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The Spatial Roots of Technological Sovereignty: Regional Productivity Effects

Roberta Capello[1], Carolina Foglia[1], Camilla Lenzi[1]

1. Dipartimento di Architettura, ingegneria delle costruzioni e ambiente costruito (ABC), Politecnico di Milano, Piazza Leonardo da Vinci, 32, 20133 Milan, Italy
   e-mail: roberta.capello@polimi.it; carolina.foglia@polimi.it; camilla.lenzi@polimi.it

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 conceptualise regional technological sovereignty through three complementary dimensions: local own capacity, interregional own capacity and diversified external collaboration. These dimensions provide the basis for assessing their individual contribution to regional productivity and the extent to which their effects depend on interactions between internal technological capabilities and external knowledge linkages.

Our core novelty lies in introducing novel regional indicators of technological sovereignty, constructed from patent ownership and technology-market flows. These indicators capture sovereignty not simply as the ability to invent per se, but as the ability to generate, retain, acquire and control technological assets. 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 an empirical framework to measure regional technological sovereignty using patent ownership and transaction flows. Second, it assesses how different dimensions and configurations of technological sovereignty are associated with regional productivity and whether their effects display complementarities or diminishing returns. 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 conceptualise regional technological sovereignty through three complementary dimensions:

- 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 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.
- Diversified 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 dimensions, we assess whether each contributes to regional productivity and whether their effects are mutually reinforcing or subject to diminishing returns. In particular, we examine whether the productivity effects of interregional and extra-EU technological linkages depend on the strength of regions' internal technological capabilities.

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 analysis focuses on AI-related technologies and exploits the combination of inventorship, ownership and transaction information to distinguish between technologies created and retained locally, acquired from other EU regions, and acquired from extra-EU partners.

The resulting indicators are computed 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.
- Diversified external collaboration: one minus the share of patent acquisitions by top extra-EU partners, capturing dependence on non-EU actors.

To reduce the effects of patent-related volatility and right-truncation, the technological sovereignty indicators are computed over rolling five-year windows. Raw indicators are weighted by regional per-capita patent production and normalised using variance-preserving rescaling to ensure comparability across regions.

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). Population-weighted pooled panel regressions for 2015–2023 associate TFP levels with one-year 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, country-group dummies and year fixed effects.

The empirical strategy also addresses two potential sources of bias: spatial dependence and endogeneity. Spatial robustness is assessed by introducing spatially lagged technological sovereignty indicators under alternative contiguity and distance matrices, while endogeneity is addressed through a Control Function estimator based on shift-share instruments exploiting the external AI technological frontier and predetermined regional technological capabilities.

Results

The empirical results reveal a clear hierarchy among the different dimensions of regional technological sovereignty: 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. Interregional own capacity, considered in isolation, is not statistically significant, suggesting that acquiring technologies from other EU regions does not automatically translate into productivity gains. The results further show that the effects of technological linkages are conditional on the configuration of regional capabilities. The interaction between local and interregional own capacity is negative and significant, indicating that the productivity contribution of interregional technology acquisition decreases as endogenous technological capabilities become stronger. Diversified 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). These findings remain qualitatively robust when controlling for spatial dependence through alternative spatial weight matrices and when addressing endogeneity through the Control Function approach. Overall, technological sovereignty contributes to productivity growth, but its marginal returns decline when total own capacity is combined with diversified 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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