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Techno-Globalization and Innovation

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Synonyms

Innovation internationalization; Research; Technology

Techno-globalization denotes a global pervasion in generating technological knowledge and exploiting innovations with a technological content. It also claims that globalization has been shaped and advanced with the help of technology. With regard to research and development (here *R&D*) and innovation, the term in its most modest use is shorthand for the fact that generation, transmission, and diffusion of technologies are increasingly international in scope. A fundamental typology of Archibugi and Michie (1995) differentiates between global technology exploitation, global technological cooperation, and global generation of technology. Techno-globalization subsumes different internationalization aspects: firstly, the international exploitation of domestically generated new technological knowledge on foreign markets, either embedded in innovative products or process technologies (exploited by trade or offshore production) or nonembedded (by license agreements); secondly, the internationalization of sourcing new technological knowledge by founding or buying R&D facilities abroad or through international R&D subcontracting and outsourcing (and, conversely, the selling of R&D services to foreign customers); and, thirdly, international R&D cooperation in generating new technological knowledge through joint R&D ventures, cooperative agreements, or alliances and collaborative R&D projects, where each participating partner typically retains its formal independence. The main actors of techno-globalization are commercial companies looking for business opportunities and technological competition head start at an increasingly global scale. Industrial and technological standards play a major role in favoring or preventing entrepreneurial activities in creating or penetrating specific markets. Increasingly public research organizations engage themselves in the field of international R&D pushing international R&D *cooperation* as a sub-phenomenon of R&D internationalization to become a distinct field of science and technology (*here S&T*) policy. Research about techno-globalization, however, is still confronted with methodological shortcomings, insufficient data, and data comparability.

Background and Drivers of Techno-Globalization

Techno-globalization is both a result and a driver of new forms of economic organization and

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division of labor, fortified by sociopolitical (e.g., integration of the European Union, *here* EU) and sociocultural (e.g., "global village" and Web 2.0) changes. Among its main characteristics are:

- A wide application of new technologies to organize global transactions (information and communication technologies; logistics, packaging, and transport technologies)
- Multinational enterprises (*here* MNEs) as major agents and promoters, which – next to technology trade and technology exploitation – increasingly undertake R&D at locations outside their home countries and which are implementing new management practices to (out)source R&D internationally (e.g., open innovation)
- A worldwide tendency toward market deregulation, diffusing from the triadic countries (the USA, Japan, the EU) to emerging economies and beyond, accompanied by global and sub-global diffusion of standards and norms
- An increasing mobility of production factors, especially capital, but also of (codified) knowledge, accompanied by an emergence of efficiency-oriented education systems, capable to produce human resources to manage the global exchange of goods, services, capital, information, and knowledge, not only in economically advanced post-industrialized countries but also in emerging economies with considerably cheaper labor costs
- Rising public awareness on global challenges, which do not stop in front of national borders

Economic growth and technological change, defined as the extension of knowledge in a way of new products, production, and organization technologies, are increasingly relying on innovation-relevant knowledge. The competition for new innovation-relevant knowledge has reached a global level. Technological progress has both an endogenous and an exogenous dimension. Positive exogenous spillover (e.g., by means of technology transfer) can only develop if the knowledge-receiving company (or institution) has the ability to make use of it and to enhance it through own contributions. For the development of absorptive capacities, the quality of educational institutions (e.g., universities) and science and technology policy (through an effective allocation of resources) play a major role. National economies which do not invest in knowledge production might in the long term not be able to master the speed of progress of knowledge-based economies (and societies).

Internationalization of Business R&D

Techno-globalization is not a new phenomenon. Although it might reach back decades, it became widely recognized in the academic discourse at the end of the 1980s and early 1990s. This was caused by a strong growth in the 1980s by companies' propensities to trade and to exploit their inventions and innovations internationally. Also, global technological cooperation of companies experienced a major boost during that time (Mowery 1992), however confined to few, but crucial, fields (e.g., information and telecommunication technologies or automotive industries) and with a very selective regional focus on the "classical" triadic countries (Japan, but especially on the USA and Europe). A more recent development is that companies increasingly also undertake R&D at locations outside their home countries. The location of R&D production has always been regarded as most "sticky" among all business processes, in a sense that it was perceived as least transferable to other locations or countries. Only 25 years ago, Patel and Pavitt (1991) concluded that R&D is an important case of non-globalization. Today, a vast amount of evidence draws a different picture. Internationalization of R&D has become an important trend that shapes the national innovation system of all OECD countries. Foreign-owned firms already account for around 20% of total business R&D in France, Germany, and Spain; between 30% and 50% in Canada, Hungary, Portugal, the Slovak Republic, Sweden, and the UK; and more than 50% in especially smaller countries such as Austria, Belgium, the Czech Republic, or Ireland (Dachs et al. 2012).

