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National innovation policies for technology upgrading through GVCs: A cross-country comparison☆

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ABSTRACT

This paper considers how innovation policy mixes are designed for increasing a country's participation in global value chains (GVCs) and accelerating industrial and technological upgrading. A benchmarking concept compares science, technology and innovation (STI) policies across countries taking into account country absorptive capacities, performance in GVCs and the way these policies are embedded in the national STI policy context. Data cover selected OECD and emerging economies drawing on the EC/OECD STI Policy database. An exploratory text-as-data approach is taken. National policy mixes for GVC integration and technology upgrading seem to be developed on the basis of prior positioning in GVCs. Policy mixes are polymorphs in so far as they combine different instruments across different policy domains with different functions according to national structural features and comparative advantages. While essential, especially to technology upgrading, industrial and cluster policies are not the only channels of policy intervention. Foreign direct investment (FDI)-related policies and initiatives in support of the internationalisation of firms and universities also appear to be key. Financial instruments remain the most popular policy tools for supporting integration into GVCs and countries combine a broad range of funding mechanisms with international investment promotion activities and the deployment of networking and world-class research facilities.

1. Introduction: The "innovation imperative"

The past two decades have witnessed a shift in the global economic centre of gravity towards the East and South. The so-called Shifting wealth phenomenon has been driven by strong and sustained economic performance and improved livelihoods in emerging economies, especially in China and India. The new millennium saw the resumption, for the first time since the 1970s, of a convergence in per capita incomes of the developing world with high-income countries. During the 2000s China and India grew three to four times faster than the OECD average and the number of poor countries more than halved (OECD, 2010a).

The period from 2000 to 15 was particularly favourable to global economic convergence (OECD, 2017a). Several factors contributed to the rise of developing economies. The opening of China, India and the former Soviet Union block pulled production costs of a range of goods and services down as 1.5 billion low-wage workers entered the global market economy (OECD, 2010a). Increasing demand for raw materials and energy sources, especially fossil fuel, boosted global commodity markets. This in turn steered economic growth in commodity exporting countries. As a consequence, developing and emerging economies accumulated foreign exchange reserves and surplus in their current accounts that maintained global interest rates low and further fuelled global economic growth.

Manufacturing capacity has massively shifted from the OECD area towards developing countries, especially the East Asia region, and especially faster as multinationals (MNEs) transferred their activities to new locations where local market conditions and production factors were more favourable. Production has been increasingly "sliced and diced" into segments that have been recombined along global supply chains (GVCs). Multinationals, through their investment and optimisation strategies, have been key actors in 'shifting wealth' east and south (OECD, 2010a, 2011).

The rapid spread of GVCs has provided emerging economies opportunities to reap the benefits of innovation offshoring and accelerate their structural transformation. Host countries have built absorptive capacities and developed indigenous innovation (Ernst, 2008; Fu et al., 2011), raising innovation on the policy agenda. Attractiveness for innovation has also become a policy priority in many countries, as part of a broader economic and development agenda (OECD, 2011).

Yet, recent years have seen a slowdown in convergence and

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narrowing growth differentials between OECD and non-OECD countries. Several middle-income countries are not growing fast enough anymore to converge with advanced countries and the global context has become more challenging (OECD, 2015a, 2017a). Slowing economic growth in large emerging economies, especially China, weighs on global demand and hampers growth prospects in other developing countries. Sluggish demand put a break on global commodity market expansion. Access to international finance has become increasingly difficult for developing countries and rising interest rates increase volatility in financial markets and debt-service costs. Premature deindustrialisation in developing regions is also problematic as structural shift towards services weighs on economy-wide productivity performance and encourages informality (Rodrik, 2016). In the absence of sizeable manufacturing industries, economies will need to explore new growth models, often based on skill-intensive services for which they do not have appropriate capacity. In addition the rising threat of a jobless growth put further pressure on socio-economic systems worldwide. GDP and employment growth trends have been diverging over the last two decades in almost all countries (OECD, 2015b), suggesting the world economy is deeply engaged in a long-term growth process that is not generating employment. While gradual retirement is expected to ease the situation in ageing societies, the rapid expansion of working-age populations in young low-income regions is likely to increase tensions in labour markets and risks of social unrest.

In addition, GVCs are evolving. Eroding salary cost advantages in middle-income economies, new reshoring and diversification strategies of multinationals (De Backer et al., 2016), and emerging technologies such as 3D printing and robotics that can support alternative production processes and contribute to shorten supply chains and alter localisation factors (OECD, 2016a) raise concerns about the capacity of emerging economies to escape the 'middle-income trap' and move towards an innovation-driven growth. Moreover such a structural shift would require further technology upgrading which primarily relies on GVC integration at earlier capability stages. And upgrading though GVCs is primarily a matter of competitiveness and innovation.

This article focuses on the composition of national innovation policy mixes aiming to foster a country's industrial and technological upgrading as a primary or secondary strategic objective. I consider policy mixes in the innovation policy domain that were active early 2016. More specifically, the paper takes stock of and compares the policy approaches of OECD members countries and observers economies targeted to increasing countries' participation in GVCs and moving along value chains towards segments of higher value added. For that purpose, I develop a new experimental benchmarking approach which takes account of the nature and intensity of countries' linkages in value chains and of the way policies are embedded in the national STI policy context. The core data source is the STI Outlook 2016 published by OECD and its policy database. This paper focuses on fifteen countries (G7, Korea and seven emerging economies) with large STI systems and different structural features and degrees of maturity. The analysis allows indicative description of country-specific policy approaches in the field and the respective fine-tuning to national frameworks.

The article aims to contribute to the literature on benchmarking STI policies by comparing the mix of policies across countries, an issue of significant attention in recent literature (Flanagan et al., 2011; Kivimaa and Kern, 2016; Rogge and Reichardt, 2016). The article illustrates the articulation of policies related to industry and technology upgrading through GVCs and points at the underlying approaches across countries. Finally, the article derives conclusions on approaches to policy design and calibration and provides indications for future research work in comparing different country-specific STI policy mixes.

The remaining of the article is structured as follows. Section 1 builds the background concepts on the forms of industrial and technological upgrading and outlines the concept of policy mix. Section 2 develops data methodology and hypothesis. Section 3 provides the results of the analysis and relevant discussion.

2. Background

2.1. Industry and technology upgrading: Broadening the policy scope

Industry and technology upgrading are intrinsically related. Upgrading is usually referred to as a structural change in a country's industrial composition, specialisation and knowledge base, characterised by a gradual development of production, technology and knowledge capabilities and a shift towards higher value-added activities and more profitable, sophisticated and skill-intensive industries (Ernst, 2008; Gereffi, 1999). The notions of "endowment structure", "latent comparative advantages", "differentiation" and "smart" specialisation are central to the concept (Akamatsu, 1962; Foray, 2015; Lin, 2011). Upgrading can take place at the firm, industry, inter-industry, and country levels but it remains a non-linear process as moving from one stage to another requires mobilising new set of technical, financial and organisational factors (see Radosevic and Yoruk, 2015 for an overview of past and recent contributions to the research on technology upgrading).

Upgrading capacity is nested in the stock of knowledge-based capital (KBC) a firm or a country can accumulate, maintain over time and leverage for innovating (OECD, 2013a, 2013b). Those assets include computerised information (e.g. software and databases), innovative property (R&D and intellectual property rights –IPRs-) and economic competencies (e.g. brand equity, firm-specific skills such managerial skills, networks and organisational structures and processes) (Corrado et al., 2005). Improvements in production, technology and knowledge capabilities stem from increased investment in -and accumulation of- these intangible assets.

However the drivers of technology upgrading differ along the stages of a country's economic development and according to the distance to the technology frontier (Acemoglu et al., 2006; Radosevic and Yoruk, 2015). Countries at early stages of development pursue an investment-based strategy, which relies on existing firms and managers and aims to maximize investment. As the economy approaches the frontier, selection becomes more important and economies switch to an innovation-based strategy with shorter-term relationships, younger firms, less investment, and better selection of firms and managers. Similarly, while imitation using latent competitive advantages is more relevant in transition from low to middle-income levels, technological diversification becomes a major factor in catching up to high-income levels (Lee, 2013).

Participation in GVCs accelerates the accumulation of KBC as firms and countries can tap into global knowledge stocks and build on spillovers from other firms and economies. Yet integration into GVC does not automatically translate into technological or economic upgrading (Gereffi et al., 2005; Humphrey, 2004; OECD, 2013b). This is linked in part to the way value is created and captured within the GVC and in part to the mode of chain governance.

Upgrading within GVC is a matter of competiveness and innovation. Value creation within GVC results from the low replicability of the products and services supplied and a firm's success depends on abilities of -or difficulties met by- competitors to supply similar or substitutable products or services (Kaplinsky and Morris, 2002). Upgrading in GVC therefore occurs when firms and subsequently countries acquire capabilities to supply products and services that are more difficult to reproduce.

Economic competencies are in general more difficult to replicate than the two former groups of KBC –computerised information and innovative property- that are more codified by nature. Economic competencies have been found to contribute to a larger extend to GVC integration, as measured by value-added embodied in exports (OECD, 2013c, 2013d, 2013e). But in practice this is the complex integration of different forms of KBC that makes firms' and countries' competitive advantage.

