

## PRODUCTIVE SPECIALIZATION AND CLUSTERS IN THE AGRI-FOOD SYSTEM OF NORTHERN PORTUGAL

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### Abstract

The Região Norte of Portugal is a region where the primary sector has historically played a significant role. It is generally an aging region, with a large area considered as low-density and with a low level of purchasing power, revealing deep asymmetries in terms of economic and social cohesion. This study aims to analyse the profile of the agri-food industry, that is, the food and beverage industries, in the north of Portugal in terms of productive specialization. This work started by collecting a set of variables such as employment, people employed, GVA and value of sales and services provided, depending on the level of disaggregation of the classification of economic activities and the availability of data. Based on this statistical data, location and specialization indicators were calculated, namely the location quotient. Then, using statistical software, clusters were built that enabled us to draw a picture of the agri-food system. This work was relevant to identifying the relative specialization of Norte NUTs III regions, the relative location of activities and the outlining of productive areas. It is expected that it will contribute to the definition of effective policy instruments to be developed in the region by the responsible organisation for regional development, based on the region's profile and with the aim of an intelligent specialization strategy.

**Keywords:** productive specialization, clusters, regional development

**JEL classification:** R12; R58

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### 1. Introduction

Portugal's Common Agricultural Policy Strategic Plan (PEPAC) follows the general guidelines of European policy, namely the 'Farm to Fork' Strategy, which is part of the European Green Deal and aims to accelerate the EU's transition to a sustainable food system (European Commission, 2020). This means, according to Fernandes, F. and Baptista, A. (2023), that it must have a neutral or positive environmental impact; contribute to mitigating climate change and adapting to its impacts; reverse the loss of biodiversity; guarantee food safety, nutrition and public health, ensuring that everyone has access to sufficient, nutritious and sustainable food; and preserve the affordability of food, while also generating fairer economic returns, fostering the competitiveness of the EU supply sector and promoting fair trade. It must also comply with a set of national guidelines, with the core element of the vision being 'Enabling active land management based on innovative and sustainable agricultural and forestry production'.

The agri-food sector, which is a crucial sector for the economy, as it covers a wide-ranging and diversified activities that involve various stages of the food production chain, from agricultural production to distribution and sales to the end consumer. It is therefore vital for feeding the population, but also for the global economy, being responsible for generating jobs, promoting rural development and contributing to international trade. However, the agri-

food sector face multiple challenges, both on a local scale (in the case of the infrastructure inherent in the entire value chain; access to technology, financing issues, regulations and climate change) and on a global scale (which adds to the challenges mentioned on a local scale, issues such as food safety, environmental sustainability, distribution and logistics, international trade constraints which include competitiveness and issues linked to inequality and social inclusion).

For Região Norte, a developing region covered by the convergence objective in the European Union's cohesion policy, the challenges in terms of competitiveness on a global scale, as well as in terms of combating inequality and social inclusion associated with small producers and rural communities, are unavoidable issues. In this context, knowing the production profile of its NUTs III regions, the location of production activities and regional specialisation is crucial to meeting the challenges of the agri-food industry. This detailed understanding can bring several benefits and help develop effective strategies to overcome the obstacles faced by the sector. Thus, this work will focus on studying the production profile of the agri-food sector in the Região Norte. After a brief characterisation of the region, we present the objectives, conceptual framework and methodology of the study. In the next point, we analyse the location of the agri-food sector and regional specialisation at NUT III level for Região Norte. Afterwards we perform a cluster analysis in order to identify relevant spatial agglomeration of agri-food activities. Finally, we discuss the main results and present some conclusions in terms of the relevance of the study's results to the smart specialisation strategy of Região Norte.

## 2. Objectives and methodology

In this study we analyse the profile of the agri-food sector in the north of Portugal (Região Norte), identifying the relative specialisation of Norte's NUTs III regions, the relative location of agri-food activities and the outlining of productive areas.

In order to characterize the specialization profile of Região Norte and its subregions we used standard specialization indices measuring the extent to which activities are concentrated or dispersed across a given space. These indices make it possible to evaluate the specialization profile and the degree of specialization/diversification of a region, considering a given sectoral distribution of the retained variable (usually employment or Gross value added (GVA)) and the characteristics of the reference space, usually the national economy.

The location quotient (QLik), as a measure of relative specialization, compares the relative contribution of a sector (k) to a given region (i) with the share of the same sector to the reference space (Delgado and Godinho, 2011). It is given by the following formula:

$$QL_{ik} = \frac{\frac{x_{ik}}{x_i}}{\frac{x_k}{x}}, 0 \leq QL_{ik} \leq +\infty \quad (1)$$

If the variable is employment, for region i, then  $x_{ik}$  is regional employment in sector k,  $x_i$  is total regional employment,  $x_k$  is total employment in sector k for the reference space and  $x$  is total employment in the reference space.

Location quotient values greater than unity indicate that sector k has a relative contribution to the variable, in the region, greater than that in the reference space. In this sense, it can be said that region i is specialized in sector k in relation to the reference space. In the case  $QL_{ik} < 1$  the region is not relatively specialised in sector k.

It should be noted that the location quotient may also be used as an index of relative concentration of a given activity across a set of regions. In this case a location quotient greater than 1 means that the variable (employment, for instance) in a given sector (k) is concentrated, in relative terms, in an individual region (i).