Howells (2008) contextualizes the new wave of R&D globalization as an ongoing process of increasing spatial division of R&D where, besides the geographical widening, a deepening of R&D

activities is occurring too. Business R&D is widely considered a production-related activity as input into the innovation process and a knowledge-generating activity as input into the transformation of manufacturing-based economies into knowledge-based economies. In more general words, "R&D either follows production" or "R&D follows excellence." In the first mode, the so-called adaptation mode, companies need to perform some R&D in foreign markets to adapt to local tastes and requirements and/or to take advantage of cost arbitrations in the global division of scientific labor. In the second mode, the augmentation mode, companies are driven by the search for excellent R&D conditions, particularly access to quality and scale of human resources and to a developed public research base.

Especially the first of these two modes was decisive for the emergence of the so-called BRICS countries (i.e., Brazil, Russia, India, China, and South Africa) as R&D locations of foreign companies. In part, the BRICS are increasingly also emerging as hotspots for R&D excellence, but the notion of "R&D following excellence" is still predominately a core issue of intra-triadic exchange with a few new smaller high- or post-industrialized countries catching up, such as Israel or Singapore. In general, however, regions and cities are more relevant units and sites than countries in corporate R&D's competitive quest for investment, scientific facilities, or global talent (The Royal Society 2011). According to Dachs et al. (2012), foreign-owned firms in the USA spent around EUR 30 billion on R&D in 2007. The corresponding amount for Germany is EUR 11 billion and EUR 9 billion for the UK. The R&D expenditure of US firms in the EU (considered as one entity, not taking intra-EU relationships into account) and of EU firms in the USA taken together accounts for two-thirds of R&D expenditure of foreign-owned firms in manufacturing worldwide. In absolute terms, overseas R&D expenditure of US firms in the EU more than doubled between 1994 and 2008, but in relative terms, the rise of Asian countries as R&D locations for US firms has led to a dramatically declining share of US overseas expenditure in the EU (from around 75% in 1994 to around 60% in 2008). Brazil, Russia, India, and China are not only host countries for R&D activities of foreign-owned firms, but a few of their companies are also increasingly setting up R&D activities in the EU and the USA.

R&D expenditure of foreign-owned firms concentrates on R&D intensive, high-technology, or medium-high-technology sectors. Thus, techno-globalization predominantly takes primarily place in pharmaceuticals, machinery and equipment, electrical and optical equipment, information and telecommunications (here *ICT*), motor vehicles, and other transport equipment. Some sectors offer better preconditions for a decentralized organization of R&D because their knowledge base is less cumulative with fewer size advantages in R&D or allow also an easier exchange of knowledge. This is the case for ICT, but also for business services as important nonmanufacturing sector, for instance, in Israel or the UK. The lowest degrees of internationalization of R&D are found in low- and medium-low-technology sectors such as textiles and clothing, wood, paper, rubber and plastics, or basic metals and metal products. Though data is scarce, the existing evidence suggests that service industries tend to be characterized by lower levels of R&D internationalization compared to manufacturing industries (paragraph based on Dachs et al. 2012).