Case studies of specific value chains have shown that value creation

within a GVC is distributed unevenly across activities (OECD, 2013c, 2013d, 2013e). The highest level of value creation is often found in upstream, such as concept developments and research and development (R&D) activities, and downstream activities such as branding, marketing and customer services, as these activities both contribute to differentiate final products in consumer markets and often require tacit and non-codified knowledge that is less easily transferable and duplicable. Conversely, activities based on well-established standard and modularity, such as final assembly, are subject to more intense competition.

Upgrading in GVC takes different forms (Kaplinsky and Morris, 2002).

- Process upgrading as firms acquire capabilities to process tasks more efficiently (lower defect rates, faster delivery) and address more complex or specific requirements. Process upgrading is mostly based on learning-by-doing.
- Product upgrading as firms acquire capabilities to supply higher quality or more sophisticated products and services faster than rivals.
- Functional upgrading as firms acquire capabilities to move along GVC and become competitive in upstream and downstream segments of higher value-added.
- Chain upgrading as firms acquire capabilities to reconfigure their tangible and intangible resources and integrate others GVCs engaged in higher value added production.

Upgrading trajectory is likely to start from process upgrading (Gereffi, 1999) that is mostly based on learning-by-doing. Subsequent forms of upgrading require more advanced technological capabilities, skills and business know-how and “dynamic” capabilities (OECD, 2013c, 2013d; Pietrobelli and Raboletti, 2011; Teece et al., 1997). Although value chains are not the only approach for upgrading (Humphrey and Schmitz, 2002), the reliance on GVCs is particularly strong during the initial production and technology capability stages (Radosevic and Yoruk, 2015).

The co-ordination within GVC, and the nature of the relationships between lead firms and suppliers in particular, could hamper functional and chain upgrading. The mode of GVC coordination depends on the complexity of transactions, the ability to codify transactions and the capabilities of the supply base to meet buyers' requirements (Gereffi et al., 2005). For instance, lead firms can increase complexity by requesting just-in-time supply or high product differentiation. In turn, this complexity could be lower by setting technical or process standards. If supply base capabilities are low, the lead firm is likely to exert more direct control on suppliers and the value chain is likely to be vertically integrated and governed with high degree of explicit coordination and large power asymmetry in favour of the lead firm. If supply base capabilities are high, arm-length market linkages can set up and the degree of explicit coordination and power asymmetry decrease. In a vertically integrated value chain, functional upgrading is only feasible if the lead firms are willing to transfer technology and knowledge to their suppliers.

Multinationals, through intra-firm trade, foreign direct investments (FDI) and their optimisation strategies, are key actors in GVCs. They have played a central role in the fragmentation of production worldwide (OECD, 2013b) and have been key drivers of ‘shifting wealth’ east and south (OECD, 2010a, 2011). Multinationals benefit “ownership advantages” as they hold proprietary technology and knowledge, or specific brand names or production processes as part of their asset portfolio (Dunning, 1980). As they seek for “location advantages” (e.g. natural resources, labour supply, local knowledge providers or final market size in the host country) and they find “internalisation advantages” to integrate abroad rather than develop arm-length contracts with external partners (e.g. needs to protect proprietary technology, lack of intellectual property protection and enforcement in the host country), they increasingly set up affiliates abroad.

Yet, multinationals function as networks within networks – i.e. the international production networks of GVCs- (Dicken, 2015) and have increasingly been relying on third-parties for their operations. MNEs combine trade and local sales by affiliates with other forms of market access, such as franchising, licensing and partnerships, that provide them with greater strategic and operational flexibility (Cadestin et al., 2018). In this setting, affiliates are often used to transfer capabilities rather than produce inputs.

Although the rapid spread of GVCs has provided them opportunities to reap the benefits of innovation offshoring, developing countries are not as fully integrated into MNEs networks as they are in global trade (Cadestin et al., 2018). In addition developing economies may face difficulties in meeting international capability requirements and standards and according to the mode of governance prevailing in the value chain, they may be locked-in to “hierarchical” or “captive” relationships that prevent any further functional upgrading (Gereffi et al., 2005). Therefore further upgrading through GVC requires building stronger capabilities autonomously and reshaping supply firms' relationships with chain partners, especially lead firms and MNEs. In that perspective, it has become crucial for emerging economies to create indigenous innovation systems that are able to absorb new knowledge drawn from GVC participation (Ernst, 2008; Fu et al., 2011; Pietrobelli and Raboletti, 2011).

Policy makers have paid increased attention to fostering their country's participation in value chains and setting the right conditions for upgrading within GVC. Whereas improving GVCs participation is primarily addressed through trade and border policies (e.g. import tariffs, duties, bilateral and multilateral trade agreements etc.) and investment policies (FDI, competition and product market regulation) (Kowalski et al., 2015), encouraging industrial and technology upgrading rather falls into the scope of industrial, innovation, entrepreneurship and skills policies.

Setting the right conditions for upgrading within GVCs requires therefore going beyond the scope of trade and investment policies and revisiting the set of policies that may facilitate the settlement and expansion of foreign affiliates, on the one hand, and support the development of an indigenous innovation system on the other hand.

Policies that support participation in GVC mainly encompass trade related policies, import tariffs, bilateral and multilateral trade agreements, competition and product market regulation (contractual relationships, simplification of administrative procedures etc.).

Policies that support upgrading within GVC mainly encompasses innovation and skills policies, i.e.:

- Policies to attract foreign direct investments in science and technology and to increase location attractiveness for international research centres (e.g. tax policies, intellectual property –IP- laws and enforcement etc.);
- Policies to encourage innovative entrepreneurship, in particular ease access to capital and skills for start-ups;
- Policies to reinforce linkages and potential spillovers between GVC participants and the local knowledge base, such as research and education institutions (e.g. cluster policies, policies for technology transfer etc.);
- Policies to encourage internationalisation of domestic innovation actors, including universities and small-and-medium-sized entreprises (SMEs);
- Policies to encourage international mobility of talent;
- Policies to develop the right skills mix for innovation, by mobilising education and training system capacity.

2.2. Policy mix: Concepts, challenges and operational approach

Technology upgrading is a multidimensional process that requires technology, interaction with the global economy and structural change,

which is itself the result of another multidimensional process involving technological, industrial, and organisational change (Radosevic and Yoruk, 2016). The wide variety of forms for upgrading through GVC and the large range of relevant policy areas require that an exploration follows a "policy mix" approach.

The "policy mix" concept has become popular among innovation policy communities as increasingly complex innovation environments require more holistic approach in governance (Kergroach, 2018; OECD, 2010b, 2015a). Yet there is no widely acknowledged definition of the concept (Flanagan et al., 2011). Rogge and Reichardt (2016) propose an overview of the few definitions found in the literature. De Heide (2011) proposes to define the concept of the policy mix as "… the combined set of interacting policy instruments of a country addressing R&D and innovation". In general, academic articles rather discuss the concept in normative terms and identify the desirable features of a policy mix in terms of "coherence", "consistency", "coordination", "efficiency", "appropriateness", "balance", "stability", "predictability", "comprehensiveness", "legitimacy", "credibility" etc. (Borras and Edquist, 2013; Cunningham et al., 2013; Flanagan et al., 2011; Guy et al., 2009; Nauwelaers et al., 2009; OECD, 2010b; Rogge and Reichardt, 2016).

The challenge is to re-think policy making in a more radical and transformative way (OECD, 2016b). The system innovation discourse places the policy mix as the core of a new horizontal policy approach to systemic problems, that provide new rationale for policy intervention and requires combining new policy tools, changing the governance architecture, engaging more actors into policy making, building policy intelligence and sequencing policy action along the different phases of transition. Yet, main obstacles for appraising national policy mixes relate to conceptual shortcomings (Cunningham et al., 2013; Flanagan et al., 2011; Rogge and Reichardt, 2016) and practical issues in operationalising a mapping on a large scale (Kergroach, 2018).

Mapping exercises, so far, have failed capturing the complexity of path-dependent policymaking processes, the sequencing of policies or the great variety of actors engaged in the innovation policy process (Flanagan et al., 2011; Kay, 2006). A growing number of academic papers has also underlined the narrow focus of many mix evaluation exercises that fail capturing the multidimensional interactions shaping the policy mix (Borras and Edquist, 2013; Cunningham et al., 2013; Edler et al., 2012; Flanagan et al., 2011). Similarly, operational developments have remained limited due to a lack of comprehensive and broadly-shared concepts, appropriate and comparable policy data, and agile and adaptable data management systems (Kergroach, 2018).

Fig. 1 presents how rationales, strategic objectives, instruments and targets are articulated within a policy mix. (See Fig. 2.)

3. Material and methods

3.1. Data sources and methodology

In this paper, I use the operational definitions of the European Commission/OECD Science, Technology and Innovation Policy (STIP) Database – formerly OECD Science, Technology and Innovation Outlook (STIO) policy database (EC/OECD, 2016; OECD, 2012b, OECD, 2016a). The "policy mix" term could be understood as the set of and interactions among policy rationales, arrangements and instruments implemented to deliver public action in specific policy domains (Kergroach, 2018; OECD, 2016a). The term refers both to the composition of a policy, i.e. its distinctive components, their features and relative balance, and the possible interactions between its components.

The EC/OECD STIP database is built on the basis of country responses to an international biennial policy survey. Responses are provided by government representatives to the OECD Committee for Scientific and Technological Policy (CSTP) and to the European Research and Innovation Committee (ERAC).

