



**HAL**  
open science

# **Does the geographical indications protection policy encourage more sustainable agriculture in the territories? Moving from claims to empirical evidence**

Julie Regolo, Cédric Gendre, Thomas Poméon

## **► To cite this version:**

Julie Regolo, Cédric Gendre, Thomas Poméon. Does the geographical indications protection policy encourage more sustainable agriculture in the territories? Moving from claims to empirical evidence. *Ecological Economics*, 2025, 238, pp.108717. <10.1016/j.ecolecon.2025.108717>. <hal-05234723>

**HAL Id: hal-05234723**

**<https://hal.inrae.fr/hal-05234723v1>**

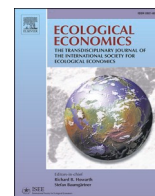
Submitted on 2 Sep 2025

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons CC BY-NC 4.0 - Attribution - Non-commercial use - International License



## ANALYSIS

# Does the geographical indications protection policy encourage more sustainable agriculture in the territories? Moving from claims to empirical evidence<sup>☆</sup>

Julie Regolo, Cédric Gendre, Thomas Poméon<sup>\*</sup>

US-ODR, INRAE, 31320 Auzeville-Tolosane, France



## ARTICLE INFO

## JEL classification:

Q01  
Q18  
Q56

## Keywords:

Sustainable development  
Geographical indications  
Territory  
France

## ABSTRACT

This article aims to assess the impact of the Geographical Indications (GIs) protection policy on the sustainable development of agriculture in mainland France. More specifically, it analyses the impact over the last decade of the increase in the territorial magnitude of agri-food GIs on agricultural economic performance, agricultural employment and agricultural pressures on the environment (biodiversity and water quality). The magnitude of GIs is assessed using two distinct indicators: the proportion of farmers involved in GIs and the diversity of GI products within each territory. We use data at a fine territorial scale (cantonal level – NUTS4) and a meso-economic approach. We estimate a difference in differences econometric model to continuous variables, and we control for the effect of the presence of operators involved in organic farming in the territory, and of payments under the second pillar of the Common Agricultural Policy, which may impact sustainable development indicators. The results show that, all other factors being equal, cantons where there has been an increase in the presence of GIs over the last decade have seen greater improvements in their economic, social and environmental performance than cantons where there has been no increase. They also indicate the distinct and complementary effects of GI diversity and intensity in the territory, in terms of contribution to sustainable development.

## 1. Introduction

Geographical Indications (GI) protect the names of products with specific features, qualities or a specific reputation and which are linked to their area of production. These products are protected against copying or fraud, while the geographical system guarantees that they were made to high standards in their region of origin. Initially introduced in a few European countries (France, Spain and Italy in particular), they have been recognized and regulated by the European Union since 1992 (EU Regulation No. 2081/92), through the Protected Designation of Origin

and Protected Geographical Indication labels. In addition to consumer protection, the European agricultural policy of recognizing and protecting GIs aims to promote the economic and social development of agriculture and rural areas (see EU Regulation No. 1151/2012; Sylvander et al., 2005). GIs can also be an instrument for preserving the environment and biodiversity through their roots in the territory and the protection of terroirs (Hirczak and Mollard, 2004; Thévenod-Mottet, 2010; Belletti et al., 2017; Vandecastelaere et al., 2010, 2021). The new regulation on GIs put forward by the European Council and Parliament goes even further, explicitly highlighting the link between GIs and

<sup>☆</sup> An earlier version of this paper has been presented to the International conference on « Worldwide Perspective on Geographical Indications », co-organized by the Food and Agriculture Organisation of the United Nations (FAO) and the Centre de coopération internationale en recherche agronomique pour le développement (CIRAD). We thank the participants at this conference and especially Delphine Marie-Vivien, Giovanni Belletti, Marcelo Champredonde and Valerie Olivier Salvagnac for interesting discussion and helpful comments. The authors also thank the two anonymous referees for their helpful and relevant comments, and Alexandra Poméon and Katie Booth for their valuable support for translating this article from French into English. Funding from the French National Research Agency (ANR) as part of the project « Geographical Indications as Global Knowledge CommOns (GingKo). Reassessing current models of regulation and collective action towards more sustainable social-ecological systems » (ANR-22-55-0011CE-05) are gratefully acknowledged.

<sup>\*</sup> Corresponding author.

E-mail address: [thomas.pomeon@inrae.fr](mailto:thomas.pomeon@inrae.fr) (T. Poméon).

sustainability,<sup>1</sup> and in so doing makes GIs a policy instrument for sustainable development.

The notion of sustainable development was popularised by the United Nations Brundtland Commission (1989) and then formalised at the Earth Summit in Rio in 1992. This concept asserts the need to view development in terms of a combination of environmental, economic and social objectives, to ensure that development is balanced, based on these three pillars, and “sustainable”, through an approach founded on solidarity with future generations. It has since been incorporated into numerous policies, including the European Union’s agricultural and rural policies (Fischler, 1999). By applying this approach to agriculture, the productivist policies prevailing until the 90s are nuanced, or at least combined with other objectives: maintaining/creating quality jobs in rural areas, ensuring the viability of the agricultural economy while protecting natural resources, ecosystems and the biosphere. The objective of sustainable development is at the heart of the European Green Deal and its application to agriculture and food in the Farm to Fork Strategy.

The question therefore arises as to whether, and to what extent, the GI protection policy does indeed contribute to the sustainable development of agricultural areas. This claim, which explains the prominence given to GIs in European agricultural, rural and food policy, does not always command consensus, and sometimes lacks objectification. In the scientific literature, the assessment of the overall impact of these labelled products on the development of territories remains little explored, largely due to the limited availability of data (Ceï et al., 2018a; Raimondi et al., 2024). In this article, we therefore aim to study the overall impact of an increase in GIs on the three areas of sustainable territorial development.

The issue of identifying the impact of GIs on territorial development has so far been based mainly on disparate case studies of certain GI products and sectors across Europe and the world. The effects examined relate to different dimensions of sustainable development, depending on the study. They use ad hoc, heterogeneous evaluation grids, depending on the resources allocated to these evaluations (data, human resources, etc.) (Carbone et al., 2014; Vandecandelaere et al., 2018). In addition to academic research, there is also a wealth of grey literature on the subject, reflecting the interest of stakeholders in this area (for example the studies of the *Observatoire économique des SIQO en Hauts-de-France, 2019*, *Observatoire économique des SIQO en Hauts-de-France, 2021*). This phenomenon reflects a desire to integrate sustainable development more fully into the production and management of sectors, but also an awareness of the anticipated but so far ill-defined role of GIs in reinforcing it; and at the same time strengthening the case for GIs as a legitimate public policy tool. The wide variety of sectors covered by GIs makes it particularly difficult to generalise about their impact and performance, as they apply to all types of production (raw or processed products, animal or plant products, niche or internationally renowned products, production areas of just a few hectares or covering entire regions, etc.).

However, recent studies have sought to highlight an overall effect of GIs. The European Strength2Food project assessed the sustainability of 19 European GI products using a common grid of indicators, comparing them with conventional products (Arfini and Bellassen, 2019; Bellassen et al., 2022). In France, using data at farm level from the Farm Accountancy Data Network (FADN), Sengel et al. (2021) assessed the economic and environmental performance indicators of several cheeses with GIs compared with other non-GI cheeses. Nevertheless, these studies do not allow conclusions to be drawn on the generic impact of

GIs on the territory, especially as they are often carried out in sectors for which data exist or which are actively involved in a sustainable development approach. Noting this lack of evidence on the overall/generic effects of GI policy, Ceï et al. (2018a and 2018b) and Raimondi et al. (2024) sought to assess the overall impact of GIs on employment and rural development in Italian territories. Raimondi et al. (2024) studied the impact on value added and agricultural and industrial employment in three European countries (Spain, Italy, France). Flinzberger et al. (2022a, 2022b) assessed the correlation between the presence of GIs and landscape-related socio-ecological indicators in European territories (tourism, agro-ecological infrastructure). Stranieri et al. (2023, 2024) focused their analysis on the impact of GIs on the competitiveness of agricultural and food sector at NUTS2 level. They also include considerations about the interactions between GIs and the regional innovation system.

The lack of fine data means that they are unable to conduct analysis below departmental level (NUTS3). These studies are also limited in the way they measure the magnitude of GIs across the territory, which they proxy as the number of products under protection in the area (cross-referencing the production areas defined in the specifications and the administrative divisions). Inclusion in the protected area indicates the possibility of production but does not reflect the actual role of the GI in local production systems.

The originality of our study lies firstly in the new data on GIs which make it possible to overcome this limitation. We use original data on GI-certified operators in France to characterise the significance of GIs at cantonal level (NUTS4) and explore the distinct effects of two complementary indicators: the proportion of farms with certification for GI products, and the diversity of GI products represented. We adopt an empirical and territorial approach; our unit of observation is the French “canton” (NUTS-4), which is bigger than an exploitation (microeconomic approach) but finer than the national territory (macroeconomic approach). In the rest of the paper, we qualify this approach as a “meso-economic approach”. We aim at measuring the generic impact of GIs in France, rather than specific to a product or sector. We also explore the effect on the environmental pillar of sustainable development, which is still largely unexplored in relation to GIs. More specifically, we assess whether cantons that have seen an increase in the level of GIs on their territory have also experienced an improvement in their economic, social and environmental performance, all other factors being equal. We focus our analysis on the case of non-wine GIs in France, given the specific features of the wine sector and the uncompletedness of data over the period studied.<sup>2</sup> France, a country with a long tradition of GI protection and the second European country in terms of the number of GI products, is a representative case study, offering a wide range of GI production, involving almost 20 % of farms in 2020.

Using a difference-in-differences econometric model on continuous variables (Acemoglu et al., 2004), we successively evaluate the impact of the increase of agri-food GIs in French cantons between 2013 and 2020, on agricultural profit per non-salaried annual work unit (NSA-WUs), agricultural employment, and on a proxy indicator of the pressure of agriculture on biodiversity (a composite indicator of presence of nitrates, phosphates and pesticides in water, landscape crop diversity, and share of permanent grassland in the utilised agricultural area (UAA)). We control for the effect of the presence of operators involved in Organic Farming (OF) in the territory as well as payments under the second pillar

<sup>1</sup> [https://www.consilium.europa.eu/en/press/press-releases/2023/10/24/strengthening-geographical-indications-council-and-parliament-strike-deal/?utm\\_source=dsms-auto&utm\\_medium=email&utm\\_campaign=Strengthening+geographical+indications%3a+Council+and+Parliament+strike+deal](https://www.consilium.europa.eu/en/press/press-releases/2023/10/24/strengthening-geographical-indications-council-and-parliament-strike-deal/?utm_source=dsms-auto&utm_medium=email&utm_campaign=Strengthening+geographical+indications%3a+Council+and+Parliament+strike+deal) (web archive link, )

<sup>2</sup> In France in 2020, 489 GIs were linked to the wine or spirit sectors, and 247 to other agri-food sectors. More than 90 % of wine production is under GI protection (INAO, 2021), the vast majority of wine-growing cantons have GIs and variations over the last decade have been very slight. Therefore, like Ceï et al. (2018b), we have decided to exclude wines and alcoholic beverages from this study and to focus on GIs in the agri-food sector. Finally, data on wines and alcoholic beverages are not available in relation to operators certified before 2017.

of the Common Agricultural Policy (CAP) that may contribute to sustainable development.

In the following section, we discuss the expected effects of the GI policy on sustainable development, in the light of the literature. Then, in section 3, we set out in detail the problems involved in determining a relevant metric for measuring the magnitude of GIs on a territory. We describe their dynamics on the basis of original and exhaustive data over time and space. In Section 4 we present the econometric model and the variables used to approximate the performance of territories from a sustainable development perspective. The results are presented in Section 5 and discussed in the conclusion.

## 2. The expected effects of GIs on sustainability

The strong link between GI products and the territories from which they originate is reflected in the objectives of the policy. The European Regulation No 1151/2012, claimed that GI policy is able to improve the income of local farmers. The recent European Regulation 2024/1143 emphasizes that geographical indications can play an important role in sustainability and strengthens the role of GIs in sustainability by integrating environmental, agricultural, and economic priorities. According to Article 7, sustainable practices must contribute to environmental, agricultural, or socioeconomic objectives, in addition to economic and rural development objectives.<sup>3</sup> Importantly all aspects of sustainable development must be integrated into management decisions regarding the use of GIs as a policy tool to promote sustainable development at local level (Flinzberger et al., 2022a).

Few studies adopted a comprehensive and quantitative approach of GIs' impact in terms of sustainable development, including economic, social and environmental pillars. Previous works on GIs' effect generally focused on one or some aspects, being theoretical, case-studies based or more generic empirical approaches. Economic effects are by far the most studied effects, which is quite logic regarding the historical rationale for GIs. Existing studies mainly focused on European countries (Bellassen et al., 2022; Flinzberger et al., 2022a, 2022b). Bellassen et al. (2022) used a common framework applied to several case studies and showed that GIs (and organic certification, also considered in this study) outperforms comparable value chain on most economic and social indicators, and are similar for main environmental indicators. Flinzberger et al. (2022a, 2022b) built on a large database linking at NUTS3 level the number of PDOs and socio-ecological and structural indicators to establish correlation between PDO and sustainable features. They considered these correlations globally, and also by area (Mediterranean vs. non Mediterranean countries) and by product category. More than a causal relation, their findings spotlight the main features of the areas where PDOs are more (or less) developed. They allow to propose some policy recommendations on how better use GIs as rural development instrument, but not to understand and quantify the effects of GIs regarding sustainability.

In the following sub-sections we will propose several hypotheses based in scientific literature about expected effects of GIs on each main aspect of sustainability. On that basis we will then presented in section 4 our strategy to provide an answer to these hypothesis, with an original approach quantifying globally the effects of GIs in French at a fine scale.

<sup>3</sup> Environmental goals include climate change adaptation, resource conservation, circular economy practices, pollution control, and biodiversity protection. Agricultural objectives focus on reducing pesticide use and antimicrobial resistance, improving animal welfare, and supporting young farmers. Socio-economic criteria ensure fair income for producers, promote local development, create jobs, and improve working conditions in agricultural and processing sectors.

### 2.1. Expected effect of GI intensity on economic sustainability

The idea that GIs can positively affect the economy of the area where their production takes place relies on several economic foundations (Cei et al., 2020; Monier-Dilhan et al., 2021; Moschini et al., 2008). On the demand side, the GIs policy is a tool to reduce the information gap between producers and consumers (Marette et al., 1999; Josling, 2006; Anania and Nistico, 2004), and then to favour the higher consumers' willingness to pay (WTP) for these products with specific quality attributes (origin and method of production).

