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Technological sovereignty and European productivity: a regional perspective

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Introduction

The debate on European technological sovereignty has intensified in recent years, as the EU faces persistent productivity gaps, increasing asymmetric dependences and the geopolitical pressures. These concerns have been central to the Open Strategic Autonomy (OSA) agenda (Edler et al., 2021; Edler, 2024) and the Economic Security Strategy, which emphasise the need to secure critical technologies, reduce unilateral dependencies, and reinforce Europe's capacity to act autonomously in global technological systems. Yet, despite the strategic relevance of technological sovereignty, existing conceptualizations remain predominantly national in scope. They overlook the profound regional heterogeneity that characterises Europe's innovation landscape. Yet regional differences in knowledge creation, ownership, and technological integration are central to understanding how Europe can achieve technological sovereignty in practice.

This paper addressed this gap by advancing a regionalised and operational conceptualisation of technological sovereignty, based on the idea of sovereignty as embedded agency (Edler et al., 2021) and aligned with the OSA principle of being "as open as possible, as autonomous as necessary". Building on the first operationalisation attempts proposed by the Joint Research Centre (Kroll, 2024) and moving beyond linear views of the Research and Development (R&D) chain, we adopt a knowledge-network perspective and propose that regions contribute to technological sovereignty through three distinct modes of knowledge creation. These modes provide the basis for analysing whether complementarities or trade-offs arise and whether external collaboration entails productivity costs when internal capacities are weak.

Our core novelty lies in introducing the first regional indicators of technological sovereignty, constructed from patent ownership and technology-market flows. These indicators capture sovereignty not as the ability to invent per se, but as the ability to control, retain, and strategically circulate technological assets (patents), addressing a major gap in the sovereignty literature, which has so far lacked operational and regional measures. This approach is particularly relevant in light of the spatial decoupling between invention and innovation documented in the literature (Arora &

Gambardella, 2010; Akcigit et al., 2016; Capello & Lenzi, 2013): regions may host inventive activity without retaining ownership or control over the resulting technologies.

The paper pursues two main aims. First, it develops a robust empirical framework to measure regional technological sovereignty using patent ownership and transaction flows. Second, it assesses how different sovereignty configurations shape regional productivity dynamics and whether complementarities or trade-offs exist. The results offer policy-relevant insights for designing place-based strategies that strengthen Europe's strategic openness while reducing asymmetric dependencies, a key challenge highlighted in the OSA and economic security debate.

Literature background: defining technological sovereignty from a regional perspective

Technological sovereignty moves beyond a simplistic linear decomposition of the innovation chain (i.e. from the research stage to the development one (Bush, 1945; Godin, 2006)) and aligns with systems of innovation perspectives (Lundvall, 1992; Edquist, 1997), addressing European Union calls for place-based innovation strategies that strengthen technological resilience and strategic autonomy (Edler, 2024). Within this systems perspective, we propose that the achievement of technological sovereignty might occur through three alternative modes of knowledge creation, based on:

- Local own capacity, capturing the endogenous ability of a region to generate and retain technological knowledge through patent ownership. This reflects the solidity of the regional knowledge base and its absorptive capacity (Asheim & Gertler, 2005; Doloreux & Parto, 2005; Rissola & Haberleithner, 2020).
- Interregional EU own capacity, measuring the extent to which a region acquires technological assets from other EU regions (Ferrer-Serrano et al., 2025; Hoekman et al., 2010). This knowledge creation mode captures intra-EU technological integration and the ability to leverage European knowledge complementarities without increasing dependence on extra-EU actors.
- External collaboration, reflecting the degree of dependence on extra-EU partners in patent acquisitions. This mode captures global openness (Chesbrough, 2003) and connectivity (Berman et al., 2020), which may be beneficial but can also expose regions to strategic vulnerabilities (Edler, 2024).