The unit of observation is the "major national policy initiative". There is a trade-off to find between capturing the completeness of a policy mix and preserving the simplicity –and feasibility- of an evaluation. In that respect, there is a common understanding among the innovation policy community on the need to focus evaluation on the "key", most "relevant", "meaningful" or "important" policy initiatives in the mix (Kivimaa and Kern, 2016; Magro and Wilson, 2013; Rogge and Reichardt, 2016; Veugelers, 2015).

All policy initiatives are accounted on the same scale (one unit, unweighted), irrespective of their budget appropriations or their size in terms of input/output/outcome. Although this experimental approach cannot pretend to reflect the magnitude of policy intervention (e.g. in terms of budgets), it has advantages in terms of simplicity and accountability of regulatory and "soft" non-financial instruments (Kergroach, 2018). In addition, with the data currently available, a budget-based quantification of policies is difficult to envisage. Indeed the harmonisation of public budgets data requires conducting a prior broad and deep methodological work as to ensure reporting is made along common standards and guidelines and data are internationally comparable (OECD, 2015c). Issues under discussion would include: definition of the relevant spending allocations to take into account, accounting for funding matching mechanisms, double counting and undercounting, treatment of overheads, administrative and compliance costs, articulation across different levels of governance etc. This lengthy exercise has been undertaken during the last revision of the OECD Frascati Manual with the introduction of a new section on the treatment of indirect R&D tax incentives.

Each observation (or unit) – the major policy initiative- has several properties that reflect different areas of interaction in the policy mix (Fig. 1). A policy initiative serves a single (or multiple) policy goal(s) and:

- aims to achieve a single (or multiple) strategic objective(s),
- makes use of a single (or multiple) policy instrument(s),
- is generic or targeted if it addresses a single (or multiple) target population(s) and/or a single (or multiple) sector(s) and/or technology(ies).

A policy initiative takes place in a particular policy domain, in a particular geographic space and at a particular time. The properties of a policy initiative are actually the possible areas of interaction in the policy mix, as described in Kergroach (2018).

Taken together, the 54 countries covered in the STIO/STIP survey account for an estimated 98% of global R&D (OECD, 2016a). This paper focuses on fifteen countries with large STI systems but different structural features and degrees of maturity. They include the G7 countries (Canada, France, Germany, Italy, Japan, United Kingdom, United States), Korea and seven emerging economies (Brazil, Chile, China, Colombia, Costa Rica, Russian Federation, South Africa).

The STIO/STIP database addresses all relevant areas of STI policy, involving initiatives spread across different Ministries and national agencies. Theoretically the entire national innovation system can be subject to upgrading and the full innovation policy mix could be geared towards this end. For the purpose of this article, I constrained the scope of analysis to the policy initiatives that are the most closely related to the topic, as reflected in respondents' input.

Hence, I selected the STIP data as follows:

Policy initiatives dedicated to attract FDI and support the internationalisation of SMEs.

"Dedicated" policy initiatives to attract FDI and support the internationalisation of SMEs refer to all policy initiatives reported in responses to the following questions:

- *Recently, have new STI policy initiatives been implemented to support the internationalisation of SMEs? Or have existing ones, if any, been substantially revised? Are these policy initiatives specifically targeted to some industries, activities or disciplines? Are any programmes specifically aimed at young innovative firms?*

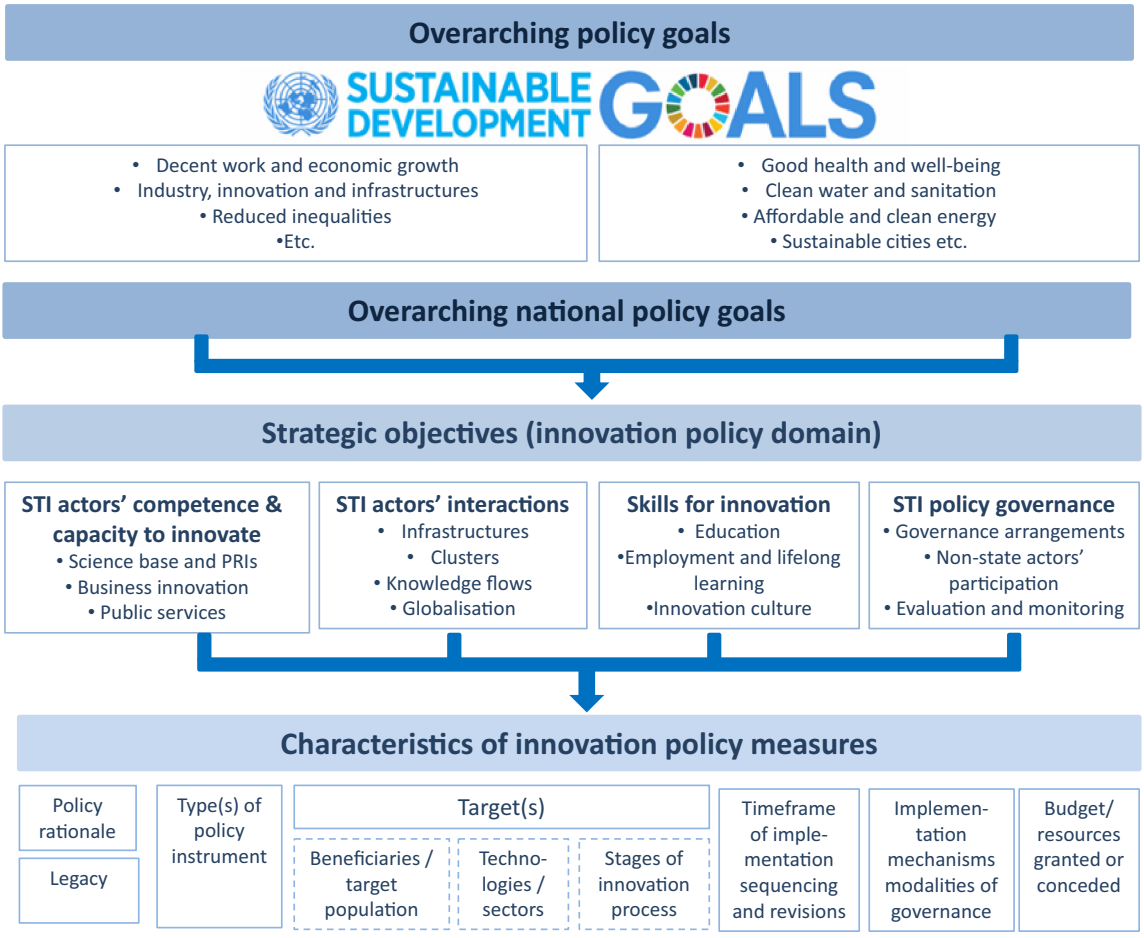

Fig. 1. From overarching policy goals to the characteristics of an innovation policy initiative.
Source: Author's elaboration based on OECD (2014a) and Kergroach (2010, 2018).

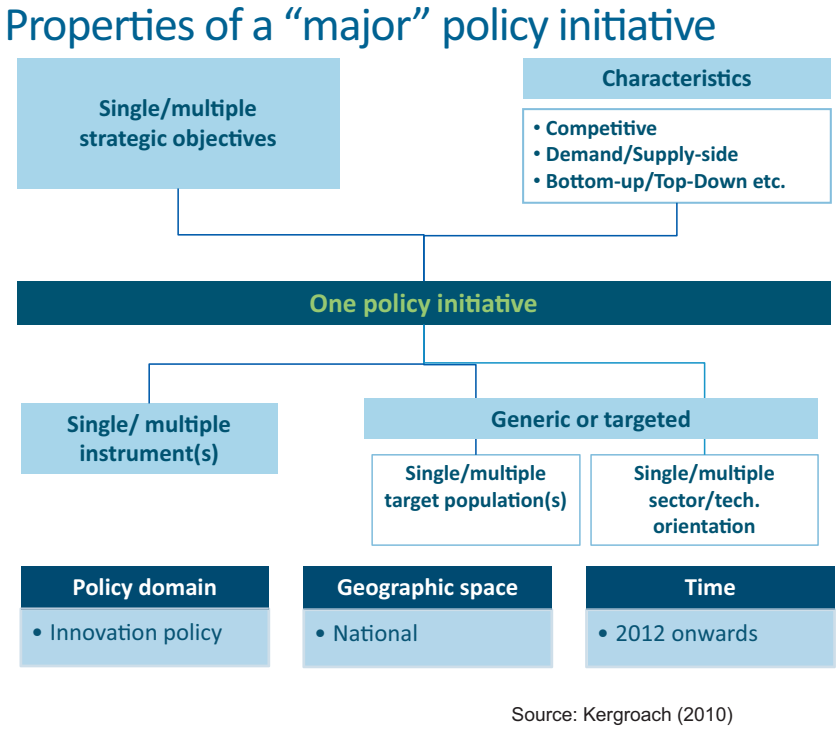

Fig. 2. Properties of a policy initiative.
Source: Kergroach (2018) based on earlier works and revised with OECD (2012a, 2014).

Table 1
Keywords for a textual exploration of the STIO/STIP database.