There is a consensus that the development of regional specialisation and location of productive activities indicators make an important contribution to understanding the productive profile of a territory and, consequently, to outlining development policies.

The application of this methodology has yielded good results in various published works, which vary both in their territorial scope, with the possibility of using a more or less micro scale, and in the level of disaggregation of economic activities. The degree of disaggregation depends not only on the purpose of the work but also on the availability of statistical data, which sometimes becomes a major obstacle.

As examples, we can mention studies that seek to analyse all the regions of a country and all economic activities - such as Sequeira 2024; Keogan, Calá and Belmartino, 2020; Diniz and Carvalho, 2015. Another type of application of this methodology are works very focused on specific sectors, such as Fernandes and Baptista, 2023, Parré and Chagas, 2023, Pacheco-Almaraz et al, 2021, all in the agri-food sector, or Martínez, Navarro and Garnica, 2017, in the automotive sector, or even in specific regions such as Abrita et al., 2023, in the municipalities of Mato Grosso, Brasil, Flores-Cevallos et al., 2023, in the province of Cotopaxi, Ecuador, or CCDRC, 2020, about Região Centro of Portugal.

With regard to the methodology used to analyse the identification of clusters, i.e. homogeneous groups in the data, a multivariate statistical process will be used. The only variable for which information is available at county level and for the subclasses of the classification of economic activities (CAE) is the "number of establishments" (INE, 2023a), therefore this will be the variable used for the clustering process. This method seeks to group individuals, in this case municipalities, according to existing information, so that the individuals in a group are as similar to each other as possible, and as different from the other groups as possible.

Consequently, in methodological terms and in accordance with the usual procedures recommended by various authors (Marôco, 2021; Pestana and Gageiro, 2014), we first applied the IBM SPSS software (version 27) to use hierarchical grouping methods (grouping based on distance, including the average distance between clusters method). These made it possible to analyse and compare the various possible solutions and the number of clusters to be selected. This was followed by the use of a non-hierarchical method (k-means) as a strategy to confirm the results obtained. The number of clusters to be selected was estimated by applying the distance between clusters criterion, analysing dendograms and the R2 criterion.

### **3. Data**

We collected a set of variables such as employment, people employed, GVA and turnover, depending on the level of disaggregation of the classification of economic activities and the availability of data.

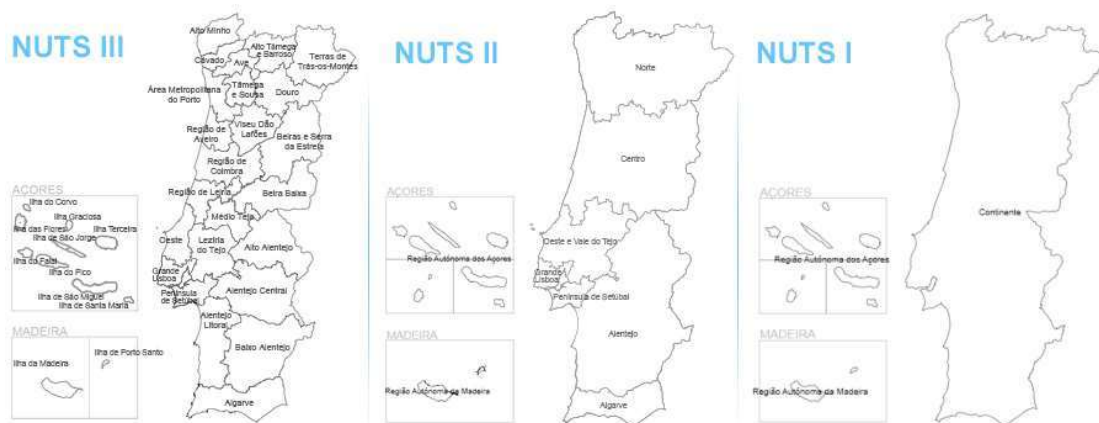
Based on this statistical data, location and specialization indicators were calculated, namely the location quotient, the specialization coefficient and the entropy index. For relative specialization indices (location quotient and specialization coefficient) we took the distribution of the variables in the country as reference. We used Statistics Portugal, Integrated Business Accounts System (INE, 2023b), which includes all enterprises from sections A to S of Portuguese Classification of Economic Activities, revision 3 (CAE Rev. 3), with the exception of section K (Financial and Insurance Activities) and section O (Public Administration and Defense; Compulsory Social Security).

To study the relative location of agricultural and animal production activities as well as some food and beverages sectors, at 4 and 5 digit level of CAE Rev. 3, we used information on the Central Balance-Sheet published by Banco de Portugal, which allows sectoral analysis of nonfinancial corporations, comprising data on the number of enterprises, number of employees and turnover.

### **4. Brief characterisation of the Region**

In terms of classification by the nomenclature of territorial units for statistics (NUTs), figure I shows the division of Portugal into NUTs. Thus, and reading from right to left, Portugal is a NUT I, Região Norte is a NUT II which comprises 8 regions at NUT III level: the metropolitan area of Porto and seven other NUTs III regions, namely, Alto Minho, Alto Tâmega, Ave, Cávado, Douro, Tâmega e Sousa (TamSousa), Terras de Trás-os-Montes (TerrasTM).