On the supply side, collective organisation related to GIs may enable value chain actors to better control the added value generated and its distribution, especially by influencing the structure and organisation of supply chains: visibility, stability, market access, access to institutional support, etc. (Monier-Dilhan et al., 2021). Besides, GIs protect the product's reputation and then generate a price premium on the market (Menapace and Moschini, 2012; Shapiro, 1983). GI may create a rent for a limited number of producers which are located in the geographic area and have limited yields (Moran, 1993; Landi and Stefani, 2015).

There is a large literature studying the effect of GI on the WTP of the consumers for some products (Corre et al., 2022; Deselnicu et al., 2013). It shows that consumers usually attach a greater value to GIs, despite the occurrence of positive label effects is heterogeneous across GI products. On the supply side and up to the value chain, GI producer generally benefit from a premium compared to their non-GI counterparts, although this does not always offset the higher costs associated with GIs (production, certification, or coordination costs) (Chever et al., 2012; Areté Research and Consulting in Economics, 2013; Vandecandelaere et al., 2018; Jeanneaux et al., 2019; Monier-Dilhan et al., 2021). Arfini and Bellassen (2019) and Sengel et al. (2021) show that GIs increase the value created at the farm level for most of GI products. The results at the NUTS3 or NUTS2 level also show positive economic effects on the territory, especially in terms of value added and competitiveness (Cei et al., 2018b; Crescenzi et al., 2023; Stranieri et al., 2024). However, some literature reviews (Cei et al., 2018a; Török et al., 2020; Li et al., 2024) stressed the facts that these positive effects are heterogenous. This heterogeneity encompasses geographical aspects, product categories, features of the value chain (volumes, export-oriented or domestic market, etc.) and also methodological considerations. Monier-Dilhan et al. (2021) also pointed this variability among cases out, including the question of the fair distribution of the price premium along the value chain, especially for farmers. But in most cases, GIs are associated with an increase of incomes for farmers, even if the magnitude of the effect may vary.

Despite some caveats, it exists a quite large consensus to affirm that GIs can improve the economic outcomes. GIs benefit globally to the actors of the GI value chain but also to the whole territories where it takes place and even to neighbouring territories (Donati et al., 2021; Raimondi et al., 2024). We then propose the following hypothesis:

**Hypothesis 1.** *An increase in the proportion of farms with a GI in a given area should lead to an increase in the agricultural value created per farmer in the area.*

### 2.2. Expected effect of GI intensity on social sustainability

Providing employment is a key way in which GI might contribute to positive social outcomes for producers and communities. GI specifications by requiring certain production standards and/or providing larger economic margins, may result in agricultural enterprises employing greater numbers of people (Gerz and Dupont, 2006). Indeed, less economically efficient farms may be more socially sustainable, if they need to employ more people to achieve the same outcomes as competitors (Hilal et al., 2021; Raimondi et al., 2024). At NUTS3 level, Raimondi et al. (2024) put forward a significant relation between GIs and employment, both in agricultural and industrial sector, at short and long

term and even with spatial spillover. Positive effects on employment were also put forward at NUTS3 level by Crescenzi et al. (2022, 2023).

Cahen (2023), based on GI experts interviews in France and the analysis of specifications, summarized the main factors in the French GI specifications that increase labour intensity. First, many GI specifications include the requirement to carry out certain stages of production manually to ensure the quality of the product. For example, in the vegetable sector, manual harvesting is compulsory for the PDO Espelette chilli pepper, manual braiding for the PDO Roscoff onion, or manual crating for the PDO Béa du Roussillon. Similarly, in livestock farming, mechanisation is sometimes prohibited to preserve quality (a ban on milking robots; and/or a ban of ladle-moulding robots for some GI cheeses). Secondly, some practices to guarantee quality such as access to grassed areas and the cares for livestock, or the tree trimming (for tree cultivation), require more working time. In addition, testing, checking and verifying quality and compliance with specification requirements can lead to additional constraints in terms of working time. Some PDOs also explicitly limit the number of animals per worker in their specifications (e.g. the Crottin de Chavignol PDO).

Most specifications limit the intensity of production, which may be associated with a higher labour intensity (Détang-Dessendre and Depeyrot, 2023). For example, in livestock farming, the number of animals per hectare per year is often restricted. The often-claimed on-farm processing also limits the stocking density and the size of buildings (European Commission, 2008). In tree farming (for example, in olive production), the number of trees per hectare is also limited to ensure adequate spacing.

Finally, geographical indications can also enhance regional tourism through their strong association with the territory's identity and reputation, thereby promoting agricultural employment—particularly within farms that engage in agritourism activities. (e.g. Suh and MacPherson, 2007).

In the literature, GI have been shown to generally require high levels of labour and so create more employment than conventional agriculture (e.g. Bouamra-Mechemache and Chaaban, 2010; Gerz and Dupont, 2006; Török et al., 2020). Gerz and Dupont (2006) showed that the Comté PDO generates five times more jobs than the Emmental sector. Hilal et al. (2021) assessed labour intensity and wages for 17 PDO and PGI products compared to their conventional counterparts. The study found a 13 % higher employment rate compared to the reference product, with relatively higher rates in livestock farming than in crop production. Détang-Dessendre and Depeyrot (2023) showed that participation in a GI is associated with a significant increase in employment for the same volume of milk, even when accounting for grazing constraints. This effect can exceed 10 % for certain PDOs. However, some articles have also shown that geographical indications, which sometimes carry strong economic value, promote the growth of powerful commercial units that focus on productivity growth rather than on fostering employment (Besky, 2014; Hilal et al., 2021).

Therefore, we propose to test the following hypothesis focusing on the effect of GIs on farm employment:

**Hypothesis 2.** *If the share of farms involved in GI increases in a given area, an increase in agricultural employment can be expected, all other factors being equal.*

### 2.3. Expected effect of GI intensity on environmental sustainability

It is important to note that the legal requirements for GI do not necessarily include sustainability standards or address environmental concerns in their current form (Raffray, 2023). However, there is a growing concern for all stakeholder, including policy makers as GI producers, to find a way to match GIs and environmental performances. Indeed, by recognizing and promoting products using traditional methods in specific geographic regions, GI (and in particular PDO) help preserving traditional landscape management and management

practices behind it (Hirczak and Mollard, 2004; Belletti and Marescotti, 2011; Bérard and Marchenay, 2006; Flinzberger, 2023). This includes traditional farming and production techniques, but also the natural resources and biodiversity of the region (Milano and Cazella, 2021).

Many field studies and specifications suggest that GIs may have a positive impact on the environment by preserving biodiversity (conservation of habitats and landscapes), in particular by allowing the maintenance of relatively extensive farming with low pesticide use, restricted use of fertilizers and low use of concentrates for animal feeding (Hirczak and Mollard, 2004; Thévenod-Mottet, 2010; Belletti et al., 2015; Flinzberger et al., 2022a, 2022b; Lambotte et al., 2021). For example, most dairy GI specifications include constraints on breeds (endemic breeds are often preferred) and grazing periods, and limits the intensification of production. Specifications for Comté PDO from 2015 require for example that most feed comes from the geographical area, that each cow has a minimum of one hectare of grassland and that temporary grasslands represents a maximum of 15 % of the farm forage area. The revisions of the specification in 2024 even increases the exigence of these requirements. Imposing production system autonomy, i.e. supplying livestock with food from local crops, also encourages agricultural production diversification on territories.

Empirical results on environmental aspects are mixed and sparse. Flinzberger et al. (2022a, 2022b) showed that geographical indications in general, and the 'Protected Designation of Origin' label (PDO) in particular, were geographically related to several social-ecological indicators that the scientific community associates positively with sustainable landscape management (high nature value farmland, semi-natural agriculture, tourism, and cultural heritage indicators). Bellassen et al. (2021) and Cortesi et al. (2022) have assessed the carbon footprints of certain GIs, with in general not significant difference linked with GI certification. Bodini et al. (2021) compared the water impact and water footprint for 23 food quality schemes products (including organic, PGI and PDO products) against reference products, including animal products and vegetal products. They showed that the Codes of Practice for PDO seem to imposes lower water requirement to sustain farming activities as well as reduced use of mineral fertilizers, pesticides, and herbicides. Their results suggest that the farming systems employed in PDO productions has lower pollution impact on surface water. However, they found no impact for the PGI studied, and a large heterogeneity in the results per products. Therefore we will test the following hypothesis:

**Hypothesis 3.** *A relative increase in the share of GI farms in a given area lead to a reduction in the environmental impact of agriculture, especially regarding impacts on biodiversity, everything else being equal.*

### 2.4. Expected effect of GI diversity on sustainability

From an economic point of view, GIs value local resources, not only based on productivity but also on quality in relation to culture, history, and local know-how (Sylvander et al., 2007). This may benefit to other local products and favour territorial strategies of valorisation of a basket of emblematic local products, through for example touristic activities (Pecqueur, 2001). Through these reputation effects with territorial spillover, the value created by a GI product can be reinforced by the presence of other GIs in the same territory. Moreover, increasing the number of GIs in a given territory can also make it possible to pool the management costs of the consortiums and the costs of organizing controls, and thus reduce the cost of procedures through economies of scale (Olivier-Salvagnac et al., 2024). Therefore, it is interesting to test if the economic effect of GI may be strengthened with GI diversity.

**Hypothesis 4.** *Increasing the diversity of GI products increases the agricultural value created per farmer in the area.*

It is acknowledged that GI diversity preserve and promote the agricultural production diversity, by helping the conservation of the

diversity of many rural heritages (Sylvander et al., 2007; Mazé, 2023; Olivier-Salvagnac et al., 2024). The diversification of agricultural production at territorial level is increasingly recognized as a pivotal factor in facilitating the agroecological transition towards enhanced sustainability. Production diversity makes agricultural systems more robust and resilient to cope with economic, climatic and health hazards, by diversifying risks (Lurette et al., 2020; Puech and Stark, 2023). This may contribute to stabilize agricultural employment.

**Hypothesis 5.** *Increasing the diversity of GI products in an area increases agricultural employment.*

Finally, diversity of living organisms in agricultural production (species, varieties, crop rotations, etc.) preserves biodiversity and allow to use fewer chemical inputs. Moreover, bringing livestock and crops closer together favors circular economies, wherein waste from one sector serves as input for another. This synergy not only limits the reliance on external agricultural inputs but also maintains productivity levels, thereby preserving ecosystems and enhancing sustainability. (Kremen and Miles, 2012; Caquet et al., 2020; Magne et al., 2019).

GIs are thus recognized as a potential tool for sustainable development, but the importance of their diversity within a given territory must not be overlooked (Olivier-Salvagnac et al., 2024).

**Hypothesis 6.** *Increasing the diversity of GI products contribute to reduce the environmental impact of agricultural production.*

Finally, the effect of GI diversity, i.e. of the coexistence of several GI product categories in a same territory, remain a quite unexplored field. Case-studies generally treated each product separately, or in some case they considered jointly GIs product from the same category in a given area (Hirczak and Mollard, 2004; Frayssignes, 2008). Papers using number of GIs in NUTS2 or NUTS 3 level could indirectly contribute to analyse the effect of GI diversity, as we can assume a significant correlation between number of GI product and the number of GI categories represented. Nevertheless it doesn't consider that some area cumulates several GIs for the same categories (like mountainous one with GI cheese production, like Alpes or Massif Central in France); nor that production of each GI product can be more reduce than the official area (see section 3). It is thus an original contribution to integrate explicitly the GI diversity as a potential incentive for more sustainability.

### 3. Detailed characterisation of the magnitude of GIs in the territory over the period 2013–2020

#### 3.1. From a zonal approach to an exhaustive survey of the weight of GIs in farming systems in the French territories

Literature examining the magnitude of GIs in quantitative terms is often hampered by a lack of data. Measurement is dependent on the only publicly available, exhaustive data on the location of GIs: the municipalities officially included in the geographical areas where production and/or processing of GI products are authorised, as defined in the specifications for each GI. Raimondi et al. (2024) assess the impact of GIs over the period 1993–2014 on socio-economic development (productivity, employment) at NUTS3 level in three European countries (Italy, France and Spain). Their measurement of the level of GI is the number of GIs authorised in the territory. Cei et al. (2018b) compute an index measuring the number of non-wine GIs in the “Italian provinces” (also at NUTS3 level), weighted by the surface area of the municipalities where the GI has official protection.

However, the fact that a municipality officially falls within the geographical area defined in the specifications does not mean that this municipality actually has operators involved in GIs. It is a necessary but not a sufficient condition. To assess the role of GIs in local farming systems, we also need to know whether operators in the sector are actually involved in GI production. The system of certification by a third party, made compulsory by the regulations, means that all operators are

checked by certifying bodies and therefore listed in their databases. Given the cost of certification, it is highly likely that operators will only take this step if they are actively involved in GI production. In France, the 10-year partnership between the National Institute for Origin and Quality (INAO) and the Rural Development Observatory Unit (ODR)<sup>4</sup> of the National Research Institute for Agriculture, Food and Environment (INRAE), in the framework of the Territorial Observatory for Quality and Origin (OT-SIQO), has made it possible to gather data on all certified operators (mainly agricultural producers and processors) and their location between 2012 and 2020 (Regolo and Poméon, 2021). Using these data, which are unique in Europe, we can exhaustively and accurately assess the extent to which the agricultural sectors in a given territory are involved in GI schemes, based on the actual presence of certified agricultural operators. These data show that almost 20 % of the cantons (NUTS4 – LAU1) included in an official GI protection area do not in fact have any GI-certified operators working on their territory.<sup>5</sup>

OT-SIQO data on GI-certified operators are available at the fine scale of municipalities (over 34,968 municipalities in France). However, this highly disaggregated level can be a source of error, as the information on the location of the municipality is sometimes based solely on the post-code, and confusion can arise between the address of the establishment and the location of the activity. Moreover, this level seems of little relevance for understanding the effects of GIs on the sustainable development of the territory, which may extend beyond the territory of the operator's municipality. We therefore decided to aggregate the data at cantonal level, which is a finer geographical level than that commonly used in the literature, and which constitutes a coherent and relatively homogeneous geographical entity in terms of the dynamics of local agricultural systems (similar biophysical, economic, social and political conditions).

According to the previous section, two complementary indicators are relevant for measuring the magnitude of GIs in the territory: the proportion of GI-certified farms, which we consider to be an indicator of intensity, and the diversity of GI products.<sup>6</sup>

The diversity of GIs in the territory is approximated by the number of products for which there is at least one GI-certified farm (carrying out an agricultural activity) in canton  $i$  at time  $t$ . (NBPROD<sub>it</sub>).

The share, as a percentage, of farms with GI certification in canton  $i$  at time  $t$  (ShCF<sub>it</sub>), is calculated as follows:

<sup>4</sup> The *Observatoire du développement rural* (Rural Development Observatory) is a service unit at INRAE, which hosts and processes large-scale administrative databases on agricultural systems and policies in France, drawing on institutional partnerships with public bodies in charge of agricultural, rural and environmental policies.