Fostering participation in GVCs (group A)	Encouraging technology upgrading and structural transformation (group B)
Foreign	Upgrading
Foreign investment/fdi	Competitiveness
International investment	Diversif***
Mne/multinational*	Structural change/adjustment
International firms/companies	Economic/industrial transformation
Foreign firms/companies	Production/productive structure
Global enterprise*	Technological change
Global business	Technological capabilities
Abroad	Restructuring
Overseas market/expansion	Catch-up/catching-up/catching up
International/global/foreign market	Production capabilities/capability
Export	Productivity
Global value chain/value chain	Reindustrialisation/re-industrialisation
Attractive/competitive location	

Note: author's selection based on OECD (2016a), including its policy profile on "Attracting international S&T investments by firms".

- *Recently, have new STI policy initiatives been implemented to attract and retain foreign direct investments (FDI) for R&D and encourage the location of foreign R&D activities? Or have existing ones, if any, been substantially revised?*
- *Recently, have new STI policy initiatives/programmes been implemented to maximize knowledge spillovers from FDI? Or have existing ones, if any, been substantially revised. Policy initiatives dedicated to improving participation in GVCs*

Given that most policy initiatives aim to achieve multiple strategic objectives and can be reported under different sections of the EC/OECD STIP questionnaire, I also intended to capture the policy mix for improving GVC participation with relevant initiatives following a textual exploration of the dataset (Table 1). The policy initiatives identified with the keywords presented in column (A) of Table 1 are hereinafter referred to as policy initiatives dedicated to improving participation in GVCs.

Recent research aiming to benchmark national innovation policies for technology transfer and commercialisation by universities and public research institutions (PRIs) followed the same approach and showed that countries combine instruments across different policy domains beyond the public research domain, including business innovation, entrepreneurship and industrial policies, in accordance to their public research orientation and business absorptive capacities (Kergroach et al., 2017). The authors also reinforces the point of adopting more comprehensive and strategic approaches for evaluating knowledge transfer and commercialisation policies considering the various transfer mechanisms and policy levers available. In another research area, Alschner et al. (2017) mapped the global landscape of preferential trade agreements (PTAs) by looking at textual similarity among a large structured text corpus of PTAs. The authors provided new insights into the process of normative convergence between legal regimes and showcased how textual similarity and text-as-data approaches can be integrated into research in trade economics.

Policy initiatives dedicated to encouraging technology upgrading and structural transformation.

The policy initiatives identified with the keywords presented in column (B) of Table 1 are hereinafter referred to as policy initiatives dedicated to technology upgrading.

Obviously differences between the two last categories of initiatives –GVC participation versus technology upgrading- are not clear-cut and overlaps exist. Some initiatives may therefore belong to both.

Results and aggregations have been hand-checked in a second stage.

3.2. Elements for comparison

It is widely acknowledged that innovation policy mixes are country-, context- and time-specific, as one solution cannot fit all and forever. Structural features of national STI systems are therefore key factors for determining how policy intervention takes shape. Yet policy making in practice is path-dependent and other elements of the policy processes, such as political bargaining, instrument lock-ins, resistance across government levels, are also determinant (Kay, 2006; OECD, 2010b; Rogge and Reichardt, 2016).

This article considers three structural aspects that are likely to have a significant impact on the design and efficiency of policies for technology upgrading and explores how national policy mixes may have adapted accordingly.

First, the analysis considers the development stage of the countries and national R&D capacity. A mentioned earlier in this paper, countries with less advanced capabilities and skills are more likely to be engaged in vertical relationships in value chains and to rely on GVC integration for further upgrading (OECD, 2013c, 2013d; Pietrobelli and Raboletti, 2011; Radosevic and Yoruk, 2015; Teece et al., 1997). Therefore I differentiate the G7 countries (Canada, France, Germany, Italy, Japan, United Kingdom, United States) plus Korea, one the one hand, and seven emerging economies (Brazil, Chile, China, Colombia, Costa Rica, Russian Federation, South Africa) on the other hand.

Second, the analysis looks into the intensity of countries' linkages in GVCs. Integration of countries into GVCs can be measured by indicators that track the origins of value added embodied in exports and final demand (OECD, 2015d). Estimates of foreign value added (or import) content of exports highlight the importance of imports for export performance. As they reflect the relationship between suppliers of intermediate inputs and their buyers, these estimates are referred to as "backward linkages" in global value chains. Estimates of domestic value added content in partner countries' exports (calculated as the sum of domestic value added in exports of intermediates that are then embodied in other countries' exports) show how domestic industries reach consumers abroad even when no direct trading relationship exists. These estimates refer to "forward" linkages in GVCs.

Third, the analysis takes into account the absorptive capacity of the business sector, i.e. firms' capacity to participate in R&D activities, absorb foreign knowledge and accumulate intangible assets. Filippetti et al. (2017) investigated the impact of internationalisation on a country's innovation performance and found some evidence of the non-linear effect of a country's absorptive capacity on this relationship. I use business R&D expenditure (BERD) as a percentage of GDP as a proxy of firms' capacity to absorb external knowledge and to engage in collaborative research with multinationals (Fig. 3). The pool of skills and talents locally available is also key for innovation absorption and diffusion, skills, innovation and technological change being complementary and intrinsically linked. Adult population educational attainment at tertiary education level provides a proxy for benchmarking country's skills-based absorptive capacity (Fig. 4).

4. Results and discussion

4.1. Composition and density of the policy mix for GVC integration and technology upgrading

All countries under review in this article have policies in place to attract FDI and support the internationalisation of domestic SMEs and, more generally, to improve their participation in GVCs (the specific case of the US is explored below).

When taking into account the entire national policy mix for STI, this strategic objective of improving GVC participation appears in a number of policy initiatives as a primary or secondary policy goal (Fig. 5). Policy density for GVC integration, i.e. the relative number of policy initiatives aimed to this particular objective, is relatively homogeneous

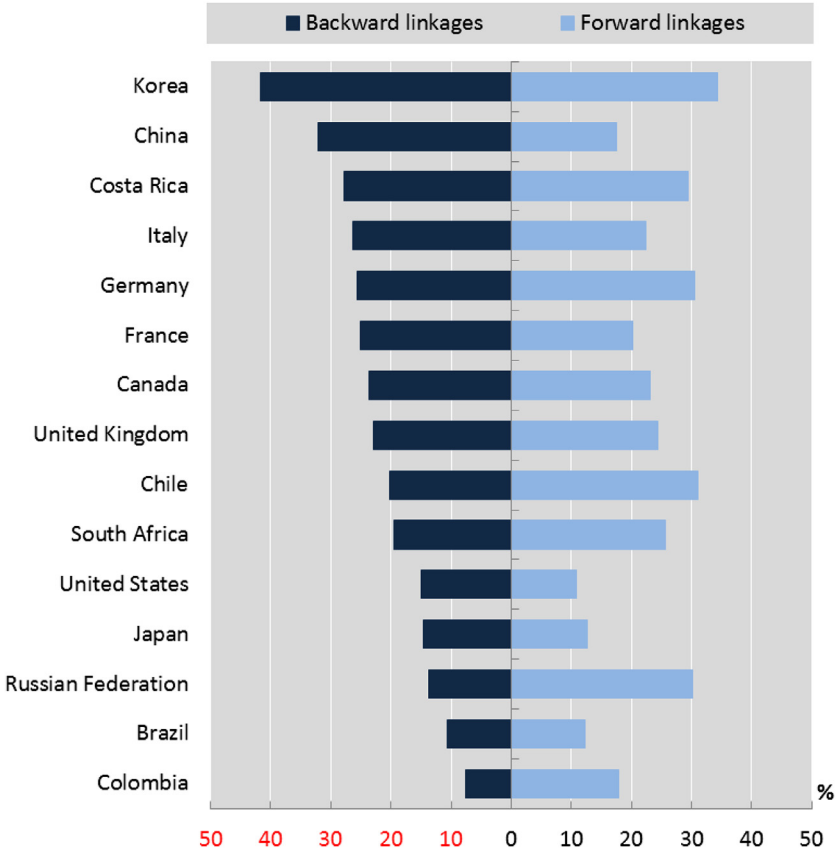

Fig. 3. Integration into GVCs: Backward and forward linkages.
Note: Backward participation in GVCs is defined as foreign VA embodied in exports, as % of total gross exports of the exporting country (DEXFVAPSH). Forward participation in GVCs is defined as domestic VA embodied in partner countries' exports, as a percentage of total domestic value added in gross exports (VALUX_FFDDVA). See definitions at http://www.oecd.org/sti/ind/tiva/TIVA_2016_Definitions.pdf.
Source: OECD-WTO (2016), OECD-WTO: Statistics on Trade in Value Added (TiVA) Database, http://oe.cd/tiva. Data extracted on 30 May and 20 August 2017.

