
4. The rise of emerging economies: implications on appropriate technology development in theory and practice

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INTRODUCTION

Appropriate technology is generally discussed in relation to local socio-economic development, and as an alternative to capital-intensive technology transfer from industrialized nations to developing countries. Even if the appropriate technology movement grew out of the Organisation for Economic Co-operation and Development (OECD) energy crisis of the 1970s, and focuses as of today mainly on environmental and sustainability issues (Albert, 2019; Schumacher, 2011), it can be also traced in emerging countries. India is a vibrant example since Gandhi's inspired pre-independence and independence times (Tiwari, 2017).

Since the turn of the 21st century, the concept has evolved to become multifaceted. In some situations, appropriate technologies correspond to simple levels of know-how able to solve local problems (D-Lab, 2021a; Seyfang and Haxeltine, 2012). In some others, it refers to adequate engineering solutions addressing environmental and other societal issues (Agarwal and Brem, 2012; Brem and Wolfram, 2014; D-Lab, 2021b; Zeschky et al., 2011).

This evolution is mainly due to a transformation of terminology influenced by the rise of emerging economies since the 1990s. Due to earlier periods of global expansion (starting in the 1960s and 1970s), multinational corporations did not only build up foreign manufacturing and sales in emerging economies, they also increasingly started to internationalize their research and development in these regions towards the end of this last century (Gerybadze and Reger, 1999). This process deprived industrialized countries from their monopolistic control of technology and know-how prevailing throughout the 19th and 20th centuries. "Intermediate technology" – as promoted by emerging economies first for their own domestic development – has become a kind of subset of appropriate technology that is less costly than technology transferred from OECD countries through traditional foreign direct investment or international development aid (Foster, 1999). These traditional aid programs were thereby also criticized as being poorly efficient for local communities, thus having little impact on their social and sustainable development. Simultaneously, since these types of solutions and technologies were considered as more labor-intensive than the traditional aid programs, an important employment creation argument could not be disregarded (Agbesor, 1984; Gunasekera and Codippily, 1977; Thwala, 2008). Appropriate technology as a terminology has often been replaced by some others more meaningful in emerging and other developing economies such as: alternate or adaptive technology (Gosalia, 1976; Vyasulu, 1976), capital-saving technology (Agnihotri, 2015), light engineering technology (Nabi and Ahmed, 1984), labor-intensive technology (Agbesor, 1984), bottom-up technology (Prahalad and Hart, 1999, 2000), or grassroots innovation (Utz and Dahlman, 2007), just to name a few.

Recent industrialization of emerging countries has also led to a new distinction between hard and soft technologies developed with limited external assistance, such as hardware in the case of China, or software in the case of India. In recent years, thanks to rapid scientific and technological developments in both China and India in the main, the concept of “reverse technology” has appeared and spread worldwide (Agnihotri, 2015). Reverse technology refers to cheap or simplified technology able to sell everywhere, including in OECD countries, due to its attractiveness to consumers and its focus on low social class needs. Among the most striking examples we find Tata Motors’ ultra-low-cost car named Nano, famously developed and produced in India, or Nokia’s US\$15 mobile “Nokia 1100,” the world’s cheapest mobile, that was the world’s most sold electronic device in 2007 with more than a million items sold per week (Virki, 2007). Yet the success story of the pharma generics industries in India and South Africa and their successful focus on both, low-cost generics for OECD countries as well as urgently needed drugs for the African continent, including HIV/AIDS, waterborne diseases, malaria and dengue, is not least due to this development but also generates a strong future positioning of these economies in the area of medical biotechnology (Chaturvedi, 2008).

Furthermore, the variety of science and technology disruptive developments and innovations in emerging economies also tends to target various socio-economic and sustainable development objectives of great magnitude in all three emerging continents. Present literature and practice dealing with appropriate technology do not provide a clear answer as yet for how developed countries and their high cutting-edge technologies can address and solve such fundamental problems in emerging and other developing countries (Patnaik and Bhowmick, 2019).

EMERGING COUNTRIES AS CHEAP TECH PROVIDERS

Like the early four Asian dragons of the 1970s–1980s (Hong Kong, Singapore, South Korea, Taiwan), the second generation of emerging countries has been commonly known for its labor-intensive production and overall cheap costs. Since its major economic reforms starting in 1979–80, China has become the world’s leading supplier of consumer electronics, accounting for 24 percent of the global exports in this sector. Since its liberalization reforms of the early 1990s, India has developed as a global hub for Information and Communication Technologies (ICTs) and related support services. Nowadays, the service sector makes up more than 60 percent of India’s GDP, at US\$2.8 trillion GDP (CIA, 2021). No wonder that Chinese and Indian products and services have not only served acute development needs domestically or are being exported as low-cost alternatives to domestic products and services to OECD countries, but also serve such needs in developing countries, particularly in non-industrialized Africa. Other emerging economies of the G20 such as Brazil, Mexico, Nigeria, South Africa, Thailand, Turkey, have started to play a similar but much more modest role, while becoming substantial importers of Chinese goods (Kaplinsky et al., 2007).