<sup>5</sup> When we evaluate the number of GI products per canton over the period alternately by the existence of an official area in the specifications, or by the actual presence of certified agricultural operators, we see that the former results in a significant overestimate of the magnitude of GIs in the area, with numbers very often higher than in the case of the latter, even though these indicators are positively correlated at 0.53 %.

<sup>6</sup> We computed several indicators and carried out an analysis of correlations and respective contributions. The indicators computed include the Shannon product diversity indicator, the number of sectors represented (according to several types of categories), the number of GI products with a production area, the number of GI products with at least one farm, the absolute number of GI-certified farms. The results for the different indicators are very similar and stable.

$$ShCF_{it} = \frac{\text{Number of farms with GI certification for farming activities}_{it}}{\text{Total number of farms}_{it}}$$

The total number of farms per canton is calculated on an annual basis using data from the *Mutualité Sociale Agricole* (MSA)<sup>7</sup> on non-salaried agricultural workers and excluding winegrowing farms.<sup>8</sup>

We have excluded from the analysis GI products not derived from agricultural activities as defined by agricultural statistics, such as salt production (*Sel de Salies-de-Béarn*, *Sel de Guérande* PGI), forestry (*Bois du Jura* and *Bois de Chartreuse* PDO), fishery and aquaculture products (*Moules de Bouchot de la Baie du Mont-Saint-Michel* PDO, *Bulot de la Baie de Granville* PGI, *Huitres Marennes Oléron* PGI, *Coquille Saint-Jacques des Côtes-d'Armor* PGI and *Anchois de Collioure* PGI) and processed products with no geographical restrictions on raw materials (*Raviole du Dauphiné* PGI, *Gâche Vendéenne* PGI and *Brioche Vendéenne* PGI, *Pâtes d'Alsace* PGI, *Bergamote de Nancy* PGI). The cantonal reference database used initially included 1697 cantons. To ensure the quality of the data, only those cantons with at least ten non-winegrowing farms were retained. Our final sample is therefore a balanced data panel of 1517 cantons over 8 years, i.e., 12,136 observations.

Table 1 shows the descriptive statistics for the two indicators of the level of GI in the territory over the period 2013–2020. 22 % of observations have GI indicators equal to 0, with medians of 5 % of farms and 1 GI product. At the other extreme of the distribution, a quarter of the observations have more than 15 % of GI-certified farmers and/or at least 4 GI products. These figures conceal the heterogeneity between cantons at a point in time *t*, as well as variations in the indicators over time. (See Figs. 1 and 2.)

Maps 1a and 1b below show the intensity and diversity of GIs at the start of the period studied, in 2013. They highlight the heterogeneity of GI significance in France.

The maps show that in 2013, GIs' intensity is higher in mountainous and disadvantaged areas (Massif Central, Alps and Jura, as well as Corsica). The Landes, the PACA region, Corsica and the southern Massif Central are characterised by a high diversity of GI products (with cantons with more than ten products). In Auvergne, the diversity of GIs is above all a reflection of the diversity of renowned livestock products, particularly PDO cheeses (*Bleu d'Auvergne*, *Saint-Nectaire*, *Salers*, *Cantal*, *Laguiole*, *Fourme d'Ambert*). In Corsica and South-East France, a number of different sectors coexist, including olive oil, honey, fruit and cheese.

**Table 1**  
Descriptive statistics on indicators of GI magnitude by canton over the period 2013–2020 (base used: 1517 cantons).

	Share of GI-certified farms (ShCF)	GI diversity (NBPROD)
Number of observations	12,136	12,136
Minimum value	0	0
First quartile (25 %)	0.01	1
Median	0.05	2
Third quartile (75 %)	0.15	4
Last decile (90 %)	0.32	6
Maximum	1	14
Average	0.10	1.13
Standard deviation	0.16	1.08

Source: Authors' calculations based on ODR-INAO data.

<sup>7</sup> MSA (*Mutualité sociale agricole*) is the French compulsory social protection scheme for salaried and non-salaried agricultural workers.

<sup>8</sup> For details on the data, see: [https://odr.inra.fr/intranet/cartowiki/in dex.php/Fichiers\\_des\\_cotisants\\_non\\_salari%C3%A9s\\_regroup%C3%A9s\\_par\\_exp loitation](https://odr.inra.fr/intranet/cartowiki/in dex.php/Fichiers_des_cotisants_non_salari%C3%A9s_regroup%C3%A9s_par_exp loitation). The indicator for the number of farms was calculated alternately with data from the 2010 and 2020 agricultural censuses, and correlation is above 0.8.

In the Landes region, we find the following PGIs: *Kiwi de l'Adour*, *Volailles des Landes et du Gers*, *Bœuf de Bazas*, *Bœuf de Chalosse*, *Canard du Sud-Ouest*, *Jambon de Bayonne* and *Asperge des Sables des Landes* (see Fig. A.1 in the Appendix for the diversity of sectors).

### 3.2. Increase in GI intensity and diversity in the territories over the period 2013–2020

Table 2 shows, for each year, the number of cantons according to the level of the indicators for GI diversity (NBPROD) and intensity (ShCF). The levels shown correspond to the quartiles set out in Table 1. GIs are increasingly present in France. The number of cantons with less than 5 % of GI-certified farms fell considerably between 2013 and 2020 (441 + 355 = 796 without GIs in 2013 compared to 693 in 2020). Similarly, the diversity of GIs increased over the period. In 2020, 381 cantons had more than 4 active GIs, compared to 272 in 2013.

Maps 2a and 2b below highlight the heterogeneity of GI dynamics between cantons. They show the average variation in the indicators of GI intensity (2.a) and diversity (2.b) over the period 2014–2020 compared with 2013 (average of the absolute variations between the reference year 2013 and each subsequent year, in line with the econometric model).

Fig. 2a shows that, on average, almost half of the cantons saw the share of GI-certified farms fall or remain stable (sometimes at 0), while the other half saw this share increase to varying degrees. Over the period, 25 % of cantons saw an increase of more than 1 percentage point in the share of GI-certified farms on their territory.

The increase in the relative number of GI-certified farms in a territory potentially conceals very different dynamics, with some territories experiencing sharp declines in the share of farms. According to data from the 2020 agricultural census, mainland France saw a loss of around 100,000 farms compared with the previous census in 2010.

It is therefore interesting to note that in our sample, the vast majority (84 %) with a growing share of GI farms have seen an increase in the absolute number of GI farms, i.e., existing farms have become GI-certified or new GI farms have been set up. In the remaining 16 % of cases, the number of farms involved in GI products fell, but by less than the total number of farms in the canton, reflecting a relatively stronger preservation of GI farms in the territory (particularly in Landes, Dordogne, Lot-et-Garonne and Savoie). These phenomena are illustrated on Fig. A.2 in the Appendix. Lastly, between 2013 and 2020, 58 new GI specifications were registered for France by the European Union, including 16 fresh meats, 13 meat products, 9 dairy products and 14 fruits and vegetables; a total of 21 PDOs and 37 PGIs (e-Ambrosia portal).<sup>9</sup>

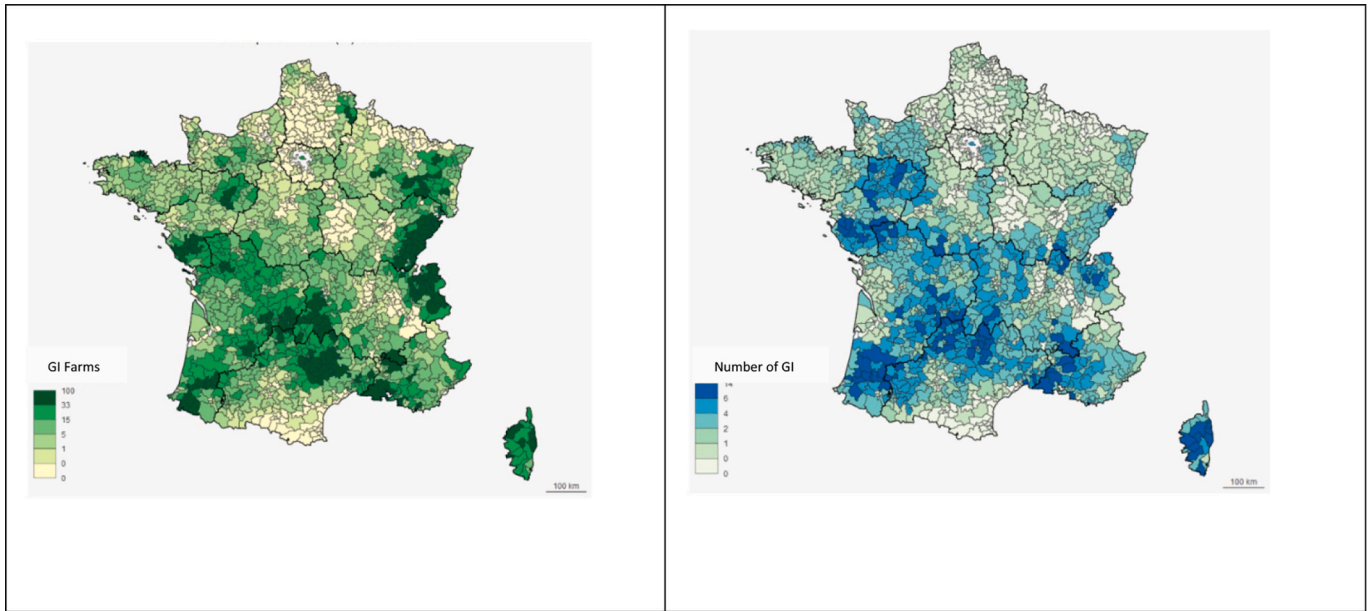
Fig. 1b shows that the diversity of GIs by canton between 2013 and 2020 also increased for more than 50 % of the cantons. In some territories (in red on Fig. 2a and in green on Fig. 2b), fewer operators are involved in GI products, but there is a wider diversity of GI products. The diversification of GIs is linked in particular to new products being recognized.

## 4. Strategy for the evaluation of the impact of GI on sustainable development

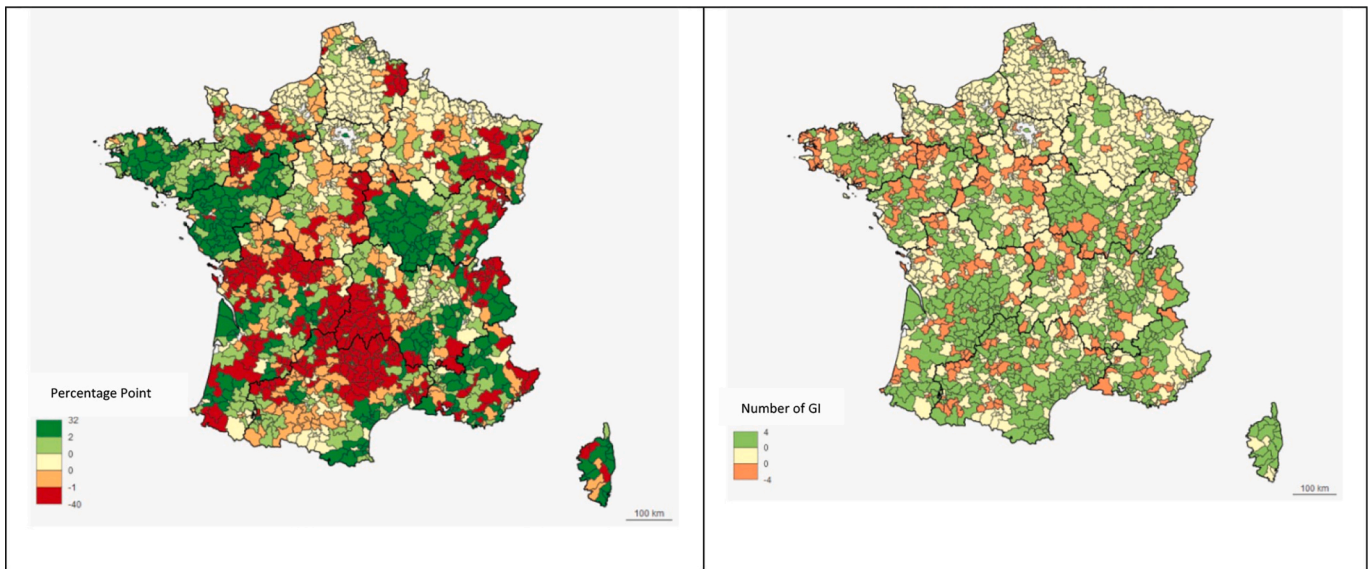
### 4.1. Econometric model

We apply the difference in differences model with continuous variables, used by *Cei et al. (2018b)* and *Acemoglu et al. (2004)*, and evaluate the following equation systematically for the three pillars of sustainable development:

<sup>9</sup> <https://ec.europa.eu/agriculture/eambrosia/geographical-indications-register/>



**Fig. 1.** Share (%) of GI-certified farms (ShCF) (left, 1a) and number of products represented (NBPROD) (right, 1b) with Geographical Indications in 2013 by canton, mainland France.  
(Source: Authors' calculations based on ODR-INAO data)



**Fig. 2.** Average variation (%) in the share of GI farms (left, 2a) and the number of GI products (right, 2b) over the period 2014–2020 compared with the 2013 level by canton, mainland France.  
(Source: Authors' calculations based on ODR-INAO data.)

$$Y_{it} = \alpha_i + \alpha t + \gamma T_{it} + \delta T_{it} D_t + \theta D_t + \sum \beta X_{it} + u_{it} \quad (1)$$

This model should enable us to assess whether cantons  $i$  whose GI level ( $T_{it}$ ) has increased compared to 2013 ( $D_t = 0$  in 2013, otherwise 1) have seen their performance ( $Y_{it}$ ) increase more than cantons that have not had an increase in GIs, “all other things being equal”, i.e. once controlled for all the other factors that can influence performance ( $X_{it}, \alpha_i, \alpha t$ ).  $Y_{it}$  is the performance indicator, successively economic performance (measured by agricultural profit per non-salaried work unit – NSAWU), social performance (measured by agricultural employment) and environmental performance (measured by a composite index) in canton  $i$  in year  $t$ .  $u_{it}$  is an error term that we assume to be identically and independently distributed.

$T_{it} = \{ShCF_{it}, NBPROD_{it}\}$  is the vector of treatment variables, measuring the intensity and diversity of GIs in canton  $i$  at time  $t$ . The  $\gamma$  parameter assesses the initial level (in 2013) of performance of cantons with a relatively high level of GIs compared to cantons with a low level.

GIs have historically been linked to relatively marginalised territories, with difficult structural conditions (mountainous regions), which are not conducive to intensive agriculture, and which would have a stronger incentive to look to GIs to maintain their activity (Ceï et al., 2018b; Ceï et al., 2021; Parrot et al., 2002; Rudow, 2014). We therefore expect to see a negative symbol for  $\gamma$  on economic and social performance (employment), i.e., GIs are more often located in cantons that have lower economic performance on average.