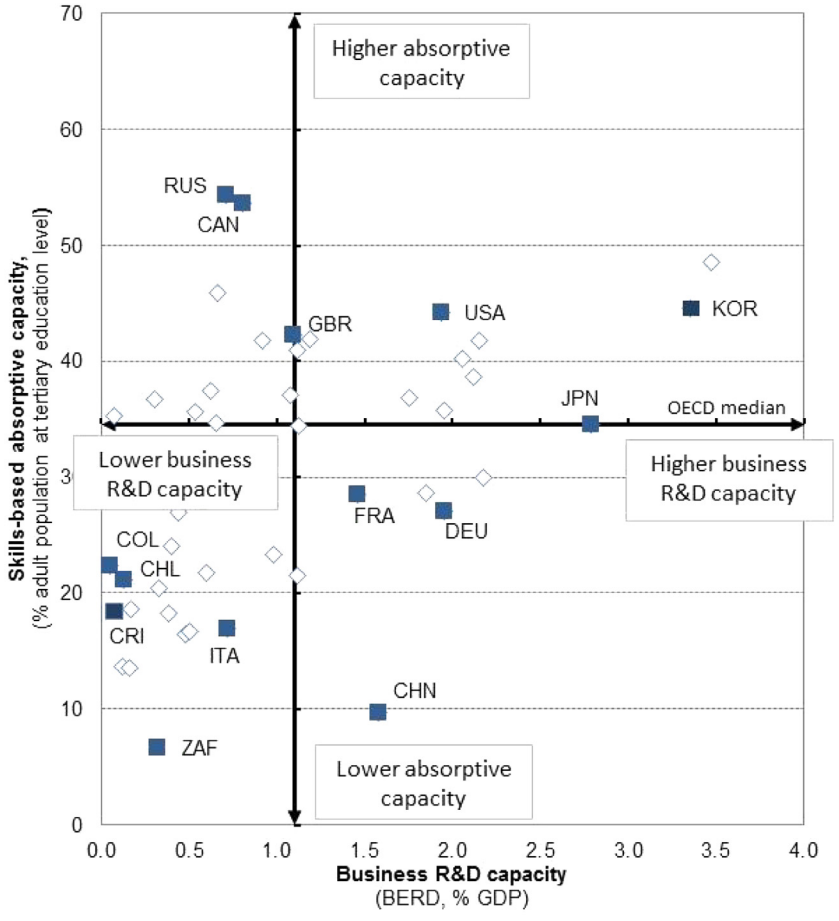

Fig. 4. Absorptive capacity: R&D and skills.
Note: Brazil is not presented in the chart as data for business R&D intensity is not available. Educational attainment at tertiary level is 13.75% of adult population (2013).
Source: OECD (2016c), Main Science and Technology Indicators (MSTI) database, December, www.oecd.org/sti/msti and OECD (2016d), Education and Training Databases, http://stats.oecd.org/.

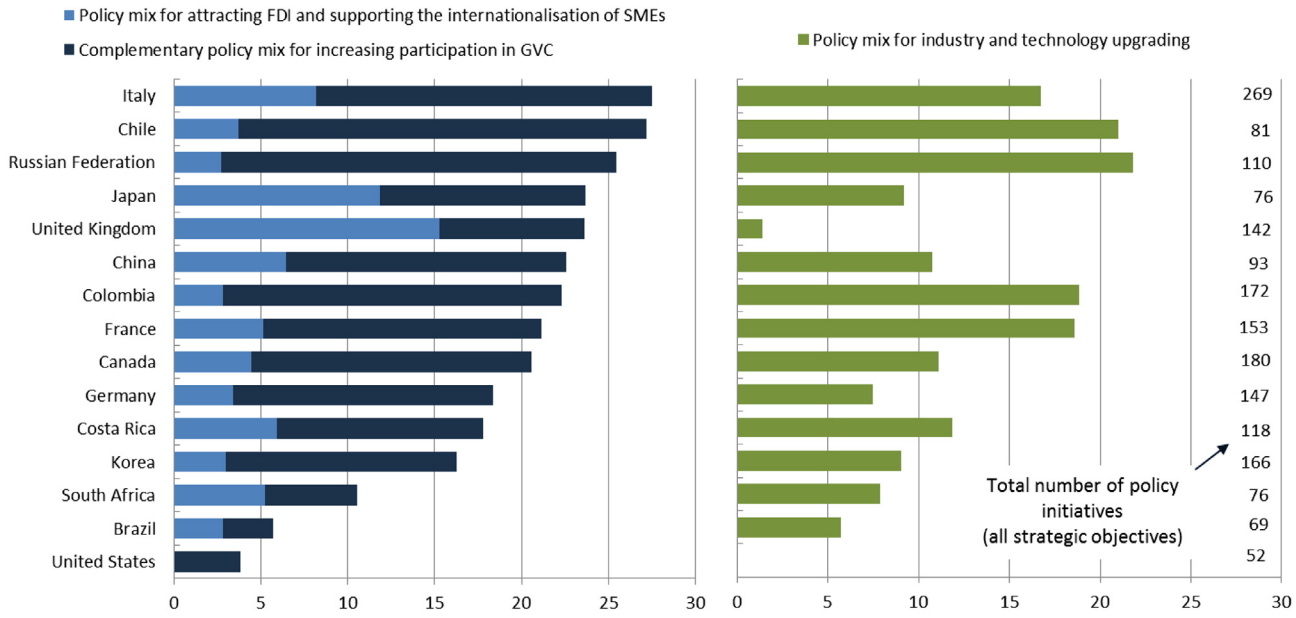

Fig. 5. Density of the policy mix for participation in GVCs and technology upgrading, as a % of total active policy initiatives, early 2016.
Note: author's calculations. The density of the policy mix refers to the number of policy initiatives that are deployed for a particular strategic objective (here an increased participation in GVCs and technology upgrading), expressed as a percentage of total active policy initiatives (based on Guy et al., 2009 and Kergroach et al., 2018).

across most countries, ranging from 17% (Korea) to 28% (Italy). Initiatives addressing the FDI issue or aiming to the internationalisation of domestic SMEs account for a more limited share of total policy measures, i.e. between 3% (Brazil, Colombia, Russia) to 15% (UK). As a comparison, Kergroach et al. (2017) following a similar methodology, found that the percentage of national STI policy initiatives aiming to improve knowledge transfer of universities and public research institutes ranges from 6% to 14% and increased to 29% to 53% if a broader textual similarity-based definition is adopted.

A first observation arising from these data is that the policy density for GVC participation does not seem related to the development stage of a country, signaling the universality of the topic. A second observation is that a too strong focus on FDI-related policies and policies for SMEs' internationalisation (i.e. the first set of questions presented in Section 3.1 -i) internationalisation of SMEs, ii) the location of foreign R&D activities and iii) maximising knowledge spillovers from FDI) would limit the scope of my analysis as it would narrow the "breadth"[1] of the actual policy mix used to encourage participation in GVCs. This results advocates for the use of complementary approaches in benchmarking policy mixes, including text-as-data approaches.

At country level, Japan and the United Kingdom stand out from other countries with larger policy portfolio dedicated to FDI and SMEs' internationalisation. Japan has adopted several cross-cutting measures over the past decade with a view to scaling up its promotion activities and addressing issues of low inward FDI and low participation of foreign affiliates in domestic R&D (OECD, 2016c). The 2010 New Growth Strategy stated the promotion of Japan as an Asian Business Center for R&D centres and regional headquarters as one of the 21 National Strategic Projects (EC/OECD, 2016). Similarly the UK has deployed a broad range of promotion and assistance service measures with a view to increasing its low share of exporting SMEs (UK Department for Business Innovation and Skills, 2012). The UK Trade & Investment (UKTI) Department aims to encourage more SMEs to enter international markets and strengthen the links of high-growth technology-focused SMEs with GVCs.

The cases of Brazil, South Africa and the United States are also noteworthy as these countries show much lower shares of policy initiatives aiming to increase participation in GVCs. Reasons are manifolds. First, Brazil and the United States also have a low degree of participation in GVCs and high domestic content of their exports (OECD, 2013a, 2013b, 2013e). Brazil and the US due to the large size of their domestic market tend to source intermediaries from local supply chains rather than from abroad and rely less on backward linkages than other OECD countries or non-OECD economies. Their participation in GVCs is mainly driven by downstream links, through exports of agriculture, mining, chemicals and basic metals in the case of Brazil, and export of chemicals and business services in the case of the US. Likewise South Africa is weakly engaged in GVC, FDI remains limited and exports constrained by its natural resource-based economic structure (OECD, 2007, 2013c, 2013d). It is also unclear how big a handicap geographical distance from major global markets may be for South Africa's integration into GVCs (World Bank, 2016). And regional value chains in the region remain significantly underdeveloped.

A second explanation is data-related. In the case of the US, the government actively promotes exports through trade policies, including by improving advocacy and trade promotion programmes, ensuring greater access to export financing, reducing trade barriers, and enforcing international trade agreements (US Department of Commerce, 2016). Yet, these policy levers fall beyond the innovation policy domain and consequently fall under the radar of the STIO/STIP Survey and this analysis. Similarly, country responses to the survey account for national support programmes and do not include state initiatives that could be prominent or the relevant level of policy action in federal States, such as Brazil and the US. This result advocates for the need to bridge concepts,

[1] "*The breadth of the policy mix refers to the range of policy goals, strategic objectives, or policy instruments for which public policy initiatives are in place. The policy mix could be broad as it covers a wide range of policy goals* etc., *or narrow if it is focused on a small range. The notion of breadth differs from the notion of comprehensiveness. The latter refers to a gap in breath as compared to a normative threshold that should be defined. A simple assumption would be that the norm is the full range of policy goals, strategic objectives, or policy instruments identified in the STI Outlook framework,* i.e. *on an international basis. The policy mix is comprehensive if it covers this full spectrum. A drawback of this approach is that it cannot be assumed that any combinations of instruments will be better than a single instrument approach* (*Gunningham and Sinclair, 2002*)."(quoted from Kergroach et al., 2018).

data and information systems across policy domains and governance levels in benchmarking policy mixes (Kergroach, 2018).