**Figure 1. The distribution of Portuguese territory by NUT level, 2024**



Source: Pordata (2024).

Região Norte stands out from the rest of the country due to the weight that the secondary sector assumes in the regional GVA (31.3%, above the national average) and for being the largest center of secondary activities in the country: 42.5% of the secondary sector national GVA, in 2020 (Fernandes and Baptista, op. cit.).

With the exception of the coastal area, it is generally an aging region, with a large area considered as low-density and with a low level of purchasing power, revealing deep asymmetries in terms of economic and social cohesion.

In Região Norte the primary sector has historically played a significant role. This region includes the Demarcated Region of the Douro (DRD), the oldest demarcated and regulated wine region, recognized by UNESCO as a World Heritage Site and internationally renowned for the production of Port Wine.

In the context of Portugal's agri-food sector and within the NUT II regions, Região Norte represents around 40% of the number of producers in the country and, in 2021, the gross added value (GVA) of the agri-food sector in the region totalled 1411 M€, distributed 30% by agriculture, animal production, hunting, forestry and fishing and 70% by the agri-food industry (INE, 2023b). This value corresponds to 25 per cent of (the total generated by the agri-food sector at national level and 4 per cent of the total GVA of Região Norte (INE, 2023a).

In agricultural terms, the region is characterised by its great physical diversity in terms of relief, altitude, soil characteristics, climate and water availability, which translates into a wide variety of crops and production systems.

As Fernandes and Baptista (op. cit.) highlight, agriculture with this diversity of crops and production conditions poses enormous challenges for public policies, which must find appropriate responses for each territory, on a place-based basis.

It is therefore precisely in order to contribute to this knowledge of the territory, which is fundamental to public policies, that we will move forward with the study of the region's productive specialisation and the location of activities in the agri-food sector.

The analysis of the relative specialization of the NUT III sub-regions (Table 1) indicates a dual specialization pattern, with inland sub-regions (Alto Tâmega, Douro and Terras de Trás-os-Montes) specialized in activities dependent on agriculture, natural resources, consumer and social services and the coastal sub-regions specialized in manufacturing industry. It should also be noted that in inland sub-regions, primary sector activities have a relevant weight in the total number of personnel employed and the gross added value of companies based there, although with much less significant values in the case of this last variable.

**Table 1. NUTS III sectors with QLik>1 (People employed (PAS) and/or Gross value added (GVA)) and share in total NUT III PAS and/or GVA >2**

NUTS III	QLik>1 (PAS or GVA) and share in total NUT III PAS and/or GVA >2%
Alto Minho	Manufacturing (PAS 27%; GVA 41%) Construction (PAS 14%; GVA 11%)
Cávado	Manufacturing (PAS 29%; GVA 33%) Construction (PAS 16%; GVA 19%)
Ave	Manufacturing (PAS 46%; GVA 55%)
AMP	Manufacturing (PAS 23%; GVA 30%) Wholesale and retail trade (...) (PAS 22%; GVA 22%) Human health (...) (PAS 5%; GVA 4%)
Alto Tâmega	Agriculture (...) (PAS 23%; GVA 5%) Mining (...) (PAS 1%; GVA 2%) Electricity (...) (PAS 0,4%; GVA 13%) Water collection (...) (PAS 2%; GVA 3%) Construction (PAS 12%; GVA 16%) Human health (...) (PAS 3%; GVA 5%) Other services (PAS 3%; GVA 1%)
Tâmega e Sousa	Mining (...) (PAS 6%; GVA 1%) Manufacturing (PAS 38%; GVA 39%) Construction (PAS 20%; GVA 24%)
Douro	Agriculture (...) (PAS 31%; GVA 12%) Human health (...) (PAS 5%; GVA 6%)
Terras Trás-os-Montes	Agriculture (...) (PAS 34%; GVA 19%) Human health (PAS 5%; GVA 6%) Other services (PAS 3%; GVA 1%)

Source: Own elaboration based on INE data (INE, 2023a)

## 5. The agri-food sector activities and regional specialization

In order to study the relative location of the agri-food sector at NUT III level, we calculated location quotients for all the activities, at 4 and 5 digit level of CAE Rev. 3, taking as variables the number of people employed (PAS) and the volume of sales and services provided (VSP).

For each sector we computed the regional contribution to total (national) sectoral employment or turnover. Activities were grouped for their significance at national level: reduced (less than or equal to 10% of selected variables), medium (higher than 10% and less than 25%) or high (equal to or higher than 25%) relevance at national level.

The sub-regions that are relatively specialized in activities in which the Northern Region has reduced relevance at national level are mainly inland regions (Alto Tâmega, Douro and Terras de Trás-os-Montes) (Table 2).