In its simple form, the difference-in-differences model estimates the

**Table 2**  
Number of cantons according to the level of GI intensity and diversity in the territory, by year (2013–2020) and by indicator\*.

Proportion of GI farms (ShCF)								
Category/Year	2013	2014	2015	2016	2017	2018	2019	2020
[0 %,1 %]	441	439	439	423	443	381	382	378
(1 %, 5 %)	355	349	356	356	335	347	319	315
(5 %, 15 %)	341	364	365	373	358	395	429	431
(15 %,100 %]	380	365	357	365	381	394	387	393
Diversity of GI products (NBPROD)								
Category/Year	2013	2014	2015	2016	2017	2018	2019	2020
[0,1]	654	614	636	609	593	593	581	581
(1,2]	235	234	230	234	249	217	223	223
(2, 4]	356	345	347	343	319	337	332	332
(4, 14]	272	324	304	331	356	370	381	381

\* The category thresholds for each indicator correspond to the quartiles. The total annual number of geographical entities is 1517.

variation in differences in performance between a treatment group of cantons that have received the policy (increase in GIs) and a control group of cantons that have not, before and after treatment. In our case, treatment variables are continuous variables and the treated group contains the cantons that have experienced an increase in the level (intensity/diversity) of GI on the territory after 2013. The variable  $D_t$  is binary (0/1), with a value of 0 if the year is 2013 and 1 for subsequent years. The parameter of interest  $\delta$  measures variation in performance over time between a treatment group of cantons (with an increase in GIs) and a control group with similar characteristics but no increase in GIs.

The other variables are used to control for other factors that could simultaneously affect the performance indicator and the level of GIs (endogeneity bias).

$\alpha_i$  is a canton-related fixed effect and includes all socio-economic, soil and climate factors and, more generally, all local conditions that are specific to canton  $i$  and time invariant. Geographical indications are based on a close link with a territory and are proposed by producers who form an Organisme de Défense et de Gestion (French protection and management body) to define production rules and suggest specifications to protect their production. Their presence in Europe is therefore closely linked to soil, climate and socio-economic factors (Parrot et al., 2002), and in particular to the social capital of the groups that proposed them (Quiñones-Ruiz et al., 2016).

These agronomic, soil, climate and social conditions are therefore linked not only to the level of GIs but also to indicators of farmers' income, employment and wages, and environmental performance. However, these factors vary little over time, and we therefore assume that they are constant over the period studied (8 years). In our panel data model, the introduction of fixed effects makes it possible to control for the impact of these factors on the sustainable development variables.

$\alpha_t$  is a time-related fixed effect and includes shocks in year  $t$  that are common to all cantons and that may be correlated with the performance indicator (e.g. drought, crisis, inflation, etc.).

The  $X_{it}$  vector includes the other controls variables that vary over time and cantons, and have a potential impact on sustainable development indicators.

First, we control for structural characteristics of territories in terms of agricultural production that may vary over time. The utilised agricultural area (UAA) in the area measures the size, and the UAA by farm

reflects the average size of farms in the canton. Farm size plays a critical role in agriculture, influencing productivity, through economies of scale, resource use efficiency, and environmental impacts (Ren et al., 2024; Ory, 2020).<sup>10</sup>

The impact of agricultural production on sustainability also depends on farmers' practices. Age is generally linked to farmers' management skills and their ability to innovate, adopt modern farming practices and technologies and obtain financing, which contribute to increase farm productivity (Ezcurra et al., 2011; Giannakis and Bruggeman, 2018), but young farmer are also more likely to adopt agroecological practices (Wezel and David, 2020). The share of operators involved in OF as well as the CAP payment perceived by farmers for agro-environmental aid also reflect the adoption of agroecological practices. This should influence positively the environmental performance. The effect of organic farming on agricultural profit and employment is also expected to be positive for France over the 2013–2020 period (Dedieu et al., 2017; Hilal et al., 2021; Coinon et al., 2023). Finally, the second pillar agricultural policy has the objective to contribute to sustainable development on the territory (Détang-Dessendre and Guyomard, 2023). The amounts of aid received by the farmers may thus have an impact on performance indicators. Therefore Xit includes, in addition to UAA and UAA per farm, the average age of farmers in the cantons, the share of organic farmers and the amount of aid from CAP second pillar perceived by farmers in the cantons  $i$  in year  $t$ .

#### 4.2. Data sources and data description for sustainable development performance indicators and control variables

To our knowledge, there are few indicators available at territorial level to measure the net economic wealth created by agricultural activities. GIs often enable products to be sold at a higher price than conventional products, because of their superior quality, but they also often entail higher production costs in order to guarantee this quality. The indicator of economic performance should then measure the net gain in value. Previous research assessing the impact of GIs on rural development has been based on indicators of agricultural value added and agricultural employment from the Cambridge Econometrics' European Regional Database and EUROSTAT (Ceï et al., 2018b; Raimondi et al., 2024), but these authors have limited their analysis to the NUTS3

<sup>10</sup> We have also tried to add as control variables a local demography indicator (number of residents in the territory) and an indicator of annual tourist frequency that may impact both the GI level and the economic, social and environmentally sustainable development (source of data: INSEE). The addition of this variable has no effect on the results which is consistent with the results of Flinzberger et al. (2022b) who find no clear correlation between the number of PDO and generic indicators on the development of tourism sector and on demography at the NUTS 3 level.

level.

The added value generated by agriculture in the region, in absolute terms or per work unit, would be a potentially relevant indicator but it is not available at the detailed geographical level of our study (canton level). The average Gross Operating Surplus (GOS) or Pre-tax profit/loss of farms would also be a relevant indicator (Arfini and Bellassen, 2019). But in France, as in other European countries, the detailed annual accounting data collected through the Farm Accountancy Data Network in France are only available for a small sample of farms (around 2 %) and are not designed to represent farms at cantonal level but rather at regional (NUTS2) level.

Therefore, we use the agricultural benefits per non-salaried agricultural work unit (AP/NSAWU) from the MSA to measure the agricultural income and thus the economic performance. It is the only indicator linked to farm profitability that is exhaustively available across the territory, and annually. Piet et al. (2021) have shown that the MSA indicator is a good proxy of Gross Operating Surplus (GOS) and Pre-tax profit/loss of farms from RICA in terms of time variation. They compared changes over a 15-year period in data on the Agricultural Profits of farms from the MSA with changes in data on GOS and Pre-tax profit/loss of farms from FADN, which are more commonly used to measure agricultural income and found that changes in these variables over time are similar.

We also use data from the MSA on salaried and non-salaried contributors to characterise agricultural employment created in the territory (Full-Time Equivalent). In order to estimate the number of non-salaried work units, we added up the shares of work carried out by agricultural workers and family workers, as calculated by ODR based on the health insurance scheme.<sup>11</sup> Salaried employment is calculated as the total number of Full-Time Equivalents on permanent, fixed-term and seasonal contracts on farms. All these indicators are computed by canton, retaining only farms not specialising in winegrowing. Finally, we use the logarithm for these agricultural profit and employment variables, which will facilitate interpretation of the results.<sup>12</sup>

With regard to the environmental performance indicator, we drew on the index of cumulative anthropogenic pressures related to intensive agriculture developed by Cherrier et al. (2021), to devise a composite indicator of water pollution linked to pesticides<sup>13</sup> and fertilizers and indicators of habitat preservation in agricultural land (proportion of grassland and landscape crop diversity).

In order to measure water pollution linked to fertilizers, we used an extensive database collected by the French public utility *Eau de France* and then compiled and made public on the national interface “*Naiade*”. The data are about nitrate and phosphate concentrations in surface water (in mg per litre of water) and are produced by a network of sampling stations along watercourses. Data on pesticides in surface water are provided by the French National Institute for Statistics and Economic Studies (INSEE) (categorical indicator of pesticide concentration by station, ranging from 1 to 5). However, these data are not yet available for 2020.

Preservation of habitats in agricultural land is approximated by the

<sup>11</sup> For more information, see the ODR page on files of non-salaried contributors grouped by farm: [https://odr.inra.fr/intranet/cartocartowiki/index.php/Fichiers\\_des\\_cotisations\\_non\\_salari%C3%A9s\\_regroup%C3%A9s\\_par\\_exploitation](https://odr.inra.fr/intranet/cartocartowiki/index.php/Fichiers_des_cotisations_non_salari%C3%A9s_regroup%C3%A9s_par_exploitation).

<sup>12</sup> For the AP/NSAWU, we use the  $\log(1 + \text{minimum} + \text{AP/NSAWU})$  in order to include negative values.

<sup>13</sup> The spraying of nitrogenous fertilizers and livestock manure on crops increases nitrate concentrations in rivers through run-off, which is toxic to flora and fauna, and alters the environment (eutrophication, encouraging the proliferation of green algae). Farming practices are the main cause of this type of pollution. Phosphates, also present in fertilizers, are another source of eutrophication in aquatic environments, particularly when combined with excess nitrates. We have not taken account of groundwater, where nitrates and other pollutants take longer to accumulate.

proportion of permanent grassland in the UAA and landscape crop diversity is calculated by ODR based on LPIS data (Shannon Index on the UAA planted with 28 crop groups, see Fig. A.1 for a breakdown of crop groups). The environmental indicator (Ienv1) is calculated by taking the simple average of the composite indicators presented above, after standardising each of them, setting them between 0 and 1 and adjusting them so that an increase in the indicator corresponds to a decrease in anthropogenic pressures (improved environmental performance).

Descriptive statistics for all performance indicators, as well as for composite environmental performance sub-indicators, are presented respectively in Tables A.1 and A.2 in the Appendix. After correction for outliers (removal of extremes in the distribution with a threshold of  $\pm 3$  standard deviations), AP/NSAWU and Agricultural Employment indicators are available for 1434 and 1491 cantons respectively for all years of the 2013–2020 period. Data are unevenly available for composite environmental performance indicators: over the 8-year period, 1489 cantons have indicators for landscape crop diversity and share of permanent grassland, around 1200 for nitrate and phosphate pollution of surface water, and only 691 for pesticide pollution.<sup>14</sup> The synthetic environmental performance indicator therefore only covers a 7-year period (2013–2019) and 638 cantons. Alternatively, we consider a synthetic indicator that excludes the pesticide indicator (Ienv2), which is therefore available for 8 years and 1171 cantons.

Control variables come from the MSA database (we compute the average age of farmers in the cantons, the total UAA per canton and the average UAA per farm). The share of organic farmers in the canton is the ratio between the number of organic farmers from the Agence Bio database and the total farmers in the cantons (from the MSA database). We use data on CAP payments from the ASP (French Agency for Services and Payment) to compute the aids from the second pillar related to sustainable development objectives. It includes investment linked to the modernisation of livestock buildings, on-farm processing, on energy performance, on vegetal plans for the environment, and on cooperatives for the use of agricultural equipment (CUMA). We add also agro-environmental and climate aids, aids related to the introduction of quality labels and aids linked to pastoralism. We use the annual amounts received by cantons during two CAP programming periods, 2007–2013 and 2014–2020.<sup>15</sup>

## 5. Results

### 5.1. Sustainable development performance correlated with GI level

Fig. 3 shows the correlations between the performance variables and the GI level indicators. First, GI level indicators are positively correlated with each other at 0.59, indicating that a higher share of farms involved in GIs is accompanied on average by greater diversity, although this is not systematic.

The two GI level indicators are positively correlated with social and environmental performance, suggesting that cantons with more GIs are subject to fewer anthropogenic pressures linked to agricultural activity, and provide more agricultural employment. Fig. A.2 in the Appendix shows that the level of GIs is positively correlated with the proportion of permanent grassland in the UAA and negatively correlated with nitrate

<sup>14</sup> Only cantons with observations for the 8 years in question have been retained for each indicator (7 years for pesticides not available in 2020). In the case of nitrate- and phosphate-related data, we have retained only measuring stations with data for at least 4 years over the period, before aggregating at cantonal level. We also removed the outliers in phosphate-related data (extremes in the distribution with a threshold of  $\pm 3$  standard deviations).

<sup>15</sup> In relation to the 2014–2020 CAP programming period, there have been delays in annual payments for certain measures, due to context-related problems in aid processing. To ensure that the results are not affected, the amounts have been spread over the total payment period.

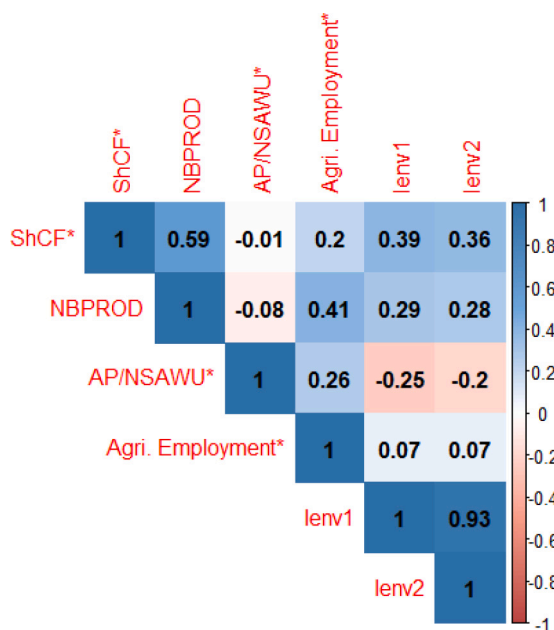


Fig. 3. Correlation matrix between GI level indicators and economic, social and environmental performance indicators.

\* Indicators with an asterisk are expressed in log (same variables as in the regression results). All coefficients are significant at a minimum of 10 % (based on Pearson and Spearman tests).

and pesticide levels in surface water.

Correlations between GI indicators and economic performance (AP/NSAWU) are close to zero. This may reflect the existence of two contradictory effects: on the one hand, GIs have historically been located in relatively disadvantaged areas with lower economic performance. On the other hand, it may be that the introduction of GIs or the intensification of GIs in these territories creates value. We disentangle these effects in the next section.

The economic performance variable is positively correlated with total employment. Finally, environmental performance is negatively associated with economic performance, unsurprisingly reflecting the strong anthropogenic pressure linked to agricultural activities in territories with high agricultural profitability.

Simple correlations conceal the complexity of the potential effects of GIs. The econometric estimate in the following section enables us to distinguish between cross-sectional effects (cantons with a greater or lesser level of GIs) and dynamic effects (effects of an increase in GIs on performance in a canton).

### 5.2. Econometric results

Table 3 below shows the main results of the estimate using the model presented in Section 3, assessing the impact of the increase in GI successively on economic performance (column (1)), social performance (column (2)) and environmental performance (column (3)). The full results are presented in Table A.3 in the Appendix.

First, the explanatory power of the model is strong for the three dimensions of sustainable development, as the model allows us to explain at least 70 % of the variance of observations (adjusted R<sup>2</sup>). In all the regressions in Table 1, at least one of the GI indicators has a positive and significant coefficient on performance, confirming the effect of GIs on sustainable development in territories.