Major motives for firms to locate R&D activities abroad are:

- The size of the host economy, which promises superior market potentials and sales prospects conducive to R&D efforts of foreign-owned affiliates, especially in light of specific market and customer preferences and requirements
- Rising costs of R&D in knowledge-intensive industries, which lead to international R&D allicances, mergers, and acquisitions
- The accessibility and quality of a developed public research base (including technological infrastructure)
- The quality, cost, and size of skilled workforce, which is important for any research endeavors
- Subsidies/incentives

However, R&D internationalization is still heavily influenced by geographic proximity and low cultural barriers, that is, factors which are conducive to reduce transaction costs. From a country's inward perspective, R&D expenditure and labor productivity of foreign-owned affiliates seem to be positively related to labor productivity of domestic suppliers, especially if incentives for spillover and competition effects are promoted by the host country's industrial and innovation policy (Edler 2008). Sometimes, local content measures, including funding of collaborative R&D projects, are in use to enforce a connection of the MNEs' R&D with domestic partners to avoid a Janus-shaped industrial organization, where productive MNEs are not integrated in domestic chains of economic value added and where local companies, thus, do not benefit from productivity spillovers and remain less efficient and profitable. From an outward perspective, home countries may benefit from the global expansion and from reverse knowledge spillovers and reverse technology transfer. Although hollowing-out effects are possible, today's empirical evidence still suggests that overseas R&D activities are usually not (yet) a substitution for similar domestic activities.

Internationalization of Science and Technology Policy

The role of S&T policy for R&D internationalization has long been regarded primarily as an accompanying "enabling" or – at least – "preventing" framework. Although academic science has been international in scope almost since its inception, public R&D expenditure remained rooted in the national context. The enabling function of internationally oriented S&T policy comprises the development of stimulating incentives or support programs, while its preventing function primarily concerns the protection of intellectual property at international scale. Above all, however, the main task of national S&T policy toward internationalization of R&D is to keep the own house clean, that is, to be an attractive place for conducting R&D and, thus, for attracting R&D inflows from abroad.

In the last couple of years, S&T policies actively started to deal with internationalization of R&D, not just to let it happen but to support it and even to direct it. Examples for this proactive understanding are incentives to attract inward corporate and institutional R&D, to establish and to participate in cross border research programs, to invest in joint R&D labs abroad, to support the mobility of researchers, and to promote political cooperation, dialogue, and trust eventually leading to coordination of R&D internationalization policies toward third countries.

Basically, two different sets of S&T internationalization objectives can be distinguished: an intrinsic dimension, which puts goals into the center of public S&T policy that directly aim to substantiate S&T (e.g., through enabling R&D cooperation among the best researchers globally or to find joint solutions for large-scale R&D infrastructures which cannot be financed by a country at its own), and an extrinsic dimension, which puts goals into the center that are meant to support other policies (e.g., facilitation of access to foreign markets through standard settings or research for development to assist technical development cooperation). The main addressees of interventionist approaches of S&T policy toward R&D internationalization are public R&D organizations and agencies.

The major motives of public R&D organizations to participate in international R&D cooperation are to access and to utilize excellent and complementary knowledge available abroad, to secure international funding, and to build up reputation through international visibility. For universities, further motives are to gain solvent students, to branch out colleges to commercialize their educational activities, and also to bolster their prestige in international rankings. Branch campus offshoring is a rather new phenomenon, connected particularly to American and UK universities, aiming to become global brands, with an initial concentration on the Middle East and a very recent shift to the Far East (Royal Society 2011).

The main objectives (Sonnenburg et al. 2008) that drive R&D internationalization from an S&T policy perspective are:

- The quality acceleration and excellence objective
- The market and competition objective
- The resource acquisition objective

- The cost optimization objective
- The global or regional development objective
- The science diplomacy objective