**Table 2. Regional activities with small relevance at national level (share of given variable – People employed (PAS) and / or Turnover (VSP) lower or equal to 10%)**

Activity (CAE Rev. 3) / Share of Região Norte in the given variable at national level	Location quotient PAS 2020	Location quotient VSP 2020	Share of sub-regional turnover in total sectoral turnover (%)
Growing of cereals (0111) PAS 7%; VSP 5%	Douro 5,6	Douro 5,6	Douro 4
Growing of vegetables and melons, roots and tubers (0113) PAS 9%; VSP 6%	Terras TM 8,9	Terras TM 9	Terras TM 3
Growing of oleaginous fruits (0126) PAS 6%; VSP 2%	Terras TM 6,1	Terras TM 1,4	Terras TM 0,5
Farming of other cattle (except dairy) and buffaloes (01420) PAS 10%; VSP 5%	Alto Tâmega 3,5 Terras TM 2	Alto Tâmega 3,7 Terras TM 1,8	Alto Tâmega 1,1 Terras TM 0,6
Raising of sheep and goats (01450) PAS 4%; VSP 1%	Terras TM 3,6	Terras TM 1,6	Terras TM 0,6

Activity (CAE Rev. 3) / Share of Região Norte in the given variable at national level	Location quotient PAS 2020	Location quotient VSP 2020	Share of sub-regional turnover in total sectoral turnover (%)
Preparation and preserving of fruit and vegetables (103) PAS 9%; VSP 8%	Alto Tâmega 5,3 Terras TM 9,4	Alto Tâmega 5,1 Terras TM 14,8	Alto Tâmega 1,5 Terras TM 5,3

Source: Own elaboration based on Banco de Portugal (2023)

As for medium relevant activities, in addition to the sub-regions already mentioned, we have Alto Tâmega e Tâmega e Sousa, Alto Minho, Cávado e Ave (Table 3).

**Table 3. Regional activities with medium relevance at national level: (share of given variable – People employed (PAS) and / or Turnover (VSP) higher than 10% and lower than 25%)**

Activity (CAE Rev. 3) Share of Região Norte in the given variable at national level	Location quotient PAS 2020	Location quotient VSP 2020	Share of sub-regional turnover in total sectoral turnover
Growing of pome fruits and stone fruits (0124) PAS 19%; VSP 16%	Douro 18,4 Terras TM 3	Douro 21,3 Terras TM 2,6	Douro 15,1 Terras TM 1
Growing of other tree and bush fruits and nuts (0125) PAS 15%; VSP 15%	Ave <1 Alto Tâmega <1 TâmSousa <1 Douro 1,1 Terras TM 1,9	Ave 1,4 Alto Tâmega 2,3 TâmSousa 1,2 Douro <1 Terras TM 6	Ave 4 Alto Tâmega 0,7 TâmSousa 3 Douro 0,6 Terras TM 2
Raising of horses, asses, mules and hinnies (01430) PAS 20%; VSP 11%	Alto Minho 1,6 AMP <1	Alto Minho 2,6 AMP <1	Alto Minho 4 AMP 6
Mixed farming (01500) PAS 13%; VSP 14%	Cávado <1 AMP <1 Terras TM 3,2	Cávado 1,2 AMP <1 Terras TM 2,3	Cávado 4 AMP 6 Terras TM 0,8
Slaughtering of animals, processing and preserving of meat and meat products (101) PAS 26%; VSP 20%	Ave 2,5 AMP <1 Alto Tâmega 3,6 Douro 1,2 Terras TM 4,2	Ave 3 AMP <1 Alto Tâmega 2,9 Douro <1 Terras TM 1,9	Ave 10 AMP 5 Alto Tâmega 0,8 Douro 0,5 Terras TM 0,7
Manufacture of vegetable and animal oils and fats (104) PAS 17%; VSP 4%	Alto Tâmega 6,2 Douro 4 Terras TM 16,1	Alto Tâmega 2,6 Douro <1 Terras TM 2,8	Alto Tâmega 0,8 Douro 0,4 Terras TM 1
Manufacture of other animal goods (108) PAS 24%; VSP 19%	Ave 1,4 AMP <1 Alto Tâmega 2	Ave 1,3 AMP <1 Alto Tâmega <1	Ave 4 AMP 13 Alto Tâmega 0,2

Source: Own elaboration based on Banco de Portugal (2023)

The activities for which the contribution of Região Norte to the national total of personnel employed and/or the volume of sales and services provided by companies is very relevant (Table 4) are viticulture, dairy cattle breeding, beekeeping, rabbit farming, the dairy industry, the processing of cereals and legumes, the manufacture of bakery and similar products and the wine industry. AMP's contribution to the volume of sales and services provided in the indicated sectors (with the exception of beekeeping and rabbit farming) is very high, although this sub-region is, as a rule, not relatively specialized in those activities.

**Table 4. Regional activities with medium relevance at national level: (share of given variable – People employed (PAS) and / or Turnover (VSP) equal or higher than 25%)**