Negative coefficients (rows 1 and 3) on GI indicators in the territory represented by  $\gamma$  in the model presented in Section 3, confirm that GIs have historically tended to be located in territories with relatively low economic performance, which are not conducive to intensive agriculture (columns (1) and (2)). These results are consistent with the literature

Table 3  
Impact of GI on sustainable development for the period 2013–2020.

Performance	Row No.	Economic: AP/NSAWU <sup>1</sup> (1)	Social: Agricultural employment <sup>1</sup> (2)	Environmental: Ienv1 (3)
ShCF <sup>12</sup>	(1)	-0.016 (0.070)	-0.097 *** (0.029)	-0.041 (0.037)
Dt* ShCF <sup>1</sup>	(2)	<b>0.135 ***</b> (0.034)	<b>0.052 ***</b> (0.018)	<b>0.036 *</b> (0.019)
NPROD <sup>2</sup>	(3)	-0.020 *** (0.003)	0.002 (0.001)	0.000 (0.001)
Dt* NPROD	(4)	<b>0.006 ***</b> (0.002)	<b>-0.001</b> (0.001)	<b>0.002 **</b> (0.001)
Share OF <sup>1</sup>	(5)	-0.217 ** (0.094)	-0.054 (0.047)	-0.003 (0.025)
Dt* Share OF <sup>1</sup>	(6)	0.113 ** (0.051)	0.052 * (0.027)	0.018 (0.013)
CAP 2ndP <sup>1</sup>	(7)	-0.002 (0.003)	-0.001 (0.001)	-0.000 (0.001)
Dt* CAP 2ndP <sup>1</sup>	(8)	0.005 * (0.003)	0.001 (0.001)	-0.000 (0.001)
Adj. R <sup>2</sup>	(9)	0.70	0.99	0.91
Num. obs.	(10)	11,472	11,928	4466
Fixed effects		Cantons, years	Cantons, years	Cantons, years

\* <0.1, \*\*p < 0,05, \*\*\*p < 0,01, Robust standard deviation in brackets.

All regressions presented include the X<sub>it</sub> control variables described in the text: average UAA per farm, total UAA in the canton, and average age of farmers.

<sup>1</sup> These variables are expressed in log.

<sup>2</sup> ShCF is the share of GI -certified farms and NBPROD the measure for GI diversity (number of GI products).

and in particular the effects presented by [Ceï et al. \(2018b\)](#) on agricultural value added per hectare of territories.

Estimates of coefficients of interest, represented by vector  $\delta$  in the model in Section 3, for the two GI indicators (ShCF and NBPROD), are shown in bold in the table (rows (2) and (4)). Overall, the results highlight a positive effect of an increase in GI intensity and diversity on economic and environmental performance (column (3)), and a positive effect of GI intensity on social performance. This validates the hypotheses 1,2,3,4 and 6 from the theoretical section but not the [hypothesis 5](#). This means that, all other factors being equal, cantons that have experienced an increase in GI intensity have also experienced a higher economic, social and environmental performance than if it have not experienced an increase in GIs.

In column (1), it is estimated that a 10 % increase in GI intensity – for example, the average canton going from 10 % of GI farms to 11 % on its territory – leads to a 1.3 % higher agricultural profit per non-salaried worker (i.e. 127 euros for an average canton where the AP/NSAWU is 9733 euros (Table A1)). Similarly, canton with one additional product results in an average 0.6 % increase in profit per NSAWU compare to that (line 4).

As regards agricultural employment in column 2, we find a positive and significant effect of the proportion of GI farms on agricultural employment in the canton, but no particular effect of GI diversity. However, the effect is small: an increase of 1 percentage point compared to the average (+10 %) result in a 0.5 % higher agricultural employment in the canton, or 1.5 Full Time Equivalent (FTE) number of workers on average (the average employment in the cantons is 295 FTE (Table A1)).

In column (3), a 10 % increase in ShCF generates a slight increase in the environmental performance indicator of 0.036 units, i.e., 4 % of standard deviation. GI diversity also has a positive and significant impact on environmental performance, with one additional GI product leading to a 0.002 increase in the index. The results for each component of the indicator are set out below (Table 4). The results are stable when using the Ienv2 indicator instead of Ienv1 (table A.4).

With regard to the effects of other variables, there is a positive effect

**Table 4**  
Impact of GI on the components of the environmental indicator for the period 2013–2020.

Environmental performance	Crop rotation div. (1)	% Permanent grassland (2)	Nitrate pollution in water (3)	Phosphorus pollution in water (4)	Pesticide pollution in water (5)
ShCF <sup>1,2</sup>	0.327 *** (0.077)	−0.030 (0.020)	−1.045 (1.030)	55.018 *** (8.616)	0.366 (0.537)
Dt* ShCF <sup>1</sup>	−0.350 *** (0.052)	−0.009 (0.012)	2.968 *** (0.691)	−22.125 *** (5.302)	−1.241 *** (0.354)
NBPROD	−0.026 *** (0.004)	−0.005 *** (0.001)	0.085 (0.064)	−2.007 *** (0.354)	0.026 (0.019)
Dt* NBPROD <sup>2</sup>	0.015 *** (0.003)	0.006 *** (0.001)	−0.055 (0.049)	1.422 *** (0.298)	−0.023 (0.0156)
Adj. R2	0.97	0.97	0.93	0.29	0.57
Num. obs.	12,093	12,093	10,611	10,495	7633
Fixed effects	Cantons, years	Cantons, years	Cantons, years	Cantons, years	Cantons, years

\* < 0.1, \*\*p < 0.05, \*\*\*p < 0.01, Robust standard deviation in brackets. Other control variables in these regressions and not presented here: proportion of farms involved in OF, amount of aid under the second pillar of the CAP, total UAA of the canton, UAA per farm in the canton, and average age of farmers.

<sup>1</sup> These variables are expressed in log after adding 1 to take account of null values.

<sup>2</sup> ShCF is the share of GI -certified farms and NBPROD the measure for GI diversity (number of GI products).

on economic performance of an increase in the involvement of farms in OF (Coinon et al., 2023; Crowder and Reganold, 2015). On average, it is estimated that a 10 % increase in the proportion of OF producers in the territory generates a 1.1 % higher economic performance. Thus, our estimates of the effects of GI intensity and OF on the economic performance indicator are very close.

It is also interesting to note that we find a positive and significant effect of increased CAP support on farm profit (column 1 of Table 3 and columns 1, 2 and 3 of Table A.3. in the Appendix), which is consistent with the Vedrine (2018) results.

Finally, Table 4 shows the detailed results of the estimates of the effect of GI level on the 5 variables of the composite environmental indicator Ienv1, i.e. landscape crop diversity, proportion of permanent grassland in the UAA, and surface water pollution by nitrates, phosphates and pesticides respectively, after controlling for all the other variables of the model presented in Section 3 (the full results of this regression are shown in Table A.4. in the Appendix). Environmental variables in this table have not been corrected for their symbols, with a positive coefficient for columns 3 to 5 indicating a higher level of pollution.

The positive effect on the environment of the increase in the share of GI farms primarily takes the form of a reduction in surface water pollution caused by pesticides and phosphates (columns 4 and 5, row 2). In the case of phosphates, it should be noted that initially, the level of GIs in the territory is associated with a higher level of pollution, which can be explained in particular by the importance of GI livestock farming. In column (3), an increase in GI intensity is positively associated with higher nitrate levels in surface water.

The positive effect of the diversification of GI products in the cantons is essentially due to a positive association with landscape crop diversity and an higher share of permanent grassland. As regards organic farming, contrary to Coinon et al. (2023) who found no effect at farm level, a significant negative association of the increase in OF on the level of pesticide pollution of surface water at cantonal level is shown in column (5) of Table A.4. in the Appendix.

### 5.3. Discussion of robustness checks and limitations

Despite our efforts to control for a large number of control variables, the share of farms with GI per canton and the number of products for which farms are committed to GI, may suffer from an endogeneity problem in their determination of economic performance. Indeed, assuming that the effect of GIs is different depending on the territory and the product concerned (Cei et al., 2020), it seems reasonable to consider that farms in the territory will be more likely to join a GI when it produces more economic value. Thus, it is possible that measuring the intensity and diversity of GIs respectively by the share of farms under GI

and the number of GI products in which farms are engaged generate a bias in the results by giving more weight to territories where GIs have a strong economic impact. It follows that the coefficient on GI intensity and on the diversity of GIs could not be due (or only partially due) to the effects of GIs on economic performance but rather (or also) to the effect of economic performance on the level of GIs (simultaneity bias).

As a robustness check, we estimate the economic effects of GI by using an indicator that measures the GI potential rather than the adoption of GI by farms. To this, we compute the number of products protected in the area (like in Raimondi et al., 2024 and in Cei et al., 2018a, 2018b) and compare the results. The disadvantage of this indicator (used by other studies), as discussed in section 3, is that it confounds the measure of the intensity of GIs in the region and their diversity. By definition, it does not allow us to assess the extent to which GIs are actually part of the canton's production.

Table A.5 column (1), (3) and (4) in the appendix show the results respectively when replacing both indicator of GI intensity and GI diversity by the indicator of GI potential, respectively for the economic performance, social performance and environmental performance. The effects of this indicator are in each case of the same magnitude and sign as the effect estimated for the GI diversity indicator (and in general slightly higher). This is not surprising as both measure the number of GI product in the canton (the first being the number of product where GI farms are involved and the second being the number of products with an official GI area in the canton). In column (2) we add the indicator of GI intensity as measured by the share of GI farms to better compare the coefficients measuring the effect of the GI potential versus the GI diversity on the economic performance. We can see that the estimated economic effect is slightly lower (0.005 vs 0.006 in the previous estimation), and the effect of the increase of GI intensity is slightly higher (0.179 vs 0.135), but these differences are not significant. These results strengthen the credibility of our conclusions.

In addition, we carried out other several robustness tests on these results. We repeated the estimates using different GI indicators on the territory (number of sectors in several categories to characterise diversity) and varying the environmental indicator (without standardisation). The results converge towards similar conclusions. Results are available on request.

Finally, we are aware of the existence of a large and growing strand of literature showing a potential bias in the coefficients when estimating difference-in-difference using linear regressions with panel data and fixed effects. De Chaisemartin and D'Haultfoeuille (2022) carry out a literature review and provide a good summary of the problem and the methods proposed for the various cases by the many authors who have studied the subject. This literature shows that in the case of evaluating the impact of a difference-in-difference policy using panel strategies with a fixed effect, the estimated coefficient actually represents the

weighted sum of the effects of the treatment on the different groups of individuals and over time. Problematically, it shows that some weights may turn out to be negative, leading to a biased estimate of the effect. It is thus possible to obtain a negative result even though the real effect on all individuals and over time is positive. This problem may occur when the effect of a policy is heterogeneous between individuals (or in our case, cantons) and may vary over time (effect at time  $t$  on the result in  $t$  versus at time  $t + 1$  on the result at time  $t + 1$ ).

GI policy effect is likely to be concerned by this heterogeneity between groups and over time, as discussed and shown by [Ceï et al. \(2020\)](#) for two products at the farm level. However, our approach is more global, as we aim to estimate the average national effect of an increase in the level of GI for geographical entities, with the same model than in [Ceï et al. \(2018b\)](#), except that we have two treatment variables when they have just one.

We assess the extent to which our estimates are potentially biased due to negative weights by using DID event-study estimators developed by [De Chaisemartin and D'Haultfoeuille \(2024\)](#), that makes it possible to estimate the average effect of the treatment on the treated (ATT) in difference of difference, with multiple groups and periods. We obtain identical signs compared to our previous method for each of the estimates, except for a coefficient relating to the effect on agricultural employment (effect of the share of GI farms on employment) which is estimated as not significant with this method. However, the estimated effects on the economic performance indicator and the environment indicator are much higher than those estimated with the fixed-effects panel. It means that we may underestimate the effects of the increase in the presence of GI farms on economic and environmental performance and overestimate the employment effects. Following [Ceï et al., 2020](#), it would be interesting to estimate more precise impact of the policy at the farm level for France for specific GI products to go deeper in the understanding of the heterogeneous effects of this policy.

## 6. Conclusion

While there are many results concerning the positive impact of GIs on sustainable development, it is difficult, or even risky, to generalise these results. Given the wide diversity of GIs (characteristics of the product, the sector and the territory concerned), the case study approach limits this possibility, despite the large number of such studies. In addition, there may be a selection bias, with success stories often attracting the attention of assessors.

Our article proposes a complementary alternative to the case study approach, by seeking to determine the existence of statistically significant links between GI level and performance in terms of the sustainability of territorial agri-food systems. While some research paved the way, our approach stands out for the originality of the data and indicators used. They enable a better understanding of this issue, with data on GIs that are more spatially precise, describing in greater detail the role of GIs in the local production context, and more recent, with significant historical depth. These are set against indicators, which are also on a finer scale and with 8 years of evolution, providing information on the three pillars of sustainability of agricultural activities. Another original feature of this research is the inclusion of environmental factors alongside the socio-economic aspects.

The results presented in this article show the overall positive effects of increased GI intensity and diversification on the territory in terms of economic, social and environmental performance over the last decade. They provide a more objective, generalised view of the impact of the growth of GI sectors on the territories concerned.

In economic and social terms, it is estimated that a 10 % increase in the proportion of GI farms in a canton leads to a 1.3 % higher profit per NSAWU and a 0.5 % higher agricultural employment in the cantons. The results also suggest that GI diversification has a complementary effect on

the income that farmers derive from their activities, with one additional GI product leading to an average 0.6 % higher average farm income. As regards environmental indicators, we show that GI intensity and diversity on the territory have a positive impact on the reduction of anthropogenic pressures linked to agricultural activity, particularly concerning the proportion of permanent grassland, landscape crop diversity and diffuse water pollution caused by pesticide use. On the other hand, an increase in GI intensity is positively associated with higher nitrate levels in surface water. For certain environmental variables, the data are sometimes more limited (lack of values for certain years/territories) and impacts are also often more complex to analyse.

To measure the significance of GIs in territories, a more precise indicator would be their exact weight in terms of proportion of the volumes produced and turnover from GI production, as well as agricultural value added, but such data do not currently exist at national level. We could also try to integrate the downstream part of the GI sectors concerned (processed products). Similarly, sustainable development indicators are proxies for complex and multifactorial phenomena, with dynamics that play out over several timeframes. However, given the existing research and the data available, our work represents a significant step forward in understanding the impact of GIs. The large number of observations and the robustness of the results (according to the indicators, the timeframe, etc.) confirm the reliability of our approach and results.

Firstly, these results are consistent with other research on the subject, involving both case studies, considered individually or aggregated, and more comprehensive approaches ([Bellassen et al., 2021](#); [Raimondi et al., 2024](#)). They also show that GI diversity and intensity both play an effective and complementary role in the sustainable development of territories. They thus confirm the value of policies aimed at protecting these labels, and their relevance alongside other major European rural development policies (CAP second pillar) in contributing to a fair, healthy and environmentally-friendly food system (Farm to Fork Strategy). Finally, they offer avenues for reflection on the implementation of these policies, confirming the importance of GI diversity and pointing to the limits of intensifying GIs within a small number of products.