On more than one occasion, cheap products and services from emerging economies have displaced home-made traditional if not appropriate technology in least developing countries, mostly in Africa. For instance, Chinese household plastic equipment has replaced locally made metal tools. Cheap semi-industrial imports from emerging economies have balanced low priced commodity exports from Africa’s least developed countries until the present day

considering the high demand for agro-food and minerals especially from Asian emerging countries.

EMERGING COUNTRIES AS APPROPRIATE OR INTERMEDIARY TECH PROVIDERS

It would be biased and unfair to reduce emerging economies to their past and still ongoing role of simple suppliers of cheap consumer goods to the developing world, and even to OECD supermarket chains such as Walmart in the USA.

Emerging economies are also increasingly recognized for various kinds of innovation outside the radar of the Western industry, but meeting the specific daily life conditions in emerging and developing countries.

First, various types of innovation have for a long time been oriented towards local and community development. This is particularly true of India and some other so-called non-aligned countries since the early Gandhi times. For instance, top-ranking Indian Institutes of Technologies (IITs) are obliged by federal ordinance to devote a segment of their R&D and training activities to address rural and urban development problems at the grassroots level, a regulation perpetuated until the present day. This may have inspired, among other reasons, the corresponding foundation of the Development Lab at the US prestigious MIT in Boston, which remains very active as illustrated in the editorship and in several chapters of this handbook.

Second, in emerging countries the concept and practice of appropriate technology has gone beyond the production of cheap consumer goods easily exportable to the developing world. It has been extended to the production of equipment and infrastructure with limited resources, and adapted to local contexts both domestically and in developing countries. Through direct investment and international assistance, the rapid rise of Chinese presence in key infrastructure projects such as hospitals, ports, rail and roads, water treatment, are well documented in Africa and Asia, not to mention the new Chinese Silk Road strategy. Other emerging economies are also present such as in Africa's agriculture and agro-food processing (e.g. Brazil, India, Thailand, Turkey), for instance.

Third, and more recently, appropriate technology in emerging economies has also been extended to innovation at the so-called bottom of the pyramid (BOP), referring to Prahalad's 2004 world bestseller *The Fortune at the Bottom of the Pyramid*. This Wharton Management School professor of Indian origin drew world attention to the priority of addressing the basic needs of the four billion people living on less than US\$2 per day or slightly above. BOP-related innovation consists in creating new business models and appropriate technologies to reach the low social strata of any given population in emerging and least developing countries (i.e. the bottom of the pyramid). This kind of bottom-up innovation is designated in India by the Hindi word *juggad* (Radjou et al., 2012), and in China by the terminology of Zizhu Changxin. This concept of producing for the masses diverges from the classical Western concept of mass production. It means to address very practical needs of daily life at grassroots levels (Seyfang and Haxeltine, 2012), user-led (Hippel, 2005) or frugal innovation (Radjou et al., 2012).

In contrast to the traditional approach of small business and appropriate technology proposed by Schumacher in the 1970s, Prahalad and his later followers have launched the fortune at the bottom of the pyramid concept in order to draw more interest to the developing world

among multinational firms. Due to saturation or slow growth of Western markets, more and more multinationals have been looking for new business opportunities elsewhere. They need to adopt new business models to be able to reach billions of potential low-class urban and rural consumers with very scarce purchasing power in both emerging countries and the developing world. For instance in the pharma sector, Indian poor farmers can afford, if any, only one or two pills to cure family sickness, as they are not able to buy a full box of medication. Young female villagers are eager to purchase cosmetics seen on TV adds, but they can afford only tiny samples sold for a few Indian rupees by small-scale distributors traveling by bicycle or motorbike from one village to another.

As most Western multinationals cannot master the whole value chain and delivery channels to reach low social classes in huge countries such as Brazil, China or India, they need to develop various partnerships with local large firms able to do so. This is why Western pharma groups have developed formally or below the radar various types of production or distribution cooperation with local industry to be able to reach the bottom of the pyramid. On more than one occasion, they have adopted similar strategies to reach the numerous and diversified middle class in rapid expansion especially in Asia (estimated around 300 million in China, and 150 million in India) but also in African and Latin American urban centers. Such North-South corporate alliances are often forged in global cities such as Casablanca, Cairo, Hong Kong, Johannesburg, Lagos, Mexico City, Mumbai, Shanghai, San Paolo, Singapore.

