoc, organised, integrated, and extended. As the different supply chain participants coordinate and carry out efforts to manage processes, the chains evolve through the different stages and improve their capacity to achieve stronger health outcomes.

However, there is a lack of understanding of what constitutes and needs to be done to attain supply chain maturity in a resource-constrained environment. The available maturity roadmaps are more intended for well-functioning supply chains that aim to optimise their current positions. Most of the existing maturity models did not create a working model to monitor dynamically shifting constraints and were internally focused.

The Frontier Markets Supply Chain Maturity Model (MM), as proposed by the Bill and Melinda Gates Foundation, is based on the observations from the earlier available models [27]. It is guided by the Theory of Constraints, which is relevant in LMICs. The framework is designed to be a self-assessment tool, to capture shifts in constraints and progress across the various component areas. The MM helps supply chain teams know where to focus their improvement efforts for the maximum impact on supply chain performance. Supply chains under resource constraints may struggle to find applicable benchmarks, so capabilities should be compared only to the appropriate maturity levels.

Purpose of study

There is no shortage of technology available in contemporary times for developing countries. But the real challenge arises in identifying the right stage for technology transfer in developing countries. Most of the LMICs fail to recognize the physical and human infrastructure that must be present to enable such a diffusion. In the absence of such capacity, major challenges can arise in a country after the technology transfer takes place. Given the lack of evidence, identifying the appropriate stage of PHSC for technology transfer is a rather challenging task. Therefore, to overcome this gap in the literature, we attempt to understand the role of technology transfer in PHSC of LMICs. Also, we focus on identifying the appropriate supply chain maturity stage when technology should be introduced to improve healthcare outcomes.

Methodology

Given the dearth of evidence in the literature, identifying the appropriate stage of PHSCs for technology transfer is a challenging task. We attempt to understand the appropriate stage for introducing technology in PHSC through review of existing literature around broad themes. We searched Google Scholar and Science Direct databases for studies that focussed on the maturity stages of PHSCs for the transfer of technology. The review includes forty-seven studies encompassing broad themes to assist in the analysis. We reviewed four studies in healthcare supply chains, seven studies focus on economic development, ten studies linked to technology transfer, six studies related to innovation, five studies on how different modes of technology transfer had impacted regional growth of LMICs, and fifteen studies underlining the evolution and importance of maturity models in improving performances. Our detailed review supported us to follow the Frontier Markets Supply Chain Maturity Model (MM), as proposed by the Bill and Melinda Gates Foundation (BMGF) for further analysis. This reference frame is used to recognize the maturity level of supply chains in developing countries and is being used by different stakeholders including the donor community, logisticians, policymakers, etc.

Analysis

Appropriate technologies

An important consideration in this context is that technology should be appropriate to the LMICs capabilities and factor endowments. Inappropriate technology is those which are transferred from developed nations and suffer from a pro-rich bias [28]. Therefore, technology needs to be tailored to the skills and consumption needs of the LMICs. The technology should cater to the needs of the poor who constitute the vast majority of the population and are often not catered for by the technology transfer in developing countries. LMICs should focus on resource recombination which is defined as the process of combining existing technologies into new technologies with new functions [29,30]. This will aid in the creation of products or services which are valuable, and not easy to imitate and substitute [31]. Such product and process re-engineering will be fuelled by demographic changes, competitive pressures, scarcity of resources, globalization, etc.

A classic example of this process is the use of mobile technology across the African countries which has been the fastest-growing mobile market in the world [32].

- Penetration of this technology has been faster and more widespread in the poorer sections of the population than what many expected [33].
- Mobile technology was viewed not only as an advancement of basic infrastructure, but also became a tool of information

exchange, financial security, and boosting entrepreneurial activities within a country [34].

- Analysis of the use of mobile technology emphasize the limitations of the earlier and modern economy to contextualize the need of the poor in the LMICs [35].

Therefore, the introduction of technology in LMICs does not guarantee the percolation of immediate benefits. It depends on a host of factors (discussed further) that determine the level of utility of the transferred technology in a developing nation.

Creating a strong “absorptive capacity” in LMICs for technology transfer

The process of technology transfer is a complex and multi-actor process that follows several factors and conditions that determine its success. Endogenous growth theories have highlighted how technology transfer can boost economic growth [36]. These theories focus on the funds available for innovation, degree of technological transfers, and the perspective of innovators. Technology transfer depends on the interaction between domestic technological activity and foreign influences, which is very difficult to achieve in LMICs [37]. Therefore, the issue is not the inability of countries to access technology. The real issue is the irregularity of response to adopting new technologies and the management of the acquired knowledge.