Further examination of causality would be interesting, in particular by distinguishing between short-term and medium-term effects and by looking at variations between sectors and labels. Finally, our study is restricted to mainland France, where data on operators have been collected and consolidated. While it would be interesting to confirm our results in other contexts, it should be noted that given the diversity of GIs, their number, the sectors concerned and their history, France is a representative case, at least as far as Europe is concerned. Reviewing and collecting lists of operators involved in GIs in other European countries would enrich the evaluation and enable us to compare the effects.

## CRedit authorship contribution statement

**Julie Regolo:** Writing – review & editing, Visualization, Supervision, Investigation, Data curation, Writing – original draft, Validation, Methodology, Formal analysis, Conceptualization. **Cédric Gendre:** Writing – review & editing, Methodology, Writing – original draft, Data curation. **Thomas Poméon:** Writing – review & editing, Validation, Project administration, Investigation, Formal analysis, Writing – original draft, Supervision, Methodology, Funding acquisition, Conceptualization.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Appendix A

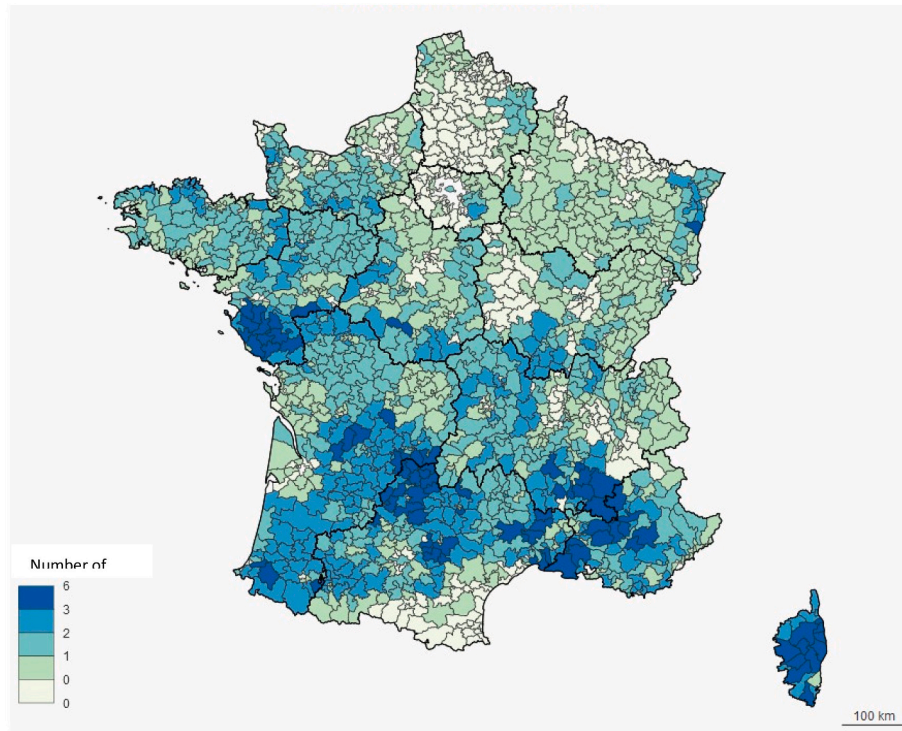


Fig. A.1. Number of GI sectors in 2013

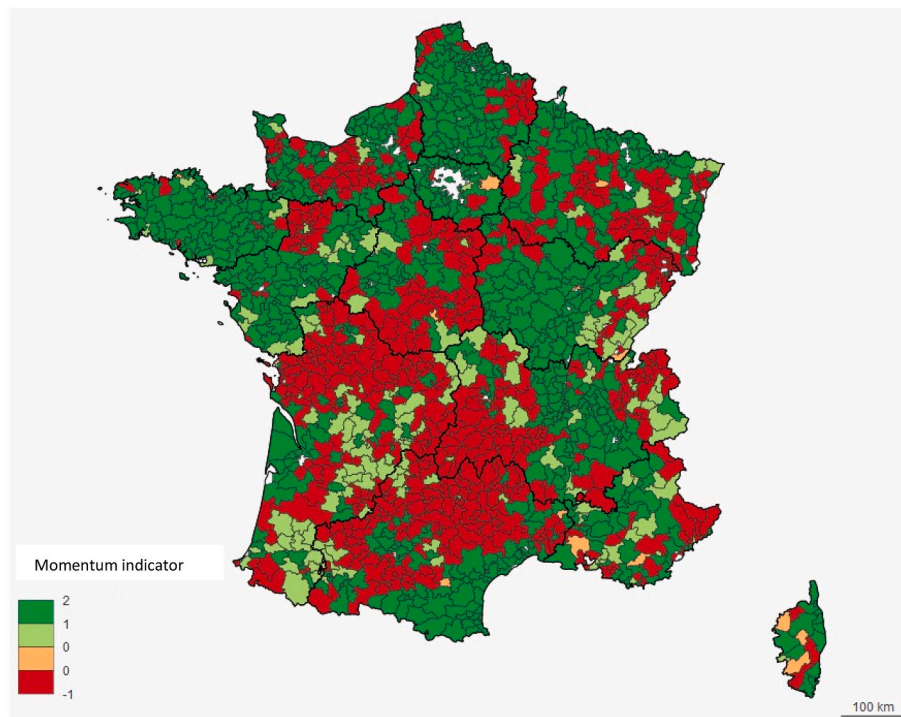


Fig. A.2. Comparison index of changes in the share of GI-certified farms vs. number of GI farms

Momentum indicator categories: -1: decrease in both indicators (number and share of GI farms, and therefore decrease in significance of GIs), 0: decrease in the proportion of farms involved in GIs but increase in the number of GI farms (ie. the number of farms has increased but by less than the total number of farms), 1: increase in the proportion of GIs but decrease in the total number of farms (relative stability of GIs in relation to the number of farms), 2: increase in both the proportion and the number. We can see that the vast majority of cantons with an increase in the proportion of GI farms also have an increase in the absolute number of farms involved in GI.

Code	Name
1	SOFT WHEAT
2	GRAIN AND SILAGE CORN
3	BARLEY
4	OTHER CEREALS
5	RAPESEED
6	SUNFLOWER
7	OTHER OILSEEDS
8	PROTEIN CROPS
9	FIBRE CROPS
10	SEEDS
11	SET-ASIDE LAND
12	INDUSTRIAL SET-ASIDE
13	OTHER SET-ASIDE
14	RICE
15	GRAIN LEGUMES
16	FODDER
17	SUMMER HEATHLAND
18	PERMANENT GRASSLAND
19	TERMPORARY GRASSLAND
20	ORCHARDS
21	VINEYARDS
22	NUTS
23	OLIVE TREES
24	OTHER COMMERCIAL CROPS
25	FLOWER VEGETABLES
26	SUGAR CANE
27	ARBORICULTURE
28	VARIA

Fig. A1. Crop groups from LPIS used to calculate diversity of land cover.

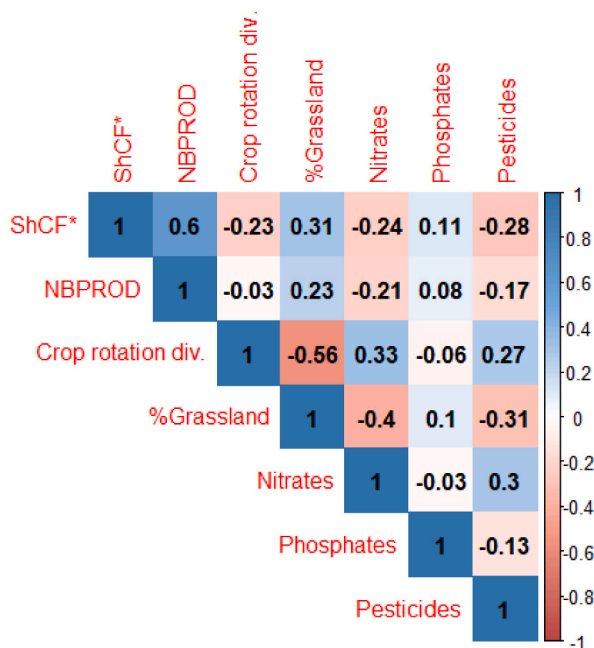


Fig. A.2. Correlation matrix between indicators of GI and components of the environmental indicators \*\*.

\* Indicators with an asterisk are expressed in log (same variables as in the regression results). All coefficients are significant at 10 % except for the correlations between the phosphate indicator and the NBPROD and DivSol nitrate indicators respectively (based on Pearson and Spearman tests).\*\* DivSol: Shannon index calculated on the basis of agricultural areas for 28 crop groups from LPIS; % Grassland: proportion of UAA in permanent grassland (crop group 18); Nitrates: average nitrate content in surface water (mg/L); Phosphates: average phosphorus content in surface water (mg/L); Pesticides: average per canton of pesticide levels in surface water according to a categorical variable: (1: total pesticides  $\leq 0.01 \mu\text{g/l}$ ; 2: total pesticides  $>0.01 \mu\text{g/l}$  and  $\leq 0.1 \mu\text{g/l}$ ; 3: total pesticides  $>0.1 \mu\text{g/l}$  and  $\leq 0.5 \mu\text{g/l}$ ; 4: total pesticides  $>0.5 \mu\text{g/l}$  and  $\leq 5 \mu\text{g/l}$ ; 5: total pesticides  $>5 \mu\text{g/l}$ ).

**Table A.1**  
Descriptive statistics of economic, social and environmental performance indicators.

	AP/NSAWU*	Agricultural employment *	Ienv1**	Ienv2**
Number of observations	11,472	11,928	4466	9368
Number of cantons	1434	1491	638	1171
Years	2013–2020	2013–2020	2013–2019	2013–2020
Minimum value	-13,057.63	6.08	0.31	0.32
First quartile (25 %)	4747.53	106.77	0.57	0.63
Average	9732.72	295.42	0.65	0.71
Median	8498.51	233.18	0.63	0.7
Third quartile (75 %)	13,975.24	433.1	0.72	0.79
Maximum	34,403.87	1109	0.99	1
Standard deviation	6846.93	233.62	0.1	0.11

\* Variables marked with an asterisk were taken in log in the econometric regressions.

\*\* Ienv1 and Ienv2 are synthetic indicators of anthropogenic pressure from agriculture; they are composed of indicators on landscape crop diversity, proportion of grassland in the UAA and surface water pollution by nitrates, phosphates (including pesticides for Ienv1, excluding pesticides for Ienv2).

**Table A.2**  
Descriptive statistics of the components of the environmental performance indicator\*

	landscape crop diversity	% permanent grassland	Nitrate pollution in water	Phosphorus pollution in water	Pesticide pollution in water
Number of observations	11,912	11,912	10,096	9560	4837
Number of cantons	1489	1489	1262	1195	691
Years	2013–2020	2013–2020	2013–2020	2013–2020	2013–2019
Minimum value	0	0	0.43	0	1
First quartile (25 %)	2.13	0.07	6.26	0.06	2.8
Average	2.44	0.26	15.23	6.33	3.21
Median	2.59	0.19	13.35	0.11	3.25
Third quartile (75 %)	2.86	0.39	22.22	0.76	4
Maximum	3.84	1	81	132.21	5
Standard deviation	0.67	0.23	10.82	16.02	0.79

\* landscape crop diversity: Shannon index calculated on the basis of agricultural areas for 28 crop groups from LPIS; % permanent grassland: proportion of UAA in permanent grassland (crop group 18); Nitrate pollution in water: average nitrate content in surface water (mg/L); Phosphorus pollution in water: average phosphorus content in surface water (mg/L); Pesticide pollution in water: average pesticide content in surface water per canton according to a categorical variable: (1: total pesticides  $\leq 0.01 \mu\text{g/l}$ ; 2: total pesticides  $> 0.01 \mu\text{g/l}$  and  $\leq 0.1 \mu\text{g/l}$ ; 3: total pesticides  $> 0.1 \mu\text{g/l}$  and  $\leq 0.5 \mu\text{g/l}$ ; 4: total pesticides  $> 0.5 \mu\text{g/l}$  and  $\leq 5 \mu\text{g/l}$ ; 5: total pesticides  $> 5 \mu\text{g/l}$ ).

**Table A3**  
Impact of GI on sustainable development over the period 2013–2020.

Performance	Row No.	Economic: AP/NSAWU <sup>1</sup> (1)	Social: Total employment <sup>1</sup> (2)	Environmental: Ienv1(3)	Environmental: Ienv2 (4)
ShCF <sup>1,2</sup>	(1)	-0.016 (0.070)	-0.097 *** (0.029)	-0.0406 (0.037)	-0.0830 *** (0.017)
Dt*ShCF <sup>1</sup>	(2)	0.135 *** (0.034)	0.052 *** (0.018)	0.0364 * (0.019)	0.0182 ** (0.009)
NBPROD	(3)	-0.020 *** (0.003)	0.002 (0.001)	0.000 (0.001)	0.001 (0.001)
Dt* NBPROD <sup>2</sup>	(4)	0.006 *** (0.002)	-0.0012 (0.001)	0.002 ** (0.001)	0.000 (0.001)
Share OF <sup>1</sup>	(5)	-0.217 ** (0.094)	-0.054 (0.047)	-0.003 (0.025)	0.018 (0.014)
Dt * Share OF <sup>1</sup>	(6)	0.113 ** (0.051)	0.052 * (0.027)	0.018 (0.013)	-0.001 (0.008)
CAP 2ndP <sup>1</sup>	(7)	-0.002 (0.003)	-0.001 (0.001)	-0.000 (0.001)	-0.001 * (0.001)
Dt *CAP 2ndP <sup>1</sup>	(8)	0.005 * (0.003)	0.001 (0.001)	-0.000 (0.001)	0.001 (0.001)
UAA <sup>1</sup>	(10)	-0.128 ** (0.060)	0.591 *** (0.040)	-0.015 (0.015)	-0.018 ** (0.009)
UAA/Farm <sup>1</sup>	(11)	0.177 *** (0.060)	-0.564 *** (0.030)	0.002 (0.014)	0.013. (0.008)
Average age of farmers	(12)	-0.000 (0.003)	-0.004 *** (0.001)	-0.001 (0.001)	0.001 * (0.001)
Adj. R <sup>2</sup>	(13)	0.69	0.99	0.91	0.94
Num. obs.	(14)	11,472	11,928	4466	9368
Fixed effects		Cantons, Years	Cantons, Years	Cantons, Years	Cantons, Years

<sup>0</sup> <0.1, \*p < 0,05, \*\*p < 0,01, \*\*\*p < 0,001, Robust standard deviation in brackets.