Different rationales are guiding these objectives: the rationale behind the *quality acceleration and excellence objective* is primarily an intrinsic one that assumes that international R&D cooperation improves the domestic science base; leads to faster and improved scientific progress as well as enhanced, or even superior, scientific productivity; and is also supportive for the professional advancement of the involved researchers (e.g., through joint publications in acknowledged international journals). The rationale behind the extrinsic *market and competition objective* is to support the market entry of domestically produced technologies/innovations abroad as well as to support the access to and a quick uptake of technologies produced abroad within the domestic economy. The rationale behind the *resource acquisition objective* overlaps partly with the two major objectives mentioned before. The access to information, knowledge, technology, and expertise as well as to singular equipment/facilities and materials is in the focus. But resource acquisition is not limited to different codified and tacit dimensions of technology transfer but extends to brain gain, gaining of solvent students and increasingly also gaining research funds from abroad or from multilateral or international sources. The *cost optimization objective* from a public S&T policy focus does not primarily mean to use cost arbitrages of other countries (e.g., lower wages abroad) as might be an argument of the business sector but rather focuses on cost-sharing approaches to create critical mass in a certain S&T arena, for example, to establish large-scale research infrastructures, and it also includes the rationale of risk sharing. The assumption behind the *global or regional development objective* is the comprehension that many risks have no frontiers (e.g., infectious diseases or climate change) or cannot be solved without international cooperation and solidarity (e.g., 17 Sustainable Development Goals aimed to end poverty, protect the planet, and ensure prosperity for all adopted by 193 UN member states in September 2015) and, thus, have to be tackled through international R&D collaboration (e.g., research for development). The main rationales underlying the *science diplomacy objective*, which often refers to global challenges and to development cooperation agendas, are to support other policies through R&D cooperation (e.g., nonproliferation of mass destruction weapons through keeping former weapon researchers busy with civilian R&D projects) and, secondly, to promote the national science base abroad in support of other objectives already mentioned above (e.g., to attract “brains” or to promote a general quality trademark like “made in Germany”).

Public S&T policies toward R&D internationalization have both a strong “inward” dimension, which is to reinforce the domestic S&T base through attraction of and connection establishment to foreign resources (e.g., human resources, knowledge, or foreign funds) and a strong “outward” dimension in linking domestic actors to foreign markets and to knowledge produced abroad (Boekholt et al. 2009). An important channel for absorption, extensively taken up by the European Commission, is to integrate foreign actors into R&D cooperation programs.

Further Aspects: Subglobal S&T Integration, Technological and Industrial Standards, and R&D Internationalization Indicators

This integrative approach, which cumulated in a general opening of the seventh European Framework Programmes for Research and Technological Development (2007–2013) and its successor, Horizon 2020 (2014–2020), the world’s largest single R&D program, toward third countries, is a further aspect of the most ambitious international S&T policy integration process ever experienced subglobally, namely, the creation of a single European research area (here *ERA*). With ERA, a harmonized, mutually open intra-European R&D arena of free movement of knowledge, researchers, and technology, with the aim of increasing cooperation, stimulating competition, and achieving an optimized allocation of resources, has been created, although the pace of change is complex and slow in several areas with still many fragmented national policies, initiatives, and practices in place.

Less advanced subcontinental integration policies in the field of S&T can be witnessed in other important regions of the world too, such as in MERCOSUR, the Common Southern Latin American Market, here especially between Argentina and Brazil, or in ASEAN, the Association of Southeast Asian Nations. Regarding the latter, the ASEAN Committee on Science and Technology has been established back in 1971 with the objective to increase the competitiveness of S&T in the ASEAN region by supporting intra-regional R&D cooperation, partly supported by the ASEAN Science Fund established in 1989.

A further important aspect of integration policies is to reduce regulative barriers preventing a diffusion of economically relevant technological activities, including knowledge generation and innovation exploitation, across national borders. After technology, regulation and standard setting have played an important role in making globalization a reality. In order to facilitate global communication, telecommunication technology – for instance – depends strongly on industrial and technological standardizations. Also, environmental standards and codes with more or less technological implications (e.g., passive energy buildings and 3-L motors) can be either encouraging or discouraging to global transactions. Typically, the standard setter has both an accumulative and first-mover advantage against the standard adopter. Triadic industries, and contemporarily also increasingly China and Russia as well as other emerging economies, have a long history in competing standards for the sake of promoting own industries globally, respectively, of preventing the intrusion of foreign companies at domestic markets. Early set standards can help to focus investments, but they can also subvert vivid innovation competition and might result in technological trajectories with too early dead end. Industrial and S&T policy increasingly aims to push international standard setting by establishing lead markets or pre-commercial innovation procurement, but often industrial standards are settled by market forces.