Activity (CAE Rev. 3) Share of Região Norte in the given variable at national level	Location quotient PAS 2020	Location quotient VSP 2020	Share of sub- regional turnover in total sectoral turnover (%)
Viticulture (0121) PAS 51%; VSP 44%	Alto Minho 1,6 AMP <1 AltoTâmega 1,1 TâmSousa 1,3 Douro 31,4 Terras TM 1,7	Alto Minho 1 AMP <1 AltoTâmega 1 TâmSousa 2 Douro 37,7 Terras TM 1,2	Alto Minho 1,5 AMP 9 AltoTâmega 0,3 TâmSousa 5 Douro 27 Terras TM 0,5
Dairy farming (01410) PAS 38%; VSP 32%	Alto Minho 1,7 Cávado 2,7 AMP <1 AltoTâmega 4 Douro 1,8	Alto Minho 1,6 Cávado 2,5 AMP <1 AltoTâmega 5,1 Douro 1,8	Alto Minho 2 Cávado 8 AMP 14 AltoTâmega 1,5 Douro 1
Beekeeping (01491) PAS 36%; VSP 28%	Alto Minho 2,1 AltoTâmega 10,7 TâmSousa 3,2 Douro 2 Terras TM 11,8	Alto Minho 1,4 AltoTâmega 15, 1 TâmSousa 3,7 Douro 3 Terras TM 19,9	Alto Minho 2 AltoTâmega 4 TâmSousa 8 Douro 2 Terras TM 7
Rabbit farming (01492) PAS 38%; VSP 58%	Cávado 1,9 Ave 1 AltoTâmega 24,8 Douro 5,5 Terras TM 21,2	Cávado 2,8 Ave 1,5 AltoTâmega 28,5 Douro 7,4 Terras TM 27,2	Cávado 9 Ave 5 AltoTâmega 8 Douro 5,3 Terras TM 10
Manufacture of dairy products (105) PAS 29%; VSP 41%	AMP 1,4 Douro 2,7	AMP 2,3 Douro 2,6	AMP 39 Douro 2
Manufacture of grain mill products, starch and starch products (106) PAS 35%; VSP 42%	AMP 1,7 Terras TM 3,8	AMP 2,4 Terras TM 1,4	AMP 41 Terras TM 0,5
Manufacture of bakery and farinaceous products (107) PAS 33%; VSP 33%	Alto Minho 1 Ave 1,2 AMP <1 AltoTâmega 1,9 Tâmega e Sousa 1 Douro 1,6 Terras TM 1,5	Alto Minho 1,3 Ave 1,8 AMP 1,1 AltoTâmega 1,3 TâmSousa 1,1 Douro 1 Terras TM 1,2	Alto Minho 2 Ave 6 AMP 20 AltoTâmega 0,4 TâmSousa 3 Douro 0,7 Terras TM 0,5
Wine industry (1102) PAS 49%; VSP 55%	Alto Minho 1,4 AMP 1,3 TâmSousa 1,2 Douro 17,9 Terras TM 1,7	Alto Minho 1,6 AMP 1,7 TâmSousa 2,4 Douro 22,3 Terras TM 2,2	Alto Minho 2 AMP 29 TâmSousa 6 Douro 16 Terras TM 0,8

Source: Own elaboration based on Banco de Portugal (2023)

## 6. Clusters and production basins

After having identified, in the previous point, the activities of the NUTs III regions in the North with a high degree of relative location and which at the same time make a strong contribution to national GVA, we will then proceed to build clusters. That is, from the 8 sectors of Economic Activity, namely:

- Viticulture (CAE 01221);
- Dairy cattle farming (CAE 01410);
- Beekeeping (CAE 01491);
- Rabbit farming (CAE01492);
- Dairy industry (CAE 105);
- Manufacture of grain mill products, starch and starch products CAE (106)
- Manufacture of bakery products and farinaceous products (CAE 107)
- Wine industry (CAE1102)

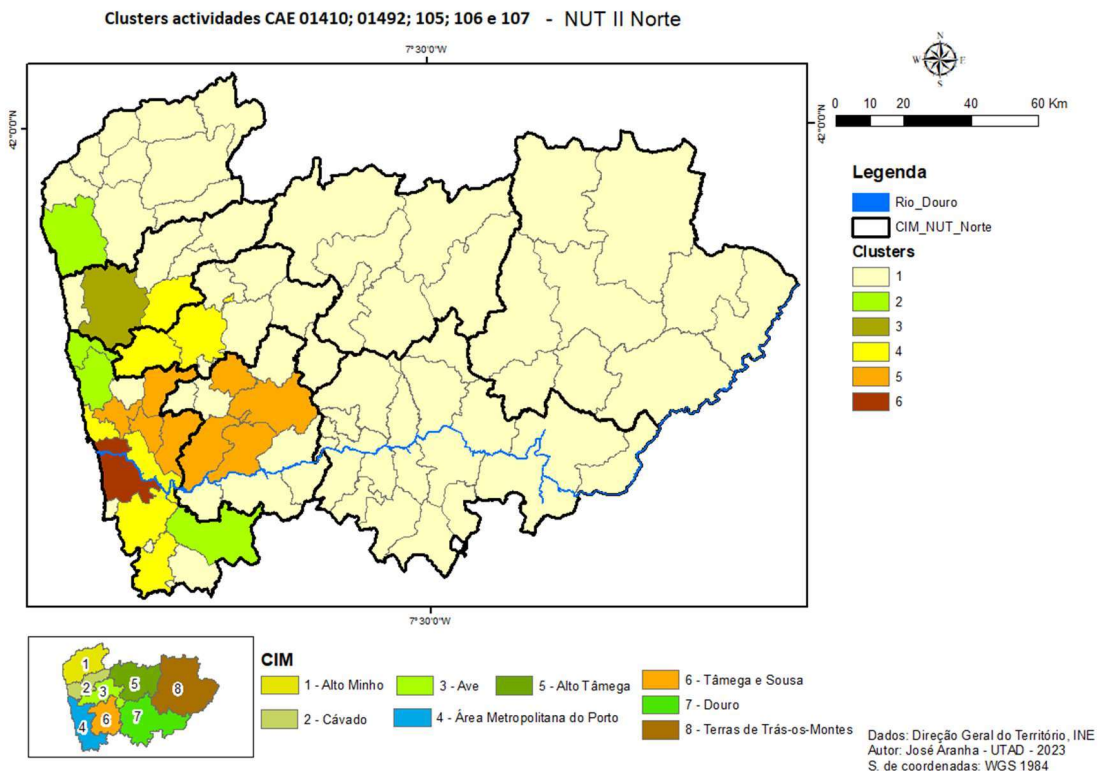
We will try to group the municipalities belonging to the NUTs III in the North by constructing clusters using a multivariate statistical process, based on the number of establishments existing in 2020 in each municipality for these sectors of activity, the only information available at municipal level for these CAEs.

