Determinants of the location choice of Big Tech firms' R&D internationalization: region-specific or technology-specific?

Motivation

With the increasing digital globalization (Autio et al., 2021), the rapid geographical and sectoral expansions of leading firms in the digital sectors, i.e., Big Tech firms, have received increasing attention among scholars in international businesses (Monaghan et al., 2020; Nambisan et al., 2019; Stallkamp & Schotter, 2021), innovation studies (Katz, 2021; Rikap & Lundvall, 2022) and economic geography (Coe & Yang, 2022; Ioramashvili et al., 2024; Kenney & Zysman, 2020).

Many of these aforementioned studies have focused mainly on the business expansion of Big Tech firms. Big Tech firms also contributed significantly to the development of digital technologies (Dernis et al., 2019). Several recent studies started to examine the R&D strategies of Big Tech firms. For example, Lundvall & Rikap (2022) and Rikap (2024) proposed that Big Tech firms' corporate innovation systems benefited tremendously from their collaborations with different universities and research institutes. However, they paid little attention to whether Big Tech firms are conducting these collaborations locally. It is important to shed light upon the locations of Big Tech firms' R&D activities.

On the one hand, an increasing volume of studies in international business and economic geography have emphasized the importance of location-specific capabilities in the R&D internationalization and the knowledge sourcing of multi-locational enterprises (MNEs) (Papanastassiou et al., 2020; Zhang & Rigby, 2022). As a result of the path- and place-dependent knowledge production (Boschma, 2017), Big Tech firms might need to tap into the knowledge bases of different regions to seek necessary knowledge for their R&D activities if they cannot find it in the headquarters locations.

On the other hand, Big Tech firms' R&D activities span across a broad spectrum of digital technologies including core digital technologies such as AI and cloud computing, and application technologies such as e-healthcare and autonomous driving. This is not only because they have the capacity to do so, but also because they could benefit from the interdependencies between different digital technologies (Teece, 2018). However, it is not clear whether the locational choices of Big Tech firms' R&D in these two types of digital technologies differ.

To bridge this gap, we investigate the locational choice of Big Tech firms' offshore R&D activities. More specifically, we distinguish the different types of R&D activities by comparing core digital technologies with application digital technologies. We expect that Big Tech firms locate their offshore R&D in different regions based on i) the characteristics of technologies, i.e. core or application digital technologies; ii) the knowledge base of host regions, i.e., knowledge similarity or complementarity between host regions and Big Tech firms. We expect that Big Tech firms are more likely to locate their R&D in terms of core digital technologies (core RDI) in regions with a similar knowledge base while locating those related to application digital technologies (apply RDI) in regions with a complementary knowledge base.

Theories and hypothese

Region-specific: knowledge relatedness

MNEs locate their R&D activities globally to pursue certain knowledge bases, as technological innovation is cumulative and geographically bounded (Balland & Rigby, 2017; Crescenzi et al., 2020; Feldman & Kogler, 2010). Knowledge relatedness, which fosters the quick

knowledge acquisition, is particularly important for Big Tech firms. To profit mostly from digital technologies, Big Tech firms need to apply these technologies in different domains, which require specific sets of knowledge that the firm cannot be expected to hold alone. Moreover, align with the winner-take-all characteristic of the digital business, Big Tech firms have to source the required knowledge as soon as possible to keep their competitiveness. In that case, tapping into the local ecosystem with related technologies would be attractive, which facilitates the company's knowledge access (Frigon & Rigby, 2024), absorption (Asheim et al., 2011), and creation (Castaldi et al., 2015; Frenken et al., 2007).

In addition, the role of knowledge relatedness on innovation is broadly understood (Castaldi & Drivas, 2023; Rigby, 2015), yet differentiated mechanisms remain less studied. Researchers notice that relatedness is essentially an outcome-based concept, i.e., it captures the overall affinity between a specific activity and a region (Hidalgo, 2021), yet under which the mechanisms are different (Makri et al., 2010; Qiao & Li, 2025). For example, similarity brings about cognitive proximity, which further increases the absorptive capacity of MNEs and facilitates knowledge diffusion. While combination efficiency is the result of complementarity in the local knowledge base, in which knowledge variety is necessary.

Technology-specific: core and application technologies

Considering the technology-specific features of Big Tech firms, the role of knowledge relatedness in Big Tech's R&D locations is more complex. On the one hand, Big Tech firms continue their original path, exploiting further technologies in digital sectors, i.e., core digital technologies. These technologies are usually complex, require highly regional capabilities, and are difficult to create from scratch. Moreover, core digital technologies have a high continuity with previous technologies, especially Information and Communications Technology (ICT) (Laffi & Lenzi, 2023). In this sense, regions with a high similarity to ICT fields might attract Big Tech's R&D in terms of core digital technologies (core RDI).