<sup>1</sup> These variables are expressed in log.

<sup>2</sup> ShCF is the share of GI -certified farms and NBPROD the measure for GI diversity (number of GI products).

**Table A4**  
Impact of GI on sustainable development over the period 2013–2020.

Performance	Row No.	landscape crop diversity	% Permanent grassland	Nitrate pollution in water	Phosphorus pollution in water	Pesticide pollution in water
ShCF <sup>1</sup>	(1)	0.327 *** (0.077)	-0.030 (0.020)	-1.05 (1.030)	55.018 *** (8.616)	0.366 (0.537)
Dt*ShCF <sup>1,2</sup>	(2)	-0.350 *** (0.052)	-0.009 (0.012)	2.968 *** (0.691)	-22.125 *** (5.30)	-1.241 *** (0.354)
NBFIL <sup>2</sup>	(3)	-0.026 *** (0.004)	-0.005 *** (0.001)	0.085 (0.064)	-2.01 *** (0.354)	0.026 (0.019)
Dt* NBFIL	(4)	0.015 *** (0.003)	0.006 *** (0.001)	-0.055 (0.049)	1.422 *** (0.298)	-0.023 (0.016)
Share OF <sup>1</sup>	(5)	0.541 *** (0.079)	-0.071 *** (0.016)	-2.317 ** (1.121)	-9.258 (6.214)	0.779 * (0.471)
Dt * Share OF <sup>1</sup>	(6)	-0.100 ** (0.050)	-0.007 (0.009)	0.760 (0.592)	0.263 (4.272)	-0.770 *** (0.285)
CAP 2ndP <sup>1</sup>	(7)	0.010 *** (0.002)	0.001 (0.001)	-0.014 (0.036)	0.715 *** (0.182)	0.016 ** (0.008)
Dt *CAP 2ndP <sup>1</sup>	(8)	-0.001 (0.002)	-0.001 (0.001)	-0.039 (0.035)	-0.597 *** (0.178)	0.006 (0.009)
UAA <sup>1</sup>	(10)	-0.346 *** (0.054)	0.009 (0.011)	0.938 (0.647)	-0.928 (2.855)	-0.128 (0.227)
UAA/farm <sup>1</sup>	(11)	0.250 *** (0.056)	-0.009 (0.012)	-1.001 (0.654)	5.77 * (3.068)	0.368 * (0.201)
Average age of farmers	(12)	-0.005 ** (0.002)	0.003 *** (0.001)	-0.033 (0.043)	-0.062 (0.211)	0.021 * (0.012)
Adj. R <sup>2</sup>	(13)	0.97	0.98	0.93	0.29	0.57
Num. obs.	(14)	12,093	12,093	10,611	10,495	7633
Fixed effects		Cantons, Years	Cantons, Years	Cantons, Years	Cantons, Years	Cantons, Years

<sup>o</sup> <0.1, \*p < 0,05, \*\*p < 0,01, \*\*\*p < 0,001, Robust standard deviation in brackets.

<sup>1</sup> These variables are expressed in log.

<sup>2</sup> ShCF is the share of GI -certified farms and NBFIL the measure for GI diversity (number of GI sectors).

**Table A.5**  
Results of the Impact of GI on sustainable development for the period 2013–2020; with GI measures by “GI potential”, ie, the number of products under GI protection.

Performance	Row No.	Economic: AP/NSAWU <sup>1</sup> (1)	Economic: AP/NSAWU <sup>1</sup> (2)	Social: Agricultural employment <sup>1</sup> (3)	Environmental: Ienv1 (4)
GI potential	(1)	-0.045 *** (0.003)	-0.042 *** (0.004)	-0.003 ** (0.001)	0.003 ** (0.001)
Dt* GI potential	(2)	0.009 *** (0.002)	0.005 ** (0.002)	0.001 (0.001)	0.002 *** (0.001)
ShCF <sup>1,2</sup>	(3)		-0.081 (0.071)		
Dt*ShCF <sup>1,2</sup>	(4)		0.179 *** (0.040)		
Share OF <sup>1</sup>	(5)	-0.155 * (0.093)	-0.155 * (0.093)	-0.057 (0.046)	0.004 (0.024)
Dt* Share OF <sup>1</sup>	(6)	0.135 *** (0.05)	0.135 *** (0.049)	0.066 ** (0.027)	0.009 (0.013)
CAP 2ndP <sup>1</sup>	(7)	-0.00 (0.003)	-0.003 (0.003)	-0.001 (0.001)	-0.001 (0.001)
Dt* CAP 2ndP <sup>1</sup>	(8)	0.006 ** (0.003)	0.006 ** (0.003)	0.001 (0.001)	0.000 (0.001)
Adj. R <sup>2</sup>	(9)	0.69	0.69	0.99	0.91
Num. obs.	(10)	11,472	11,472	11,928	4466
Fixed effects		Cantons, years	Cantons, years	Cantons, years	Cantons, years

\* <0.1, \*\*p < 0,05, \*\*\*p < 0,01, Robust standard deviation in brackets.

All regressions presented include the Xit control variables described in the text: average UAA per farm, total UAA in the canton and average age of farmers.

<sup>1</sup> These variables are expressed in log.

<sup>2</sup> ShCF is the share of GI -certified farms.

**Data availability**

Data will be made available on request.

**References**

Acemoglu, D., Autor, D.H., Lyle, D., 2004. Women, war, and wages: the effect of female labor supply on the wage structure at midcentury. *J. Polit. Econ.* 112 (3), 497–551. <https://doi.org/10.3386/w9013>.

Anania, G., Nistico, R., 2004. Public regulation as a substitute for trust in quality food markets: what if the trust substitute cannot be fully trusted? *J. Inst. Theor. Econ.* 160, 681–701.  
 Arété Research and Consulting in Economics, 2013. *Study on Assessing the Added Value of PDO/PGI Products: Executive Summary*. Commissioned by the European Commission.  
 Arfini, F., Bellassen, V., 2019. Sustainability of European food quality schemes: multi-performance, structure, and governance of PDO, PGI, and organic Agri-food systems. Springer Nature Switzerland AG. <https://doi.org/10.1007/978-3-030-27508-2>.

- Bellassen, V., Drut, M., Antonioli, F., Brečić, R., Donati, M., Ferrer-Pérez, H., Gauvrit, L., Hoang, V., Knutsen Steinnes, K., Lilavanichakul, A., Majewski, E., Malak-Rawlikowska, A., Mattas, K., Nguyen, A., Papadopoulos, I., Peerlings, J., Ristic, B., Tomić Maksan, M., Török, Á., Vittersø, G., Diallo, A., 2021. The carbon and land footprint of certified food products. *J. Agricult. & Food Ind. Organizat.* 19, 113–126. <https://doi.org/10.1515/jaifo-2019-0037>.
- Bellassen, V., Drut, M., Hilal, M., Bodini, A., Donati, M., de Labarre, M.D., Filipović, J., Gauvrit, L., Gil, J.M., Hoang, V., Malak-Rawlikowska, A., Mattas, K., Monier-Dilhan, S., Muller, P., Napasintuwong, O., Peerlings, J., Poméon, T., Tomić Maksan, M., Török, Á., Veneziani, M., Vittersø, G., Arfini, F., 2022. The economic, environmental and social performance of European certified food. *Ecol. Econ.* 191, 107244. <https://doi.org/10.1016/j.ecolecon.2021.107244>.
- Belletti, G., Marescotti, A., 2011. Origin products, geographical indications and rural development. In: Sylvander, B., Barham, E. (Eds.), *Labels of Origin for Food. Local Development, Global Recognition*. CABi, pp. 75–91.
- Belletti, G., Marescotti, A., Sanz-Cañada, J., Vakoufaris, H., 2015. Linking protection of geographical indications to the environment: evidence from the European Union olive-oil sector. *Land Use Policy* 48, 94–106.
- Belletti, G., Marescotti, A., Touzard, J.-M., 2017. Geographical indications, public goods, and sustainable development: the roles of actors' strategies and public policies. *World Dev.* 98, 45–57.
- Bérard, L., Marchenay, P., 2006. Local products and geographical indications: taking account of local knowledge and biodiversity. *Int. Soc. Sci. J.* 58 (187), 109–116.
- Besky, S., 2014. The labor of terroir and the terroir of labor: geographical indication and Darjeeling tea plantations. *Agric. Hum. Values* 31 (1), 83–96.
- Bodini, A., Chiussi, S., Donati, M., Bellassen, V., Török, Á., Dries, L., Corić, D.S., Gauvrit, L., Tsakiridou, E., Majewski, E., Ristic, B., Stojanovic, Z., Gil Roig, J.M., Lilavanichakul, A., An, N.Q., Arfini, F., 2021. Water footprint of food quality schemes. *J. Agricult. Food Ind. Organizat.* 19 (2), 145–160. <https://doi.org/10.1515/jaifo-2019-0045>.
- Bouamra-Mechemache, Z., Chaaban, J., 2010. Is the Protected Designation of Origin (PDO) Policy Successful in Sustaining Rural Employment?. In: *European Association of Agricultural Economists, 116th Seminar, Parma, Italy, October 27–30*.
- Cahen, J., 2023. Impacts des signes de qualité sur l'emploi direct au sein des exploitations agricoles. In: *Étude des données du recensement agricole 2020 [Mémoire de maîtrise TERPPA, Institut Agro Rennes-Angers]*.
- Caquet, T., Gascuel, C., Tixier-Boichard, M., 2020. Agroecology: Research for the Transition of Agri-Food Chains and Territories. *Éditions Quae*.
- Carbone, A., Galli, F., Caswell, J., Sorrentino, A., 2014. The performance of protected designations of origin: An ex post multi-criteria assessment of the Italian cheese and olive oil sectors. *J. Agricult. & Food Ind. Organizat.* 12. <https://doi.org/10.1515/jaifo-2013-0017>.
- Cei, L., Stefani, G., Defrancesco, E., 2018a. From geographical indications to rural development: a review of the economic effects of European Union policy. *Sustainability* 10 (10), 3745.
- Cei, L., Stefani, G., Defrancesco, E., Lombardi, G.V., 2018b. Geographical indications: a first assessment of the impact on rural development in Italian NUTS3 regions. *Land Use Policy* 75, 620–630.
- Cei, L., Stefani, G., Defrancesco, E., 2020. The role of group-time treatment effect heterogeneity in long-standing European agricultural policies: An application to the European geographical indication policy. *Bio-Based Appl. Econom.* 9 (1), 85–107.
- Cei, L., Stefani, G., Defrancesco, E., 2021. How do local factors shape the regional adoption of geographical indications in Europe? Evidence from France, Italy and Spain. *Food Policy* 105, 102170. <https://doi.org/10.1016/j.foodpol.2021.102170>.
- Cherrier, O., Prima, M.-C., Rouveyrol, P., 2021. Cartographie des pressions anthropiques terrestres en France métropolitaine - Catalogue pour un diagnostic du réseau d'espaces protégés. *PatriNat (OFB-CNRS-MNH)* 118, 118 p. + 21 p. d'annexes. [https://mnhn.hal.science/mnhn-04167557/file/Cherrier\\_Prima\\_Rouveyrol\\_2021.pdf](https://mnhn.hal.science/mnhn-04167557/file/Cherrier_Prima_Rouveyrol_2021.pdf).
- Chever, T., Renault, C., Renault, S., Romieu, V., 2012. Value of Production of Agricultural Products and Foodstuffs, Wines and Spirits Protected by a Geographical Indication (GI): Final Report. *European Commission*.
- Coinon, M., Chabbé-Ferret, S., Reynaud, A., Tène, E., 2023. The Impact of Organic Farming on Water Pollution and Biodiversity. In: *Workshop on Environmental Policy Evaluation*. University of St. Gallen.
- Corre, T., Monier-Dilhan, S., Regolo, J., 2022. AOP et AB : quelle disposition à payer des consommateurs pour la double labellisation ? *Économie Rurale* 381. <https://doi.org/10.4000/economierurale.10275> juillet-septembre.
- Cortesi, A., Dijoux, L., Yannou-Le Bris, G., Pénicaud, C., 2022. Data related to the life cycle assessment of 44 artisanally produced French protected designation of origin (PDO) cheeses. *Data Brief* 43, 108403. <https://doi.org/10.1016/j.dib.2022.108403>.
- Crescenzi, R., de Filippis, F., Giua, M., Vaquero-Piñeiro, C., 2022. Geographical indications and local development: the strength of territorial embeddedness. *Reg. Stud.* 56 (3), 381–393. <https://doi.org/10.1080/00343404.2021.1946499>.
- Crescenzi, R., de Filippis, F., Giua, M., Salvatici, L., Vaquero-Piñeiro, C., 2023. From local to global, and return: geographical indications and FDI in Europe. *Pap. Reg. Sci.* 102 (5), 985–1007. <https://doi.org/10.1111/PIRS.12758>.
- Crowder, D.W., Reganold, J.P., 2015. Financial competitiveness of organic agriculture on a global scale. *Proc. Natl. Acad. Sci.* 112 (24), 7611–7616. <https://doi.org/10.1073/pnas.1423674112>.
- De Chaisemartin, C., D'Haultfoeuille, X., 2022. Two-way fixed effects and differences-in-differences with heterogeneous treatment effects: a survey. *Econ. J.* 26 (3), C1–C30. <https://doi.org/10.1093/ectj/utac017>.
- De Chaisemartin, C., D'Haultfoeuille, X., 2024. Difference-in-differences estimators of intertemporal treatment effects. *Rev. Econ. Stat.* 2024. <https://doi.org/10.1162/rest.a.01414>.
- Dedieu, M.S., Lorge, A., Louveau, O., Marcus, V., 2017. Les exploitations en agriculture biologique : quelles performances économiques ? In: *Les acteurs économiques et l'environnement* (pp. [pages non précisées]). *Insee Références*.
- Deselnicu, O.C., Costanigro, M., Souza-Monteiro, D.M., McFadden, D.T., 2013. A meta-analysis of geographical indication food valuation studies: what drives the premium for origin-based labels? *J. Agric. Resour. Econ.* 38 (2), 204–219.
- Détang-Dessendre, C., Depeyrot, J., 2023. Systèmes de production et besoin en travail: l'exemple de la production laitière. In: *17e Journées de Recherches en Sciences Sociales, Paris-Saclay, France*.
- Détang-Dessendre, C., Guyomard, H. (Eds.), 2023. *Evolving the Common Agricultural Policy for Tomorrow's Challenges*. Éditions Quae.
- Donati, M., Wilkinson, A., Veneziani, M., Antonioli, F., Arfini, F., Bodini, A., Amilien, V., Csillag, P., Ferrer-Pérez, H., Gkatsikos, A., Gauvrit, L., Gil, C., Hoang, V., Knutsen Steinnes, K., Lilavanichakul, A., Mattas, K., Napasintuwong, O., Nguyen, A., Nguyen, M., Bellassen, V., 2021. Economic spill-over of food quality schemes on their territory. *J. Agricult. Food Ind. Organizat.* 19 (2), 95–111. <https://doi.org/10.1515/jaifo-2019-0046>.
- European Commission, 2008. Commission Regulation (EC) No. 543/2008 of 16 June 2008 laying down detailed rules for the application of Council Regulation (EC) No 1234/2007 as regards the marketing standards for poultrymeat, *Official Journal of the European Union L 157*, pp. 46–87.
- Ezcurra, R., Iraizoz, B., Pascual, P., Rapún, M., 2011. Agricultural productivity in the European regions: trends and explanatory factors. *European Urban and Regional Studies* 18 (2), 113–135. <https://doi.org/10.1177/0969776410370789>.
- Fischer, F., 1999. *Pistes pour une agriculture durable* [Rapport de la Commission européenne pour le Conseil, le Parlement européen, le Comité économique et social, le Comité des régions].
- Flinzberger, L., 2023. *Geographic Indications as Flagship Products for Sustainable Landscape Management in the European Union*. Doctoral Dissertation. Georg-August-University Göttingen.
- Flinzberger, L., Zinngrebe, Y., Bugalho, M.N., Plieninger, T., 2022a. EU-wide mapping of 'protected designations of origin' food products (PDOs) reveals correlations with social-ecological landscape values. *Agron. Sustain. Dev.* 42 (43). <https://doi.org/10.1007/s13593-022-00778-4>.
- Flinzberger, L., Cebrián-Piqueras, M.A., Peppler-Lisbach, C., Zinngrebe, Y., 2022b. Why geographical indications can support sustainable development in European Agri-food landscapes. *Front. Conserv. Sci.* 2, 752377. <https://doi.org/10.3389/fcosc.2021.752377>.
- Frayssignes, J., 2008. Démarches de qualité et développement territorial: Quels apports pour la géographie rurale? L'exemple des AOC fromagères françaises. *Géocarrefour* 83 (4), 295–305. <https://doi.org/10.4000/geocarrefour.7055>.
- Gerz, A., Dupont, F., 2006. *Comté cheese in France: Impact of a geographical indication on rural development*. In: *Origin-Based Products: Lessons for pro-Poor Market Development*. CIRAD and FAO, pp. 75–87.
- Giannakis, E., Bruggeman, A., 2018. Exploring the labour productivity of agricultural systems across European regions: a multilevel approach. *Land Use Policy* 77, 94–106. <https://doi.org/10.1016/j.landusepol.2018.05.037>.
- Hilal, M., Leodon, G., Dubois de Labarre, M., Antonioli, F., Boehm, M., Péter, C., Donati, M., Drut, M., Ferrer-Pérez, H., Gauvrit, L., Gil, J.M., Gkatsikos, A., Golaś, M., Hoang, V., Steinnes, K., Knutsen, A., Lilavanichakul, A., Malak-Rawlikowska, A., Mattas, K., Bellassen, V., 2021. Organic and geographical indication certifications' contributions to employment and education. *J. Agricult. & Food Ind. Organizat.* 19 (2), 161–176. <https://doi.org/10.1515/jaifo-2019-0042>.
- Hirczak, M., Mollard, A., 2004. *Qualité des produits agricoles et de l'environnement : Le cas de Rhône-Alpes*. *Revue d'Économie Régionale & Urbaine* 2004 (5), 845–868.
- Institut national de l'origine et de la qualité (INAQ), 2021. *Les produits sous signe d'identification de la qualité et de l'origine : Chiffres clés, p. 2020*. <https://www.ina.o.gouv.fr/Publications/Donnees-et-cartes/Informations-economiques>.
- Jeanneaux, P., Gillot, M., Blasquie-Revol, H., Payen, A., 2019. La compétitivité hors coût des exploitations agricoles françaises : Une analyse des effets des signes de qualité et d'origine, vol. *Analyse n° 135*. Centre d'Études et de Perspectives, Ministère de l'Agriculture et de l'Alimentation.
- Josling, T., 2006. The war on terroir: geographical indications as a transatlantic trade conflict. *J. Agric. Econ.* 57 (3), 337–363. <https://doi.org/10.1111/j.1477-9552.2006.00104.x>.
- Kremen, C., Miles, A., 2012. Ecosystem services in biologically diversified versus conventional farming systems: benefits, externalities, and trade-offs. *Ecol. Soc.* 17 (4). <https://doi.org/10.5751/ES-05052-170440>. Article 40.
- Lambotte, M., De Cara, S., Brocas, C., Bellassen, V., 2021. Carbon footprint and economic performance of dairy farms: the case of protected designation of origin farms in France. *Agric. Syst.* 186, 102979. <https://doi.org/10.1016/j.agsy.2021.102979>.
- Landi, C., Stefani, G., 2015. Rent seeking and political economy of geographical indication foods. *Agribusiness* 31 (4), 543–563. <https://doi.org/10.1002/agr.21408>.
- Li, C., Ban, Q., Gao, J., Ge, L., Xu, R., 2024. The Role of Geographical Indication Products in Promoting Agricultural Development—A Meta-Analysis Based on Global Data. *Agriculture* 14 (10), 1831.
- Lurette, A., Stark, F., Lecomte, L., Lasseur, J., Moulin, Ch.-H., 2020. A model to explore which diversity is needed to design sustainable agricultural systems at the territorial level. *Agron. Sustain. Dev.* 40 (5). <https://doi.org/10.1007/s13593-020-00649-3>.
- Magne, M.A., Martin, G., Moraine, M., Ryschawy, J., Thenard, V., Triboulet, P., Choisis, J.P., 2019. An integrated approach to livestock farming systems' autonomy to design and manage agroecological transition at the farm and territorial levels. In: *Bergey, J.E., Audouin, E., Therond, O. (Eds.), Agroecological Transitions: From Theory to Practice in Local Participatory Design*. Springer, pp. 45–68.