In addition to the application of the aforementioned methods using IBM SPSS software (v.27), namely by constructing various groupings initially using hierarchical methods, as an exploratory measure, and later using non-hierarchical methods, as a confirmatory measure, a note should be made about the double iteration of this process.

In fact, in spite of the inherent nature of the algorithm, which uses a step-by-step process, adding pairs of cases in succession, it was also necessary, in order to obtain valid processes, to iteratively experiment with combinations of the 8 activities. This process resulted in 3 grouping or clustering processes for the 86 municipalities in the North.

In the first process, the municipalities were grouped into 6 clusters, based on 5 of the aforementioned 8 activities: Dairy cattle farming (CAE 01410); rabbit farming (CAE01492); dairy industry (CAE 105); Manufacture of grain mill products, starch and starch products CAE (106); Manufacture of bakery products and farinaceous products (CAE 107). The results are shown on the map in Figure 1 and in Table 1.A in the Appendices.

**Figure 2. Northern municipality clusters for establishments in Dairy cattle farming; Rabbit farming; Dairy industry; Manufacture of grain mill products; Manufacture of bakery products, in 2020**



Source: Own elaboration based on INE data (2023a)

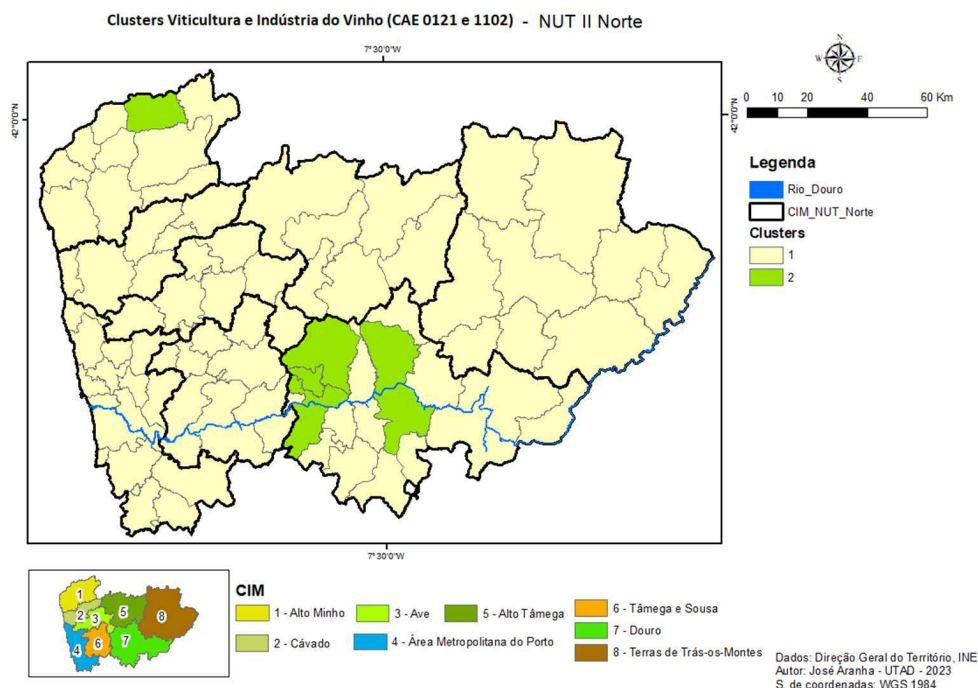


The clusters obtained have the following dominant characteristics:

- Cluster 6 - includes the two municipalities of Porto and Vila Nova Gaia, shown in red on the map, and dominates in terms of average number of establishments in the dairy industry, Manufacture of grain mill products, and also in the manufacture of bakery.
- Cluster 5 - this cluster occupies an intermediate position in most of the activities. It is made up of 8 municipalities, marked on the map in orange.
- Cluster 4 - This is the second largest cluster in the dairy industry, manufacture of grain mill products and the manufacture of bakery. Its 7 municipalities are marked in yellow.
- Cluster 3 - Made up of just one municipality, Barcelos, represented in dark green, which shows total dominance and by a long distance, by average number of establishments in Dairy cattle farming and Rabbit farming.
- Cluster 2 - counties with a strong representation in terms of Dairy cattle farming establishments and some prominence in the dairy industry. 4 counties, shown in light green.
- Cluster 1 - includes the remaining 64 municipalities of NUT II Norte (in cream), which have the lowest average values in most activities, with the exception of rabbit farming and dairy cattle farming.

In the second process of building clusters, and now taking into account the activities of viticulture (CAE 0121) and the wine industry (CAE 1102), the municipalities were grouped into 2 clusters (Figure 3 and Table 2.A in the Appendices).