Achieving industry and technology upgrading is less commonly mentioned in country responses to the STIO/STIP survey as a goal of innovation policy. Density rates for technology upgrading remain overall below rates for increased GVC participation.

There are also larger cross-country disparities in the relative number of initiatives aimed to structural adjustment. More than 20% of total policy measures in place in Chile and Russia seek to promote industrial and technology upgrading. And emerging economies tend to rank higher than advanced economies in this area. At the opposite side of the spectrum, the US and the UK made no -or almost no- reference to structural adjustment, as defined in Table 1, in their responses. Here again, data should be interpreted with caution. Promoting structural adjustment and a new approach to growth is clearly stated as a STI policy priority for the UK as the launch of a new GBP 4 billion Industrial Strategy Challenge Fund illustrates (OECD, 2016e). This is also the case in France, Japan and Korea where the policy mix for technology upgrading is larger than in the UK. There are two possible explanations for the low rates of the UK and the US. The first explanation is conceptual. The framing of innovation policies, and related policy discourse and action, rely on a model which identifies science, technology and innovation as means for improving factor productivity and achieving "the promise of catching up" (Shot and Steinmueller, 2016). Competitiveness and productivity issues are therefore central to the innovation policy discourse and references have become implicit (and unidentifiable through text-as-data methods). The second possible explanation is country-specific, the UK and the US share a philosophy of market-led innovation and limited state interventionism.

Looking at the performance of countries in GVCs, as measured by the intensity of their backward and forward linkages in value chains, there appear to be larger portfolio of initiatives for integrating GVC in countries that have stronger relationships in the value chains, i.e. outsourcing and supplier countries. Reversely, there seems to be larger portfolio of initiatives for technology upgrading in countries that have stronger relationships with downstream segments of the value chain, i.e. supplier countries (Fig. 6). These results are consistent with the previous observations made regarding Brazil, South Africa and the US. This would suggest that national policy mixes may be developed on the basis of pre-existing country's positioning in GVCs, countries with more intense backward linkages consolidating their policy mix for participating further in GVCs, and countries with more intense forward linkages seeking both to increase their participation and promote structural transformation. The sector-specific nature of GVC linkages calls for further exploration at the industry level.

4.2. Interactions among policy areas: Horizontal or vertical approach

Public intervention in the innovation policy domain pursues several strategic objectives in different policy areas (Kergroach, 2018). Public research policy, business innovation and innovative entrepreneurship policies aim to improve the competences and capacity of STI actors, i.e. universities, public research institutes and firms, to innovate. Policies for technology transfer, open science and IP rights aim to accelerate knowledge transfer and policies for R&D internationalisation, clusters and international mobility aim to increase actors' ability to connect to international knowledge networks and capture external spillovers. Education and labour market policies aim to improve the supply and absorptive capacity (demand) of innovation skills and develop a broad-based culture of science and innovation. Adjustments in governance arrangements aim to improve STI policy design and delivery, and policy evaluation to make better policies (OECD, 2014a).

National policy initiatives that aim to better integrate firms into GVCs are spread across various policy areas (Fig. 7). Overall, industrial and cluster policies remain the most popular channel for promoting GVC participation. This result echoes recent patent-based research that showed a greater attractiveness of technologically specialised sectors of regions for foreign technological activity (Dettmann et al., 2014).

Industrial and cluster policies are central to efforts to upgrade GVCs but governments also concentrate their efforts on attracting FDI, helping domestic SMEs access global markets and encouraging international mobility of students, researchers and highly-skilled. Skills policy and business innovation policy also play a key[2] role in some countries.

The development stage and the prior degree of participation in GVCs seem to explain little of how the policy mix is organised at country level. However, the structural features of national innovation systems are more informative[3].

- France and Russia combine industrial policies with initiatives for the internationalisation of universities. France recently put the emphasis of its long-standing competitiveness clusters policy on internationalisation. In parallel revised performance agreements provide the large population of French PRIs with incentives to participate in international partnerships. Russia has a large public science base, dominated by public research institutes (as per domestic higher education and government R&D expenditures), operates a series of state technology-oriented programmes in support of specific industrial sectors with new innovative territorial clusters.
- Italy combines public intervention in support of its regional clusters and smart specialisation programme with initiatives for the internationalisation of local SMEs. Italy has a very large number of SMEs, essentially microenterprises, and offers favourable administrative and regulatory framework conditions for entrepreneurship. The 2014 decree Sblocca Italia introduced a series of provisions to boost competitiveness, inter alia through the internationalisation of enterprises. The government has also increased support for the creation of technological clusters and encouraged in the framework of its Cohesion Plan the design of regional smart specialisation strategies in Southern regions.
- Germany (low enrolment of international students in German doctoral programmes) and China (low adult educational attainment at tertiary level and lack of world-class researchers) put emphasis on international mobility. In addition China is proactive in attracting FDI and fostering the construction of innovative industry clusters with a view to accelerate technological upgrading of its economy and to promote regional economic development.
- Colombia (low skills-based absorptive capacity and low business R&D intensity) encourages skills development and provides support to business R&D and innovation, while Chile (with a similar profile) seeks to increase skills supply and technology transfer by attracting international R&D centres of excellence in fields relevant to national strategic productive sectors and by strengthening domestic industry-science linkages.

In Chile and Colombia, as well as in France and Italy, the policy agenda for addressing grand challenges and programmes in support of international STI co-operation are also relevant for improving GVC integration. International STI co-operation offers opportunities to increase transnational knowledge transfer and share research costs, especially for maintaining large-scale scientific infrastructures. Incidentally, recent OECD survey found that national economic development and economic objectives remain the main policy drivers for countries to engage in international STI co-operation, ahead of geopolitical, science diplomacy or public good considerations (OECD, 2017b).

[2] It is assumed here that a higher density of 'major' policy initiatives reflects higher public efforts in the field. This is debatable and may be the subject of further research.

[3] Country information is drawn from the OECD STI Outlook country profiles 2016 (OECD, 2016e).

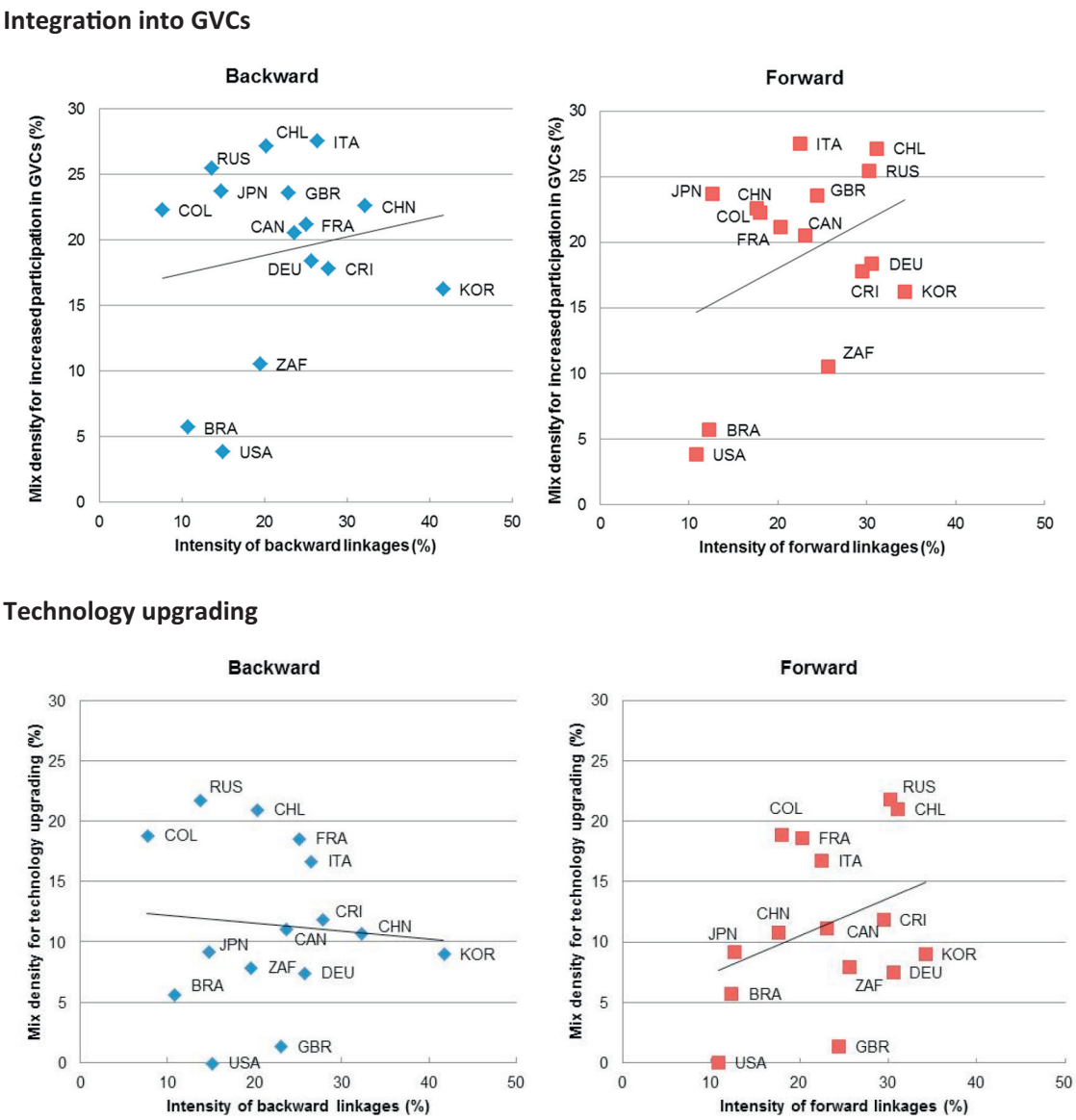

Fig. 6. Density of the policy mix for participation in GVCs and technology upgrading (early 2016) and intensity of the country's linkages in GVC (2011).
Note: author's calculations.