- Marette, S., Crespi, J.M., Schiavina, A., 1999. The role of common labelling in a context of asymmetric information. *Eur. Rev. Agric. Econ.* 26 (2), 167–178. <https://doi.org/10.1093/erae/26.2.167>.
- Mazé, A., 2023. Indications géographiques dans le contexte des transitions agroécologiques: Réenvisager l'ancrage territorial et le patrimoine alimentaire. In: *Forum Origine, Diversité et Territoires, Plenary session 2, Angers, France*.
- Menapace, L., Moschini, G., 2012. Quality certification by geographical indications, trademarks, and firm reputation. *Eur. Rev. Agric. Econ.* 39 (4), 539–566. <https://doi.org/10.1093/erae/jbs017>.
- Milano, M.Z., Cazella, A.A., 2021. Environmental effects of geographical indications and their influential factors: a review of the empirical evidence. *Curr. Res. Environ. Sustainabil.* 3, 100096. <https://doi.org/10.1016/j.crsust.2021.100096>.
- Monier-Dilhan, S., Poméon, T., Böhm, M., Brečić, R., Csillag, P., Donati, M., Ferrer-Pérez, H., Gaurrit, L., Gil, J.M., Hoàng, V., Lilavanichakul, A., Majewski, E., Malak-Rawlikowska, A., Mattas, K., Napasintuwong, O., Nguyễn, A.Q., Nikolaou, K., Papadopoulos, I., Pascucci, S., Peerlings, J., Ristic, B., Steinnes, K., Stojanovic, Z., Tomić Maksan, M., Török, Á., Veneziani, M., Vittersø, G., Bellassen, V., 2021. Do food quality schemes and net price premiums go together? *J. Agricult. & Food Ind. Organizat.* 19 (2), 79–94. <https://doi.org/10.1515/jafio-2019-0044>.
- Moran, W., 1993. Rural space as intellectual property. *Polit. Geogr.* 12 (3), 263–277. [https://doi.org/10.1016/0962-6298\(93\)90011-5](https://doi.org/10.1016/0962-6298(93)90011-5).
- Moschini, G., Menapace, L., Pick, D., 2008. Geographical indications and the competitive provision of quality in agricultural markets. *Am. J. Agric. Econ.* 90 (3), 794–812. <https://doi.org/10.1111/j.1467-8276.2008.01142.x>.
- Observatoire économique des SIQO en Hauts-de-France, 2019. *Évaluation de la durabilité des filières sous SIQO*.
- Observatoire économique des SIQO en Hauts-de-France, 2021. *Évaluation de la durabilité des filières AOP laitières appliquée au Maroilles*.
- Olivier-Salvagnac, V., Regolo, J., Menard, A., Giraudou, L., 2024. Sustainability of geographical indications (GIs) in the context of the diversification of agricultural activities in local areas. *Innovations Agronomiques* 93, 43–58.
- Ory, X., 2020. Productivity and environmental impact of farms according to their size. In: *DG Trésor economics paper no. 2020/2, February*.
- Parrot, N., Wilson, N., Murdoch, J., 2002. Spatializing quality: regional protection and the alternative geography of food. *European Urban and Regional Studies* 9 (3), 241–261. <https://doi.org/10.1177/0967642002009003878>.
- Pecqueur, B., 2001. Qualité et développement territorial: L'hypothèse du panier de biens et de services territorialisés. *Économie Rurale* 26, 37–49. <https://doi.org/10.3406/ecoru.2001.5217>.
- Piet, L., Chatellier, V., Delame, N., Jeanneaux, P., Laroche-Dupraz, C., Ridier, A., Veyset, P., 2021. Mesurer le revenu des exploitations agricoles françaises : Analyse comparée sur 15 ans d'indicateurs issus du RICA et de la MSA. *Économie Rurale* 378, 37–56. <https://doi.org/10.4000/economierurale.9402>.
- Puech, T., Stark, F., 2023. Diversification of an integrated crop-livestock system: Agroecological and food production assessment at farm scale. *Agric. Ecosyst. Environ.* 344, 108300. <https://doi.org/10.1016/j.agee.2023.108300>.
- Quiñones-Ruiz, X.F., Penker, M., Belletti, G., Marescotti, A., Scaramuzzi, S., 2016. Why early collective action pays off: evidence from setting protected geographical indications. *Renewable Agriculture and Food Systems* 31 (1), 1–14. <https://doi.org/10.1017/S1742170516000168>.
- Raffray, R., 2023. Un jour, l'AOD ? Prospective sur l'Appellation d'Origine viticole durable, fusion de l'origine et de l'environnement. *Open Wine Law* 3. <https://doi.org/10.20870/OWL.2023.7832>.
- Raimondi, V., Curzi, D., Arfini, F., Falco, C., 2024. Dynamic and spatial approaches to assess the impact of geographical indications on rural areas. *J. Rural. Stud.* 108, 103279. <https://doi.org/10.1016/j.jrurstud.2024.103279>.
- Regolo, J., Poméon, T., 2021. Présentation de la base de données sur les opérateurs habilités des produits sous signe d'identification de la qualité et de l'origine (SIQO). *Rapport Technique, Observatoire du Développement Rural, INRAE*. <https://hal.archives-ouvertes.fr/hal-03264972>.
- Ren, C., He, L., Ma, Y., Reis, S., Van Grinsven, H., Lam Shu, K., Rosa, L., 2024. Trade-offs in agricultural outcomes across farm sizes. *Earth Critical Zone* 1 (1), 100007. <https://doi.org/10.1016/j.ecz.2024.100007>.
- Rudow, K., 2014. Less favoured area payments – impacts on the environment, a German perspective. *Agricult. Econom. Czech* 60, 260–272.
- Sengel, S., Midler, E., Depeyrot, J.N., 2021. Performances des exploitations laitières bovines sous indications géographiques. In: *Centre d'Etudes et de Perspectives, Ministère de l'Agriculture et de l'Alimentation. Analyse no 173 - Février 2022*.
- Shapiro, C., 1983. Premiums for high quality products as returns to reputations. *Q. J. Econ.* 98 (4), 659–680. <https://doi.org/10.2307/1885566>.
- Stranieri, S., Orsi, L., de Noni, I., Olper, A., 2023. Geographical indications and innovation: Evidence from EU regions. *Food Policy* 116. <https://doi.org/10.1016/j.foodpol.2023.102425>.
- Stranieri, S., Orsi, L., Zilia, F., de Noni, I., Olper, A., 2024. Terroir takes on technology: geographical indications, Agri-food innovation, and regional competitiveness in Europe. *J. Rural. Stud.* 110. <https://doi.org/10.1016/j.jrurstud.2024.103368>.
- Suh, J., MacPherson, A., 2007. The impact of geographical indication on the revitalisation of a regional economy: a case study of 'Boseong' green tea. *Area* 39 (4), 518–527. <https://doi.org/10.1111/j.1475-4762.2007.00731.x>.
- Sylvander, B., Allaire, G., Belletti, G., Marescotti, A., Barjolle, D., Thévenod-Mottet, E., Tregear, A., 2005. Les dispositifs français et européens de protection de la qualité et de l'origine dans le contexte de l'OMC : Justifications générales et contextes nationaux. *Communication pour le Symposium international. In: Territoires et enjeux du développement régional, Lyon, 9-11 mars 2005, p. 22*.
- Sylvander, B., Lagrange, L., Monticelli, C., 2007. Les signes officiels de qualité et d'origine européens. *Économie Rurale* 299, 7–23.
- Thévenod-Mottet, E., 2010. Geographical indications and biodiversity. In: *Lockie, S., Carpenter, D. (Eds.), Agriculture, Biodiversity and Markets. Earthscan, pp. 201–212*.
- Török, Á., Jantayik, L., Maró, Z.M., Moir, H.V.J., 2020. Understanding the real-world impact of geographical indications: a critical review of the empirical economic literature. *Sustainability* 12 (22), 9434. <https://doi.org/10.3390/su12229434>.
- Vandecastelaere, E., Arfini, F., Belletti, G., Marescotti, A., 2010. *Linking People, Places and Products: A Guide for Promoting Quality Linked to Geographical Origin and Sustainable Geographical Indications*. FAO, Rome.
- Vandecastelaere, E., Teyssier, C., Barjolle, D., Jeanneaux, P., Fournier, S., Beucherie, O., 2018. *Strengthening Sustainable Food Systems through Geographical Indications, an Analysis of Economic Impacts*. FAO, Rome.
- Vandecastelaere, E., Samper, L.F., Rey, A., Daza, A., Mejía, P., Tartanac, F., Vittori, M., 2021. The geographical indication pathway to sustainability: a framework to assess and monitor the contributions of geographical indications to sustainability through a participatory process. *Sustainability* 13 (14), 7535. <https://doi.org/10.3390/su13147535>.
- Vedrine, L., 2018. *Évaluation ex-post des programmes de développement rural, contribution au séminaire INRAE 'PAC et développement rural', septembre 2018, Paris*.
- Wezel, A., David, C., 2020. Policies for agroecology in France: implementation and impact in practice, research and education. *Landbauforschung - J. Sustain. Organ. Agricult. Syst.* 70 (2), 66–76. <https://doi.org/10.3220/LBF1608660604000>.