Again, the choice of technology for LMICs is a crucial discussion point. Dosi [38] suggests that the market does not evaluate the technology directly; it operates, rather, as a selection device. LMICs must establish proactive policies guiding the choice of imported technologies which will help avoid long-term threats to economic growth. The selection of the technology is based on a host of factors that might not be easily available and accessible in LMICs. This can lead to incongruous and inappropriate selection of technology to import. LMICs might also overlook the fact that technologies are constantly changing which requires continuous iterations throughout the decision-making process (Muratovski, 2015).

These challenges necessitate every country to create a strong absorptive capacity for technology transfer which is a set of factors that affect the proper functioning and optimization of the process of technology transfer and that makes a country absorb more efficiently the foreign technology than another one. These include routines and processes through which the system acquires, assimilates, transforms and uses the knowledge to build a dynamic capacity [39]. According to Mowery and Oxley [40], it is the set of skills or expertise needed to manage components implicit to the knowledge transferred.

²Lane and Lubaktin (1998) referred to these in context to firms. But we can draw inspiration and try to use it in a developing country’s context

Hence, absorptive capacity is a set of routines and processes by which LMICs acquire, assimilates, transforms and exploits new knowledge transferred to develop a dynamic ability to provide impetus to economic growth.

At this juncture, we need to distinguish between the “potential capacity” and the “realized capacity”². The former will accommodate LMIC’s ability to acquire and assimilate. But this does not guarantee performance optimization. Only when the country can exploit the acquired knowledge i.e. realized capacity, will it improve economic growth and competitiveness for the country. This separation is essential to understand their respective contributions in determining the comparative advantage for LMICs [41-45].

Challenges of technology diffusion in developing countries

- A “humanitarian bravado” to underestimate the capability of the poor (a vast section of the population) to contribute towards the use of technology. This flawed logic is especially strong in the private sector which does not view the vulnerable sections of the population as a viable market [3].
- Inability to choose and/or strike a balance between the top-down or bottom-up approach. (In the former the donors and the international organizations have their expectations creating a favourable environment at the macro level. In the latter approach the real challenges of field staff and local stakeholders are better highlighted).
- There is a risk of creating an internal digital divide where the upper echelons of the economy will be able to benefit from the technology transfer and the lower strata of the population will be excluded. The cost of lost opportunities of not being fully aware of technological implications is as high as the cost of lacking the capability to access and use its contents.
- The cost of introducing new technology can be very high in LMICs.
- The initial level of development of the economy in terms of know-how to use the new technology transferred can act as an access barrier.
- The intensity and/or degree of existing competition can also create constraints for technology transfer. The entrance of the technology may be autonomous or dependent according to whether it is initiated by competitors or policymakers and the extent of competitive power enjoyed by them.
- Lack of inclusive intellectual property (IP) systems constraints the ability of the LMICs to convert their resources into productive capital

Finding

Mapping stages of the supply chain maturity model (MM) with technology introduction

The frontier markets MM is a reference framework that identifies dynamically shifting bottlenecks and helps supply chain teams

know where to focus their improvement efforts for the maximum impact on supply chain performance. Supply chains under resource constraints may be challenged to find applicable benchmarks and capabilities should be compared only to appropriate maturity levels. Therefore, it is imperative to understand the characteristics of the different stages of the MM model and how technology being introduced into the country progresses through the different stages. The maturity levels in the model are named after medals, like the ones in the Olympics. The idea is that maturity levels are earned, and supply chain teams should be proud of each level they achieve. The lowest maturity level is called ‘canvas,’ with its connotations of ‘a blank canvas’ that is full of potential.

Canvas stage

At this stage of the model, LMICs face numerous challenges due to growth constraints and bottlenecks. A better understanding can be grasped from the following summary table.

Characteristics	Description
Consistency	Characterised by the inconsistency of supply chain functions and partners might have an initial inhibition to new technology in the sector
Roles of stakeholders	Unclear, and the participants have little visibility of the demand and supply of health commodities.
Recognition of technological benefits	This is completely absent, and the health system does not fully recognize the usefulness of the technology.
Responsibilities of stakeholders	Not well defined and hence accountability is very low
Communication	Poor
Stakeholders	Realise the challenges and the need to overcome them. They are open to trying new approaches and can understand the opportunities for improvements
Capacity	Low absorptive capacity. Countries do not have the capacity to catch up with the technology evolution and exploit it for national competitiveness. Hence, countries should aim at a high rate of technology absorption through creating a strong foundation.

Table 1

However, since stakeholders identify the need to overcome constraints, the canvas stage assists the strengthening of the absorptive capacity of LMICs. This will not only ensure a simpler process of technology transfer but will also yield better utility of the imported technology. Therefore, the canvas stage is unlikely the appropriate stage of technological introduction/diffusion.