By locating the R&D in ICT-similar regions, Big Tech firms could absorb local knowledge with a greater learning efficiency. Technology similarity indicates that Big Tech firms have similar know-whats and know-hows to existing local technologies (Makri et al., 2010), which evidently lower the learning costs of Big Tech's newly entered R&D. According to prior studies, the more similar MNEs' technologies to host regions' knowledge base, the more easily the new knowledge could be understood, assimilated, and applied by MNEs. As a result, their absorptive capacity would be significantly leveraged. These arguments lead to the following hypothesis:

Hypothesis 1: Big Tech firms tend to locate their core RDI in regions with knowledge similarity (to ICT fields).

On the other hand, they also develop technologies that are far away from their digital core but enable the application of these core technologies in certain domains, i.e., application digital technologies. Application digital technologies go beyond being enhanced ICTs. They exhibit a significantly higher degree of recombination and combine different, even distant, technological fields (Laffi & Lenzi, 2023).

Knowledge complementarity – a good balance in knowledge distance and proximity – provides an appropriate synergy between Big Tech firms and host regions. On the one hand, knowledge complementarity guarantees a broad common knowledge, which offers a necessary cognitive proximity. On the other hand, knowledge complementarity refers to different knowledge fields

which can potentially be recombined. This relationship seems to indicate an optimal level of cognitive distance (Nooteboom, 2000) – neither too close (leading to redundancy) nor too far (causing misunderstanding) – that contributes to effective learning and innovation. Consequently, Big Tech firms' R&D in terms of application digital technologies (apply RDI) might value knowledge complementarity more. Given this, we propose the hypothesis:

Hypothesis 2: Big Tech firms tend to locate their apply RDI in regions with a knowledge complementarity with Big Tech firms.

Data and method

Data

Our empirical analysis primarily relies on patent applications of Big Tech firms extracted from the different versions of COR&DIP databases (Amoroso et al., 2021; Daiko et al., 2017; Dernis et al., 2015, 2019). The COR&DIP database provides detailed insights into the R&D activities and inventive outputs (i.e., patents and trademarks) of the top 2000 corporate R&D performers worldwide (Amoroso et al., 2021). The COR&DIP databases are suitable for our research because they consolidated international patent families, which contain patent applications in at least two of the top five patent offices[1] at the corporate group level[2].

We proxy the location of R&D activities of Big Tech firms using the address information of inventors in their patent applications. We retrieve the address information of inventors of Big Tech firms' patents from the OECD REGPAT database, which regionalized inventors of EPO and PCT patents, and the PatentsView database, which regionalized inventors of USPTO patents. 95 percent of patent families of Big Tech firms contain at least one patent application in one of these three patent offices.

Classifying core & application digital technologies.

We classify the patents of Big Tech firms into core and application following the EPO classification of Fourth Industrial Revolution (4IR) inventions, which combines the search in Cooperative Patent Classifications and keywords (EPO, 2020). We first identify 4IR patents of Big Tech firms and distinguish them among core (basic building blocks of 4IR), enabling (build upon and complement the core technologies) and application (encompasses the final applications of 4IR) technologies. Since one patent might be classified into one or more 4IR fields, we define 4IR patents of Big Tech firms containing at least one application domain as application digital technologies, and others as core digital technologies.

Preliminary results and further steps

Big Tech firms' invention activities exhibit a highly concentrated spatial distribution, with a few locations dominating the total patent numbers. Specifically, the top 20 invention locations of Big Tech firms account for 99% of all patents filed by Big Tech firms, indicating the significant concentration of their technological activities. Regarding technological heterogeneity, core and application digital technologies display distinct locational patterns. Taking European countries as an example, we find traditional science-intensive countries, like Switzerland, Germany, and France, are often hotspots of core RDI, while apply RDI is more likely to take advantage in countries with less strong technological capabilities but pervasive

[1] The top five patent offices are EPO, USPTO, CNIPA, JPO and KIPO.

[2] The main drawback of COR&DIP databases is that each version only contains patent applications of top R&D investors in the previous three years to avoid significant change in the corporate structure. At the moment, we simply put different version of COR&DIP databases together. We aim to retrace the change in the corporate structure of Big Tech firms following the methodology used in the DISCERN database (Arora et al., 2021).

digital infrastructure, such as Latvia and Luxembourg. To test our hypotheses, we will run regressions to examine the relationship between the local knowledge base and Big Tech firms' R&D locations.

Expected contributions

Our contribution is threefold. First, we supplement international business (IB) studies by highlighting the technology-specific factors of Big Tech firms' R&D internationalization. We distinguish Big Tech inventions between core and application digital technologies, and investigate their specific R&D location determinants. Second, we unpack the mechanism of outcome-based knowledge relatedness by distinguishing similarity and complementarity. The results show that the geographical concentration of Big Tech's R&D activities is driven by heterogenous mechanisms: the core RDI benefits from the spillovers of knowledge similarity and the apply RDI associates more with knowledge complementarity for the sake of recombination. Third, we offer a geographical perspective on the Big Tech study, connecting evolutionary economic geography (EEG) to platform studies. We provide insights for policy implications by figuring out the location strategies of Big Tech's R&D internationalization, as hosting innovative activities of Big Tech is a catalyst of knowledge spillovers and regional innovation.

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