Having identified the three modes of knowledge creation, it is reasonable to ask to what extent each contributes to the growth of European regions. In particular, we would like to understand whether there are any positive effects and, if so, whether they are complementary or generate trade-offs. Moreover, given the importance of extra-EU relations in defining sovereignty, we would like to grasp the cost of dependence associated with external collaboration of knowledge creation.

Data and methodology

The empirical strategy integrates patent-level information and technology market transactions to construct multidimensional measures of technological sovereignty at the regional level. Patent data come from OECD REGPAT (Maraut et al., 2008) and ORBIS-Patents (Bureau van Dijk). ORBIS-Patents allows us to track genuine ownership reassignments—sales, transfers, and

M&A-related changes—following established methodologies in the study of technology markets (Figueroa & Serrano, 2019; Arora et al., 2022). The construction of sovereignty measures come from the exploitation of a large patents-firms matched dataset built by identifying AI patents; linking inventors and applicants to regions using REGPAT; linking owners and ownership changes using ORBIS-Patents; identifying genuine ownership transfers between distinct firms; Aggregating ownership and acquisition flows at the regional level.

The resulting indices are computed exploiting a patent-firm-region matched dataset as follows:

- Local own capacity: share of patents owned by firms located in the region, capturing the "autarkic" capacity of regions.
- Interregional own capacity: share of patents acquired from other EU regions, reflecting intra-EU technological integration.
- Total own capacity: summation of local and interregional own capacity, capturing the autonomous sovereignty.
- External collaboration: one minus the share of patent acquisitions by top extra-EU partners, capturing dependence on non-EU actors.

To avoid mechanically inflated indicators in low-patenting regions, all raw indicators are weighted by regional per-capita patent production. Final values are normalised using variance-preserving rescaling, ensuring comparability across regions and over time.

Regional productivity is measured through Total Factor Productivity (TFP), computed via growth accounting using ARDECO data on value added, capital, and labour. Capital stocks are reconstructed using the Perpetual Inventory Method (PIM) with a 5% depreciation rate, following standard practice (Corrado et al., 2017). Panel regressions (2015–2023), weighted by population, associate TFP levels with lagged technological sovereignty indicators and their interactions, controlling for regional structural characteristics, like the share of employment in services and manufacturing, share of urban population and country-group dummies.

This methodological design directly addresses the conceptual gap identified by Edler (2024) and Mariotti (2025) and the JRC's first OSA operationalisation (Kroll, 2024): the need for operational, non-protectionist, non-autarkic measures that capture sovereignty as capacity, agency, and strategic positioning within global and intra-EU technological networks.

Results

The empirical results reveal that local own capacity and total own capacity are the strongest and most consistent predictors of regional productivity. This confirms that both autonomous capacity and embeddedness in EU technological networks are essential to achieve technological sovereignty, as emphasised in the OSA framework. External collaboration has a positive effect in isolation, which becomes negative when combined with total own capacity, reflecting non-linear sovereignty dynamics. We thus identify a "penalty" of external collaboration, suggesting that the combination is more efficient up to a specific critical mass, while it diminishes as regions own capacities increase, coherently with diminishing marginal returns in innovation systems (Ravichandran et al., 2017). Overall, technological sovereignty contributes to productivity growth, but its marginal returns decline when total own capacity is combined with external collaboration. This suggests that extra-EU openness is beneficial only for regions already embedded in EU technological networks, aligning with Edler's (2024) argument that openness strengthens sovereignty only when supported by internal capacity. Country group dummies confirm persistent structural disadvantages in Southern, Baltic, Central Eastern European Countries (CEEC), and South-Eastern countries, echoing concerns of Amaral-Garcia et al., (2023) about uneven territorial capacities to contribute to OSA and technological sovereignty. A place-based strategy that reinforces local technological bases, deepens interregional knowledge exchanges, and uses external collaboration strategically is crucial for ensuring that all regions can contribute to, and benefit from, Europe's technological sovereignty agenda.

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