Bronze stage

This stage highlights the challenges of in-country PHSC since supply chain and logistics management are considered important to health programs. But still considered as a separate support function, not a strategic function of the broader health system. Under

this context, technology can help identify and recommend solutions to these country-specific challenges. The bronze stage will help build the momentum to accomplish consistency and visibility. The summary table highlights the key characteristics:

Characteristics	Description
Consistency	Visible improvements, although not completely translated into improved performances
Roles of stakeholders	Not well defined
Recognition of technological benefits	Various pilot studies are undertaken which can act as effective platforms to introduce technology. The pilot studies generate data which can be analysed with the introduced technology to support primary evidence-based decision making.
Responsibilities of stakeholders	Common goals might not be aligned. Hence responsibility is low.
Communication	Marginal improvement
Stakeholders	Makes different kinds of partnerships more feasible wherein trust is building among the different actors
Capacity	The earlier stage will help overcome challenges through the required human and technical intervention. At the bronze stage the country can optimally utilise the imported technology with the absorptive capacity created in the earlier stage.

Table 2

Hence, if the technology is introduced in the bronze stage, it will represent a core investment helping in identifying standardized procedures and preparing the country to leverage it. The country will be able to leverage technology and achieve optimum utility.

Silver stage

At this stage, the supply chain is seen as a strategic approach to improve customer service and achieve better health outcomes. This view is supported by all the policymakers and stakeholders. At this stage use of technology can act as an input to improve existing PHSC activities. This improves credibility and motivates a country to progress to the next level by establishing metrics and routinely monitoring them to assess progress against the objectives.

The use of technology at this stage creates a strong feedback and reporting loop which will showcase what is working and what needs to be improved. Logistic data can be harnessed through appropriate technology to inform strategic re-designing through data-driven approaches. Technology helps them to share information throughout the supply chain and provides an impetus for innovations and novelty.

Gold stage

At this stage of maturity, supply chains are consistently performing, and the availability of health commodities is close to 95 percent. The supply chain is characterized by higher efficiency and achieves reducing wastage in the product, time, and money.

Characteristics	Description
Consistency	Consistent performance and improvements
Roles of stakeholders	Clarity of roles
Recognition of technological benefits	Learning and field experiences are scaled up to create a repository of knowledge for the country recognizing the benefits
Responsibilities of stakeholders	Partnerships create a more seamless entity responsible for effective availability of healthcare commodities
Communication	Standards established
Stakeholders	Believe in better health outcomes
Capacity	The country will most likely be able to start exploiting the imported technology to improve performances and achieve better health outcomes.

Table 3

Characteristics	Description
Consistency	High consistency of performance
Roles of stakeholders	No conflicts in terms of roles and superior clarity
Recognition of technological benefits	Supply chains recognise the benefits of technology to evolve to become more agile and efficient
Responsibilities of stakeholders	Governance achieved through responsibility and accountability structures
Communication	Two-way communication with timely feedback
Stakeholders	Existence of strong ownership and leadership
Capacity	The country has the capacity to integrate the technology into various functions of PHSC.

Table 4

Technology at this stage will help in creating a seamless entity improved accessibility of healthcare commodities. This stage can also advocate better use of technical information and performance data. The country can support the identification of priority areas for improvement through integrating technology in PHSC. At this stage, processes and procedures have been streamlined to remove non-value-added steps, supply chain performance becomes more predictable, and targets are achieved more often.

Graduated stage

At this stage, the health supply chains have been accredited. Capabilities are consistently displayed and are independent of the support of external donors.

The use of technology at this stage will encourage continuous improvement and help the supply chain graduate to higher efficiencies. This stage covers institutionalized coordination between the public and private sectors and promotes the required degree of competition for better supply chain impacts. In the public health

Characteristics	Description
Consistency	High consistency achieved
Roles of stakeholders	Very well defined
Recognition of technological benefits	Very lean and agile process
Responsibilities of stakeholders	Less dependent on donors and more internal responsibility achieved
Communication	Clear communication of achievements and challenges (if any)
Stakeholders	High level of trust and understanding
Capacity	The use of technology can help the supply chains in developing countries engage in context-driven innovations.

Table 5

context, the health supply chain serves a significant role in the health system and acts as the backbone for better interventions.

Therefore, the key question is at what stage of the MM should technology be introduced in LMICs. Since the absorptive capacity for the different countries will be varying, so will be their potential and realized capacity. Therefore, it will be flawed to isolate and standardize the technology introduction stage for LMICs. What can be attempted is to identify the key determinants of success that is present in a country will help in enhancing the potential capacity, and more precisely the realized capacity of LMICs to strengthen the PHSC through technology. It can be appreciated that at whichever stage of the MM model these key determinants of success are present for a country, that stage, will be deemed as the appropriate stage of technology introduction (Refer to Figure 1).