EMERGING COUNTRIES AS REVERSE TECHNOLOGY PROVIDERS

Emerging economies have also moved into other types of appropriate technology production modes. With the development of simplified technology or the use of expired licenses and patents, they have adopted various strategies to supply equipment and consumer goods in high demand both domestically but also in developed and developing economies. For instance, both China and India have become the leading global exporters of generics in the pharma sector. This enables larger segments of the population to access medication in developing countries, but also low- and middle-class segments in OECD countries. The USA being a case in point with approximately 30.4 million in these classes, and many Americans lacking no health insurance coverage. Both China and India have also moved into the production of cheap computers and laptops, enabling a brand such as the Chinese giant Lenovo to escalate quite rapidly in the global value chain (Shu, 2017), similar to Acer a few decades before in the case of Taiwan (Matthews and Snow, 1998). The case of Huawei in the mobile telephone sector is also well documented (Schaefer, 2020).

Another example comes from the US electronics manufacturer General Electrics (GE), one of the world's largest companies. A portable ECG machine for electrocardiography has been redesigned by GE's India branch by using costless materials, less plastic and smaller screens. As a result, its cost has drastically been reduced from US\$10,000 to \$1,000. These pioneer machines are now also sold in the US market, where health costs have become a major political issue (Pansera, 2013).

This phenomenon is called "reverse technology." The development and distribution of such appropriate technologies is no longer orchestrated in the headquarters of Western multinational firms (MNCs). On the one hand, significant parts of MNCs' R&D have already been

transferred to countries with lower cost and steadily growing needs for innovation, on the other hand, conglomerates from emerging countries are able to conquer OECD and global markets as well.

The development of reverse technology by emerging economies is not always successful. The case of the low priced Nano car promoted by Tata Motors in India has been a flop, despite a sustained effort by the largest Indian private conglomerate. More recently, some attempts by Chinese automotive producers to export small electrical cars to Europe (for 60 to 70 percent of the pricing of their Japanese or European competitors) have attracted attention from national and local media. However, it is too early to assess whether it could be a real business success in the medium/long term.

EMERGING COUNTRIES AS NEW APPROPRIATE HIGH-TECH INNOVATORS

For the purpose of completeness, we now review some important innovation research and development (R&D) evolutions taking place in emerging countries in the last couple of decades.

Some of them do not illustrate the discussion of appropriate technology, as they result from massive public/private investment strategies, in China in particular, and pursue a core objective to catch up with OECD countries, and in some cases to overtake if possible US-based R&D. This includes the acquisition of OECD MNCs, such as the Swiss Syngenta (agro-chemistry), the largest Chinese acquisition in Europe so far for US\$43 billion in 2017–18.

However, other R&D development inroads illustrate the various transformations of the very concept of appropriate technology.

A first evolution resides in the delocalization or re-localization of R&D centers in emerging economies mainly by MNCs, but also by high-tech small and medium enterprises (SMEs) from OECD countries. The core reason is to develop new products and services corresponding to local contexts and needs, which differ largely from those prevailing in developed countries. The objective is to develop maximum proximity to existing and potential clients in big numbers. Re-localization of R&D includes medium and high-tech production adapted to local needs, but also R&D including maintenance and repairs in local environments with various conditions and constraints often remote from North America, Western Europe and Japan.

A second evolution dealing with open entrepreneurship can also be traced both in emerging countries and other developing nations. The spread of open data and science, mainly sourced from developed economies, creates new ways and means to foster entrepreneurship in emerging countries in particular, being at the individual or at the institutional level. For instance, pure conceptual science and tech research is conducted in the West, but part or full incubation and prototyping are realized locally in emerging countries. For instance, various leading universities and schools in engineering have established partnerships and mobility agreements between West and East (in Asia in particular) to foster innovation among students and coaching instructors. With or without institutionalized agreements, and with the help of ICTs and digitalization, young people develop new transnational ideas and potential businesses without the preoccupation of physical borders, national rules and regulations. This contributes to some extent to the creation of so-called globally born SMEs (Knight, 2010; Rasmussen and Madsen, 2002) serving a multitude of countries since inception (or within a few years after inception of

the company) oftentimes in more than one continental market. This type of new entrepreneurship develops rather rapidly between Asia and North America, and between Asia and Europe (Falahat et al., 2018).

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