The policy mix for industrial and technological upgrading differs substantially from the previous one, as this experimental work suggests. The number of policy areas that are relevant for achieving structural transformation are fewer and are also different. Industrial and cluster policies are the backbone of technology upgrading. In almost all countries this is the policy area where public intervention for structural adjustment is the most intense by far.

4.3. Combining policy instruments for greater value chain integration and technology upgrading

A policy initiative makes use of one (or multiple) policy instrument (s). Those include: 1) Financial support instruments, 2) Non-financial support instruments, 3) Platforms and infrastructures, 4) Regulatory instruments, and 5) Institutions and governance (Kergroach, 2018).

Financial instruments remain the main policy tools for supporting the integration into GVCs (Fig. 8). They include grants, subsidies, loans and risk sharing mechanisms, tax incentives, equity funding and public procurement. The preponderance of financial instruments is noticeable (as compared to the mix of instruments used for other policy goals) and it is a common feature of all countries under review, irrespective of their structural characteristics, degree of prior integration into GVC and absorptive capacities.

The role of financial support for GVC participation is particularly striking in China, Colombia and Costa Rica as compared to other policy objectives.

- China has maintained a policy of special economic zones for several decades with a view of attracting foreign investors and foreign technology. The government also provides tax package and financial support to international mobility. In the special economic zones, manufacturing companies, service companies, banks and multinationals investing in the country benefit from preferential corporate tax treatment. Similarly, economic and technological development zones that have developed nearby booming megacities and important cities for local development have a greater focus on research and development (R&D). Foreign investors in these zones are offered access to world-class infrastructures in addition to tax reliefs. In parallel, China has deployed a series of tax incentives targeting firms and investors. A discretionary R&D tax allowance aims

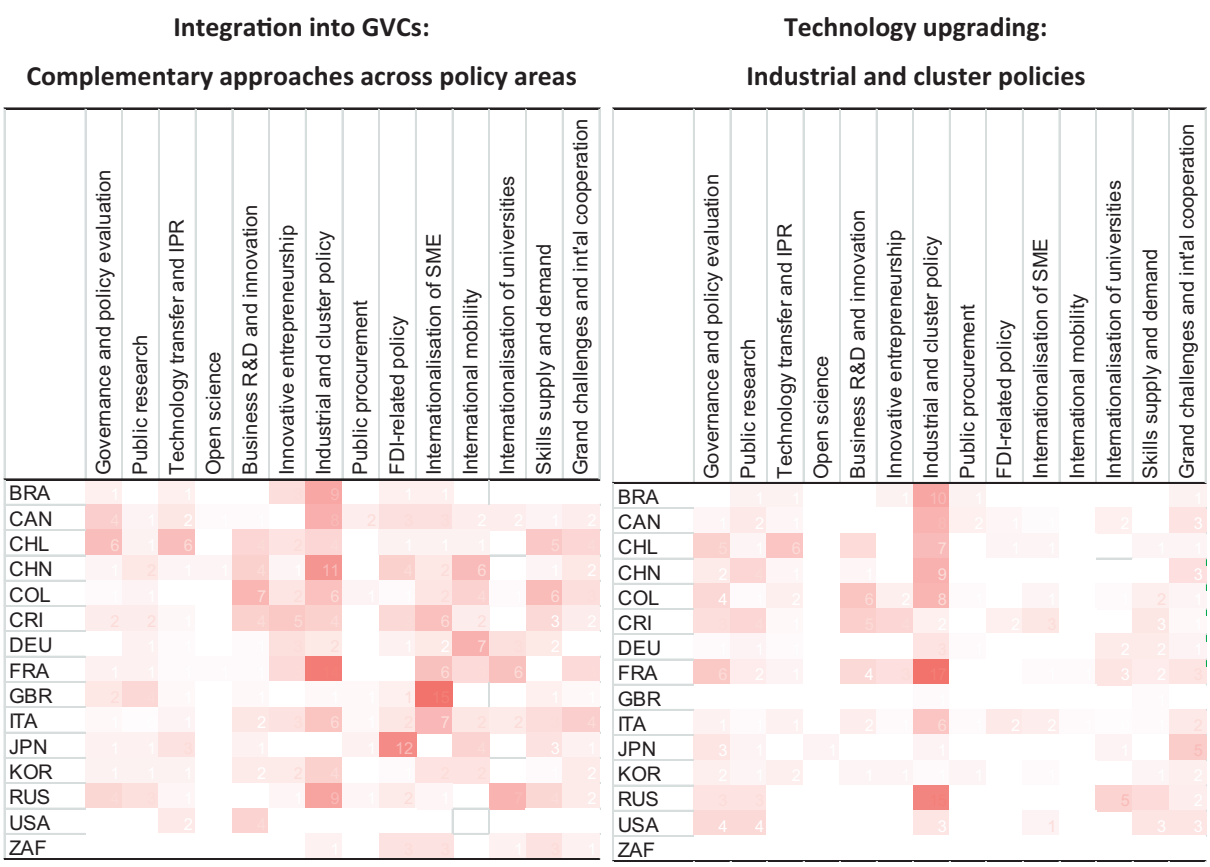

Fig. 7. Range of policy areas for integration into GVCs and technology upgrading, as a % of total active policy initiatives, early 2016.
Note: author's calculations. Shades areas reflect the density of the policy mix dedicated to GVC integration (or technology upgrading) in different innovation policy areas. The more colored, the denser. The policy areas presented in the figure correspond to various sections of the STI Outlook policy questionnaire and may reflect responses to one or several questions. Policy initiatives that are relevant to several policy areas (e.g. public research and open science) are counted for every policy area of relevance. If responses have been grouped under a single policy area for the purpose of this exercise (e.g. programmes targeting young firms and programmes targeting SMEs are grouped under innovative entrepreneurship), a same policy initiative is counted only once. Horizontal industrial innovation programmes have been treated as individual programmes for each industry targeted. This approach may overestimate the density of industrial policies, especially in Brazil and France that reported only one horizontal programme for a broad range of industries.

to boost business expenditure on R&D; a patent box aims to encourage firms to exploit intellectual property in China and co-locate R&D and manufacturing activities; a tax relief on profits generated by foreign investments aims to incentivize investors to reinvest inland. Targeted direct funding is also allocated for international mobility. Researchers, professors and new graduates receive relocation stipends, fellowships, awards and special subsidies for teaching, working or performing research in China.

- Costa Rica proposes a system of fiscal incentives similar to China through its free zone regime. The purpose of the free zone regime is to attract and retain FDI in high-technology sectors and to encourage multinationals to establish R&D activities in Costa Rica. This articulates with proactive efforts to develop a base of firms operating locally and to link SMEs to MNEs. The incentive system in Costa Rica is designed towards national SMEs. The government provides local SMEs with loan guarantees and certifications to get into international markets. Innovation and sectorial grants also aim to encourage their internationalisation. In parallel, efforts are made to improve human capital, including entrepreneurial capacities and management capacity of domestic SMEs.
- Colombia offers a larger portfolio of financial instruments and targets a broader range of actors. Competitive grants are earmarked for joint research projects involving foreign partners. The government offers tax incentives on R&D expenditure, full value-added tax exemption on imported equipment used in projects of research and technological development, and tax relief on the rent of innovative software. The Venture Capital Programme aims to strengthen domestic venture capital market through new venture capital funds mixing national and international interests and business angels networks. The Modernization and Innovation Fund allocates non-reimbursable grants for micro-firms and SMEs to develop productive linkages. Colombia also provides financial incentives for international mobility and for reinforcing linkages within the Colombian diaspora.

Most countries combine financial and non-financial support schemes for promoting integration into GVCs. Japan combines financial incentives, through location subsidies and various tax breaks, with business support networks, and a special economic zone system as to attract R&D and regional headquarters in the country. Since 2012, the Act for Promotion of Japan as an Asian Business Center also foresees accelerated residency examination status, preferential patent examinations conditions and corporate tax relief for R&D centres and headquarters.