**Figure 3. Clusters of the municipalities of the North, relative to Viticulture (CAE0121) and Wine Industry (CAE 1102) establishments in 2020**

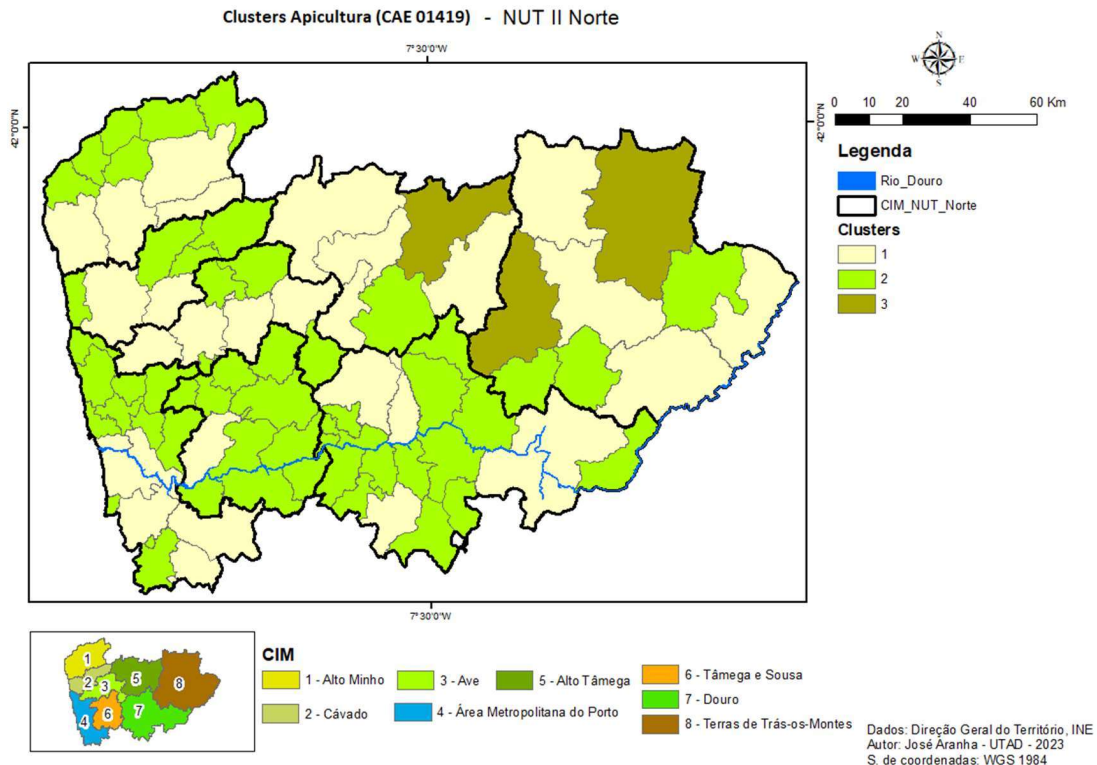


Source: Own elaboration based on INE data (2023a)

In this process linked to vineyards and wine, cluster 2 clearly emerges, made up of 7 municipalities (represented in green on the map), mostly dominated by municipalities in the Douro region. It is clearly evident that these municipalities (Alijó; Lamego; Monção; Peso da Régua; Santa Marta de Penaguião; São João da Pesqueira and Vila Real) have a higher average number of establishments in both viticulture and the beverage industry than cluster 1.

Finally, with only Beekeeping (CAE 01491) remaining, which could not be included in either of the two previous processes for reasons of statistical validation, this activity gave rise to a third process, seeking to analyse the similarities between the municipalities, also taking into account the number of establishments declared in 2020.

**Figure 4. Clusters of municipalities in the North, relative to beekeeping establishments (CAE 01491) in 2020**



Source: Own elaboration based on INE data (2023a)

Given the fact that there is only one variable, analysing the clusters is simpler and, without the need for additional tables, the municipalities were grouped according to the density of the average number of beekeeping establishments (Figure 4), resulting in 3 clusters:

- Cluster 3 - Composed by three municipalities: Chaves; Bragança and Miranda, marked on the map in dark green. These are the municipalities with the highest number of establishments, with an average of 24.6 establishments per municipality.
- Cluster 2 - Represents the majority: 52 municipalities, around 60% of the municipalities under analysis, coloured in light green. Beekeeping in this cluster is very small, with an average of 2.6 per municipality.
- Cluster 1 - Comprises the remaining 31 municipalities. Represented on the map in beige, they have an average of 8.8 per municipality.

It should be noted that the only variable available for this more micro territorial analysis - the number of establishments - will certainly not be as interesting as those available at a higher geographical level, namely the number of people employed or GVA, but this is an insurmountable limitation due to data protection.

However, we believe that the territorial diversity within each NUTs III and at the same time the specificity of the level of the activities analysed justifies the interest, even with these limitations, of the study at county level and for these subclasses at the level of the CAE.

## 7. Discussion and final considerations

The analysis of the relative location of agri-food activities and of the specialization of NUTs III regions in Região Norte allowed us to group agri-food activities for which we obtained a relative location/specialization in three distinct groups, accordingly to the contribution of Região Norte to total sectoral employment and/or turnover.

