Beyond Upstream Invention: A Supply-Chain Perspective on Measuring Agrifood Innovation

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Agrifood systems shape multiple dimensions of societies, including food security and public health, while also affecting ecosystems through patterns of resource use and environmental externalities. Innovation plays a crucial role in shaping transformation within this sector, influencing how agrifood-related activities are organised and coordinated in response to efficiency and sustainability challenges (Limpamont et al., 2024). There are several characteristics of agrifood systems that set them apart from many other sectors, some of which bias conventional STI-based indicators when assessing innovation performance in this sector as well as in regions that depend heavily on it.

First, on the production side, agrifood systems rely on a fragmented base of adopters, where change emerges through the distributed actions of numerous small producers (Dicecca et al., 2016). While large agrifood corporations play an important role in developing new technologies, the realisation and impact of such technologies depend largely on their widespread adoption across dispersed production contexts. Second, many forms of innovation in agrifood systems are not primarily technological but practice-based. In applying and adapting technologies to production or processing, frontline producers (e.g. farmers) often rely on in-house and experiential knowledge accumulated through learning-by-doing and everyday practices, rather than on formal R&D investments and collaborations (Bjerke and Johansson, 2022).

Third, STI-based innovation indicators mainly capture upstream activities, yet advances in production alone are insufficient to generate systemic change in agrifood systems. Outputs generated at the production stage need to be introduced to and accepted by markets, which hinges on the willingness of end users, whether final consumers or intermediate producers, to engage with and support them. This translation further depends on complementary intermediary infrastructures that connect business-to-business and business-to-consumer relations, including retailers and distributors. Within individual stages, as well as in the processes that connect actors across stages, multiple entry points exist through which innovation can emerge and take effect (Hainzer et al., 2019).

To address the limitations of STI-based indicators in capturing agrifood innovation, this paper conceptualises innovation as a multi-stage process unfolding across interconnected activities. Specifically, it adopts a supply-chain perspective that organises agrifood systems into a sequence of interconnected stages, including input supply, primary production, processing and manufacturing, logistics and distribution, retail, consumption, and disposal (Palazzo and Vollero, 2022; Zilberman et al., 2019; Barrett et al., 2022). Each stage comprises a set of functionally related activities through which agricultural products are transformed, moved, or used.

Empirically, the paper draws on multiple large-scale innovation data sources covering the period 1996–2024 and spanning the EU-27, the United Kingdom, and four EFTA countries (Iceland,

Liechtenstein, Norway, and Switzerland). The organisation-based and geo-localised nature of these data allow innovation activities to be traced across territories and linked to specific regional contexts. These sources include scientific publications and patents reflecting upstream knowledge creation and technological invention; EU-funded research projects capturing collaborative and policy-oriented innovation efforts; trademarks providing insight into downstream commercialisation, branding, and service-related innovation; and standards and certificates reflecting adoption, diffusion, and the formalisation of practices across markets.

To integrate these heterogeneous sources within a common analytical framework, we rely on text-based methods grounded in natural language processing (NLP), allowing innovation activities to be identified and compared based on their semantic content rather than on source-specific or technology-centred classifications. Such approaches have gained increasing attention in recent innovation research as a means of analysing heterogeneous and large-scale textual data (Bergeaud et al., 2025; Just, 2024; Kriesch and Losacker, 2024).

This paper makes three contributions. First, it conceptually operationalises a supply-chain perspective to examine where innovation occurs within agrifood systems, moving beyond assumptions of a one-to-one correspondence between specific data sources and particular stages. Second, it develops an NLP-based framework for classifying agrifood innovation across heterogeneous textual data sources within a single and consistent analytical pipeline. Third, the approach empirically integrates a large and previously fragmented body of agrifood innovation data into a harmonised analytical resource, combining evidence from multiple sources that are typically examined in isolation, while enabling the systematic analysis of spatial patterns and regional heterogeneity in agrifood innovation across Europe.

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