Compared to economically wasteful standard wars, open technical standards developed under appropriate patent policies can generate significant public benefits. Competition within an open technical standard framework, however, depends crucially on the proper functioning of industry standard setting organizations. An often cited example is that of GSM, the global system for mobile communications, which is in use in 200 countries, covering around four-fifth of all mobile communication clients. In order to avoid a similar fragmented situation as the one referring to analogous mobile communications in Europe, the *Groupe Spécial Mobile* was established in 1982 to develop a uniform intra-European standard for digital mobile communications, which later pushed other standards, for example, in the USA, aside and became a global industrial standard. In 2000, next-generation GSM standard activities have been transferred into the "3GPP" consortium, which includes relevant authorities from the EU, the USA, Japan, Korea, and China as partners.

The measurement of techno-globalization differs significantly with respect to the observed phenomenon. Indicators are usually well developed at the level of supranational and international organizations, but poor when it comes to binational or multinational programs or the participation of foreign companies or research organizations in national programs. Patent statistics can provide a number of meaningful throughput indicators for approximating business-relevant knowledge interactions at global and international level, while academic publication databases, such as Scopus or Thomson Reuters Web of Science, enable insights in international co-publication activities which are globally on the rise. Although there are a series of reports on international R&D flows, published data is frequently neither complete nor fully comparable. Among other issues, published data on sources and origins of R&D expenditures reveal methodological differences, data gaps (especially concerning specific regions and business R&D investments), timeliness in reporting, and high levels of aggregation, preventing in-depth analysis to observe the often subtle changes in the character and content of internationalized R&D. Governments and R&D funding agencies themselves do often not precisely know what share of national budget is spent for foreign actors or how money allocated to domestic actors is spent abroad or in international cooperation (European Science Foundation 2012; Verbeek et al. 2009).

Conclusions and Future Directions

Since the industrial revolution, the importance of technological change for economic development has not been questioned. Access to scientific and technological knowledge can be seen as what divides the "haves" and the "have-nots." One of the highest-value business functions in terms of its value-added contribution is R&D. For this reason, internationalization in general, and in particular of high value-added activities such as R&D, is an issue of political debate. There are first signs that in contrast to the early years of foreign direct investments in R&D in emerging economies, an investment in those countries could be more likely to be accompanied by a disinvestment in the triadic core regions. This shift in R&D locations might be amplified by a larger supply of skilled and more cost-efficient S&T workforce in emerging economies, which will shape the global R&D landscape in the future. While a lot about empirical trends and motives of firms is known and the measurement of internationalization of research organizations has just begun, there is still considerable lack of knowledge as regards the effects of techno-globalization on home and host countries, not only in terms of economy but also in terms of impact on the social fabric and cohesion as well as on the individual experience in the everyday world. In general, developed economies with developed rule of law are still the favored locations for foreign R&D investors, although the share of foreign-owned business R&D in the developing world is steadily increasing and contributing by itself to economic development and social change (Royal Society 2011).

In fact, under techno-globalization, more can be understood than only different aspects of R&D internationalization or the diffusion of technology for the sake of economic activity or academic progress. Future research on techno-globalization will have to take also noneconomic and non-R&D processes into account. The globalized impact of basic technical infrastructures, such as the Internet on political developments (e.g., the Arab revolution in 2011), or the presumably borderless use of "social" software on the design and diffusion of sociocultural trends and social innovations will probably broaden the focus of research about techno-globalization in the future. Furthermore, global sustainability, justice, and governance aspects of technology, its unequal distribution, and use in view of its contribution to induce global problems but also to mitigate global challenges will have to be readdressed. Effects of technologies induced in region "A" might have intended or unintended impact on region "B" (e.g., spatially differentiated effects of the emission of chlorofluorocarbons [*CFCs*] on the planet's protective ozone layer) and can even create global dependencies (e.g., the use of genetically manipulated seeds in Africa). This calls for more effective international cooperation and appropriate sharing of burdens and benefits in order to protect the global "commons" and the world's public goods, but what constitutes effective governance of international cooperation in STI to meet global challenges is not yet clear (OECD 2012).

Finally, the question about winners and losers needs to be reassessed. While globalization in general seems to have created a system which has benefitted the more developed countries, it also seems that globalization through technology, as a whole, has not brought preponderant negative impact on the developing countries. In fact, while some developing countries have profited enormously through techno-globalization, others lack certain factors preventing them to take active part and to gain benefits.

Cross-References

▶ Innovation
▶ Knowledge-Based Economy
▶ Knowledge Society
▶ Multi-level Systems of Innovation

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