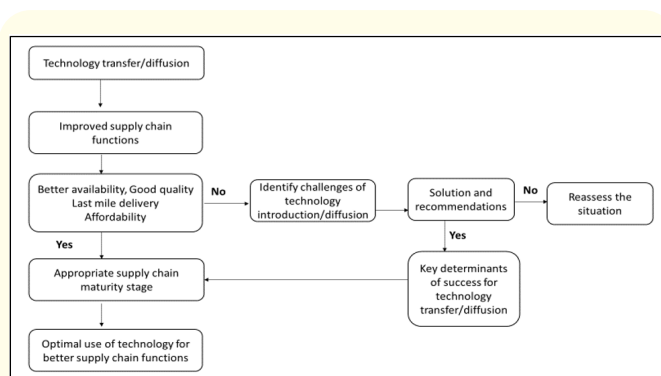


Figure 1: Outline of identifying the appropriate Maturity Model stage for technology transfer.

Key determinants of success for technology transfer in developing countries

- Local political leaders play an extremely important and active role to foster technological diffusion. Strong leadership should be promoted to envisage effective policies.

- Quality enhancing practices can be used to create a database of learning from other countries. This could be used both to support the diffusion of experiences at the micro- level and to diffuse the awareness of technological advantages to the policymakers.
- Developing a higher-level co-operation with different organisations operational at a local level, will contribute to increasing their funding capacity and efficiency. Also, efforts must be focussed on stimulating other organisations to adopt similar approaches, particularly the ones involved in the developing countries as a direct interface to the local stakeholders
- Context-driven innovation and local capacity building will help developing countries overcome inequality in technological access. Technology needs to be seen as a necessity, rather than a luxury to achieve sustainable economic growth for the developing countries
- Active donor interests to enable fundamental and meaningful changes. This will be a catalyst for the actual implementation of the required technology
- Introducing the right degree of competition at the local market will make pricing more competitive and affordable. Competition should not be too high to discourage participation, and neither should it be too low to encourage complacency
- The introduced technology should have a positive health impact. It is crucial in determining the effect of the technology on the management of the patient, on the length of hospital stay and the outcome: cure, death, sequelae, disability, and quality of life.

The mapping of the MM stages with the key determinants of success for technology transfer can be seen in the following table.

Recommendations to Overcome Challenges

- The humanitarian defiance, especially by the private sector, can be achieved by stimulating the participation of private sector operators configuring technological transfer not as a donation, but as an investment. This will facilitate the enlargement of the technology markets and boost the economic interest of the private sector.
- Through benchmarking, good practices from other LMICs can be identified. These can be scaled up as learning experiences and will act as an important base of action.
- A balance between the top-down and bottom-up approach can be achieved using of strong co-operation directly with local stakeholders for new idea generation, project design, funding proposals, implementations, etc. This will help to empower local entities, which will learn and acquire the necessary skills to deliver and sustain themselves.

Key determinants of success for technology transfer in developing countries	Canvas	Bronze	Silver	Gold	Graduated
Political stewardship	X	X	√	√	√
Database for learning	X	X	√	√	√
Stakeholder co-operation	X	√	√	√	√
Context driven innovation	X	X	X	X	√
Local capacity building	X	√	√	√	√
Donor interest	√	√	√	√	√
Competition	X	X	X	X	√
Status of technology being transferred	Absorption	Optimal utilisation	Exploitation	Integration	Context-driven innovation

Table 6: Technology transfer across the MM stages of developing countries.

- The digital divide can be eliminated by building technical capacity, literacy, and introducing technological literature in the native language. These can be achieved through a focus on establishing local consultancy companies, initially recruiting staff and then providing training for the emergence of a local workforce of skilled consultants. Support should also be channelized to improve graphical user interface and applications and facilitate translations of software to a wider variety of languages.
- Sometimes the developing nation is aware of the technological advantages, but they are not able to give priority to it instead of other strategic issues. In these cases, direct proposals or suggestions from donors can prove to be efficient and helpful.
- High costs of technology transfer can be handled through establishing an effective mechanism of low-cost second-hand technological providers that are readily available in the developing nation.
- Allocate more financial resources to technological programmes since lack of resources does not permit the launch and the fast implementation of projects that are unanimously considered as value-added and pro-poor.

Conclusion

Appropriate technologies when introduced into LMICs with the required absorptive capacity will create concrete possibilities of technology leapfrogging. A country that today decides not to use technology for its development obviously will follow the traditional development path, that was laboriously made by those countries that are developed today. But this choice can be different since technology now allows LMICs to follow easier and faster paths. The paper is a modest attempt to understand the key drivers for successful technology transfer in PHSC of LMICs. Further scope of the study includes an empirical analysis of PHSC in LMICs and learn from their experiences.

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