Non-financial instruments are widely mobilised in investment promotion policies (OECD, 2008). These instruments include access to support facilities (e.g. one-stop shop, research equipment, ICT, networks, housing etc.), access to a range of information and assistance services (e.g. training, technical expertise, or networking, marketing and advertising support etc.) and initiatives aiming to raise firms' visibility, credibility and recognition (e.g. awards, prizes, high impact events, contests, certification etc.). Non-financial instruments are

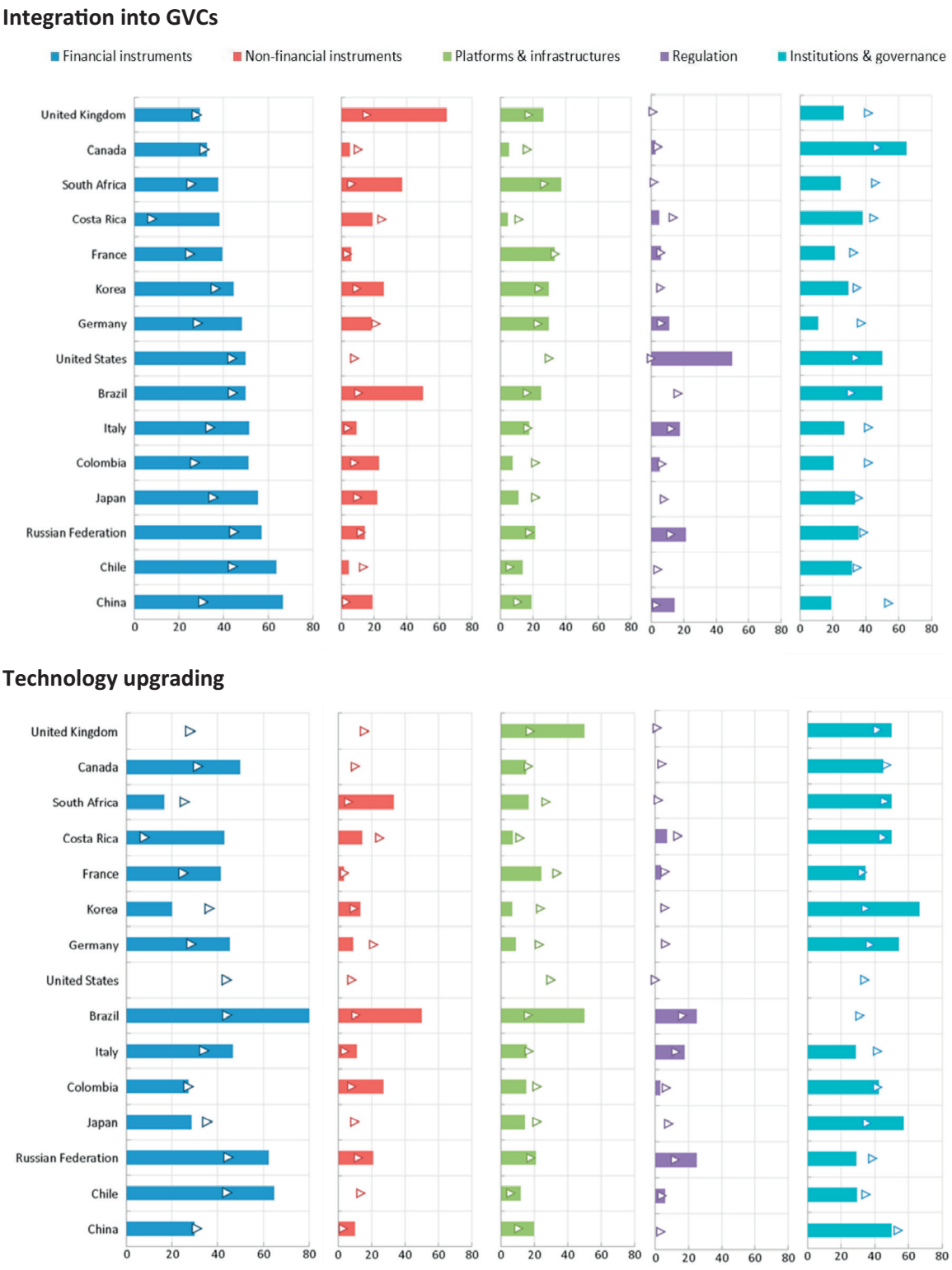

Fig. 8. Policy instruments for GVCs integration and technology upgrading, as a % of total active policy initiatives, early 2016.
Note: author's calculations. The markers signal the average density of policy initiatives that are not directly related to participation in GVCs or technology upgrading.

particularly in greater use in Brazil, the United Kingdom and South Africa.

- Brazil and South Africa offer technology extension programmes, assistance services and platforms for accessing technical expertise and skills. For example, the Planning Internationalisation initiative helps small Brazilian enterprises prepare their business plan for internationalisation. The Technology Assistance Packages give South African firms access to a range of facilities, training, technology platforms, high-end technical skills and technical expertise.
- In the UK non-financial instruments are prominent for supporting GVC participation. The Department for International Trade (DIT) administrates the "Exporting is GREAT" advertising campaign that provides advice on market entry, including on how to establish

partnerships and offices overseas. The GREAT campaign is another major international campaign to demonstrate UK capacity through impactful trade missions. The DIT also provides export services for first-time exporters and SMEs, such as an online learning tool.

More advanced countries deploy platforms and infrastructures domestically to attract S&T investments and multinationals. Platforms and STI infrastructures are “systemic” or system-enabling infrastructures and they support and strengthen interactions and knowledge flows between STI actors. This category of instruments includes large-scale interfaces, infrastructures and networking facilities, centres of excellence, technology platforms, accelerators and incubators etc.

- The Initiatives for Excellence in Germany aims to enhance the international visibility and competitiveness of universities as centres of research.
- The United Kingdom has developed several research centres and technology hubs that bring together national STI actors and aim to integrate domestic knowledge base into value chains. In addition the Research Councils UK (RCUK) run programmes in converging technologies (big data, synthetic biology, quantum technology) for sustaining the excellence of the knowledge base.
- Korea has established the Centers for Creative Economy and Innovation (CCEI) as regional hubs to attract MNEs' financing and support start-ups and innovative SMEs. In parallel the government started a global excellator programme to facilitate SMEs' overseas expansion.

Institutions and governance arrangements seems to matter less for the purpose of improving participation in GVCs than other types of instruments. Institutions and governance encompass all governance arrangements, institutions and norms, that are relevant to the national innovation system as they rule its functioning and determine its efficiency. This includes governance practices and principles, mission- and contract-based relationships between central governments and agencies and actors (e.g. performance agreements of universities) or meta-instruments (e.g. benchmarking, STI indicators, technology foresight and assessment or peer reviews etc. providing strategic intelligence).

The lower preponderance of institutions and governance arrangements for increasing GVC participation is a common feature of all countries under review in this article, except federal States such as Brazil, Canada and the United States, where guiding documents, interministerial committee and other governance arrangements are instrumental for coordinating decentralised policy action.

Technology upgrading, as defined in this article, mobilises similar policy instruments but differently. Financial instruments remain key tools but governance and platforms and infrastructures increase in relevance. The greater density of governance arrangements reflects the integration of issues related to structural transformation and new industrial revolution, upstream in the policy cycle, at the stage of national strategies' design and policy agenda formulation. This is also consistent with the idea that upgrading purposes are intrinsically integrated into the framing of national innovation policies.

5. Conclusions and final remarks

Industrial and technology upgrading is a multidimensional process and public policy interventions to improve a country's technological and productive capacities through GVC are polymorphic. They take different forms, mobilise different instruments across different policy domains in different policy mixes. These combinations, and their density, are defined by structural features, in terms of national absorptive capacities, the prior level of country participation in GVCs, and the comparative advantages of the national innovation system.

Several observations have stemmed from this exploratory analysis of the EC/OECD STI Policy database. First, participating in GVC and promoting technology upgrading is a universal topic as all countries in this review, whatever their development stage, have policies in place to address this issue.

In addition, public policy intervention for upgrading through GVC is not limited to FDI-related policies and programmes in support of the internationalisation of firms. Initiatives spread across various policy areas, calling for a cross-cutting approach in benchmarking policies. While they seem essential for building GVC linkages and achieving structural transformation in most countries, industrial and cluster policies are combined with other policies, differently according to national context. Some governments also concentrate efforts on reinforcing industry linkages with the knowledge base, promoting the internationalisation of universities, strengthening the supply of skills and encouraging international mobility of talents. In other countries, programmes in support of international STI cooperation could be equally relevant as they facilitate knowledge transfers and help pool resources. Yet, interactions among policy areas are less notable when it turns to achieving industrial upgrading and industrial and cluster programmes remain the backbone of public policy.

National policy mixes for technology upgrading through GVC seem to be developed on the basis of pre-existing country's positioning in GVCs. Countries with more intense backward linkages tend to consolidate their policy mix for participating further in GVCs, and countries with more intense forward linkages tend to seek both to increase their participation and promote structural transformation.

Financial instruments remain the most popular policy tools for supporting integration into GVCs. It is a common feature of all countries under review, irrespective of their structural characteristics, degree of prior integration into GVC and absorptive capacities. Countries provide a broad range of subsidies, loans, venture capital and tax breaks that they combine with international investment promotion activities and the deployment of networking and world-class research facilities. More advanced countries in particular have more capacity and are more likely to deploy platforms and infrastructures to attract S&T investments and MNEs.

The role of institutions and governance arrangements seem also to increase when policy action turns towards technology upgrading highlighting the intrinsic relationship between technology upgrading and innovation policy.

This work has also helped explore the potential and limitations of the STIO/STIP data that are still at an experimental stage. In particular, this exploration recalled the need for interpreting STIP data with caution, especially when it turns to federal states where public policy is implemented at subnational levels.

These results advocates for the adoption of complementary approaches in benchmarking policy mixes, including text-as-data approaches. Further research could usefully track changes in STI policy mixes, or sub-parts of the policy mix, aiming to technology upgrading, and identify possible shifts in the choice of instruments, policy making processes and cross-domain interactions.

Disclaimer

The opinions expressed and arguments employed herein are those of the authors and do not necessarily reflect the official views of the OECD or of the governments of its member countries.

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