The agri-food activities for which the contribution of Região Norte to the national total of personnel employed and /or turnover is very relevant and in which the region's NUTs III are relatively specialized are viticulture and wine industry, dairy farming and manufacturing of dairy products, manufacturing of grain and mill products, bakery and farinaceous, rabbit farming and beekeeping.

Following on from the analysis of the location of productive activities and the specialisation of regions, the next point was to group the municipalities of Região Norte according to common characteristics, i.e. to build clusters. Thus, taking into account the 8 activities in which the northern regions show a relative location quotient and at the same time a significant contribution to GVA, and based on a multivariate statistical procedure, groupings of municipalities with similar characteristics were obtained. Three cluster-building processes contributed to this process, in an iterative logic, in order to include all the desired activities.

Thus, from the first process, we conclude that in terms of the average number of establishments in the dairy industry (CAE 105); in manufacture of grain mill products, starch and starch products (CAE 106) and also in the manufacture of bakery and other products (CAE 107), the municipalities of cluster 6 (Porto and Vila Nova de Gaia) dominate, followed by those of cluster 4 (municipalities of Braga; Guimarães; Vila Nova de Famalicão; Gondomar; Matosinhos; Oliveira de Azeméis and Santa Maria da Feira).

As for dairy cattle farming (CAE 01410), the average number of establishments in the municipality of Barcelos (cluster 3) prevails, followed by the municipalities in cluster 2 (Viana do Castelo; Arouca; Póvoa de Varzim and Vila do Conde).

With regard to rabbit farming (CAE 01492), although on average it is dominated by the cluster in the municipality of Barcelos, it is an activity represented in 33 municipalities, mostly in the interior north.

The second process focused on analysing the activities of viticulture (CAE 0121) and the wine industry (CAE 1102), resulting in a map with 2 clusters, in which cluster 2, made up of 7 municipalities, mostly in the Douro region, dominated both in terms of the number of viticulture establishments and the wine industry.

Beekeeping (CAE 01491) was analysed in the last process, which showed that the activity is present throughout the north, despite with a small number of establishments, certainly also associated with some informality, with an area close to the north-east of Trás-os-Montes standing out, with a much higher relative concentration of production units.

Finally, these results from grouping municipalities into clusters based on the number of establishments are very close to those obtained in studies on regional production basins. We are referring in particular to the results presented in the last major study on the agri-food sector in Região Norte (Fernandes and Baptista, *op. cit.*), where a mapping of crops in the North is presented, based on areas, production and/or animal numbers. This is the case with vineyards, where the Douro Demarcated Region stands out as the main Portuguese wine-growing region. This work also shows the distribution of dairy farming, highlighting a strong concentration of milk production in the municipalities of Vila Conde, Barcelos, Póvoa do Varzim and Famalicão, and beekeeping, especially in the municipalities of Penafiel and Mondim de Bastos.

So, the results obtained through clustering processes based on the number of establishments can be a methodological alternative to mapping production basins based on various variables, data which is sometimes very time-consuming and difficult to obtain.

We believe that these results are relevant, taking into account the guidelines of the various official documents relating to the smart specialisation strategy (Agência Nacional de Inovação, 2022; CCDR-N, 2023a; CCDR-N, 2023b). In fact, we consider that knowledge of the regions' production profile and regional specialisation is fundamental to meeting the challenges facing the agri-food sector. Namely, this knowledge is important for:

- boosting efficiency and optimising production by exploiting comparative advantages and reducing costs through economies of scale;
- planning for more sustainable development with efficient use of natural resources and mitigation of environmental impacts, since understanding the production profile can enable more rational use of water resources, soils and other inputs, promoting agricultural practices that are better adapted to the local ecosystem;
- promoting food security by diversifying crops, reducing dependency and at the same time fostering resilience in the event of adverse events;

- encouraging innovation and research, because with detailed knowledge of regional conditions, research and the development of specific technologies that better meet local needs can be targeted and facilitates the dissemination of innovative practices and technologies adapted to the specific conditions of each region.
- to encourage better market planning and the creation of product commercialisation strategies, as well as improving the logistics associated with distribution.
- to promote regional development by creating jobs, boosting the local economy and attracting investment

Finally, knowing the production profile and regional specialisation helps governments formulate more effective public policies, targeting subsidies, tax incentives and technical support where they are most needed and it promotes a more efficient, resilient and sustainable agri-food sector.

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### Appendices

**Table 1 A. Cluster Statistics for Dairy cattle farming (CAE 01410), Rabbit farming (CAE 01492); Dairy industry (105); Manufacture of grain mill products (CAE 106); Manufacture of bakery products (107) Activities**

Descriptives									
CAE	Cluster	N	Mean	Std. Dev.	Std. Error	95% Confidence Interval for Mean		Mín.	Máx.
						Lower Bound	Upper Bound		
Dairy cattle farming (CAE 01410)	1	64	5,33	8,321	1,040	3,25	7,41	0	39
	2	4	50,50	10,083	5,041	34,46	66,54	37	61
	3	1	143,00					143	143
	4	7	14,86	7,559	2,857	7,87	21,85	2	26
	5	8	4,50	4,140	1,464	1,04	7,96	0	11
	6	2	2,50	2,121	1,500	-16,56	21,56	1	4
	Total	86	9,66	19,187	2,069	5,55	13,78	0	143
Rabbit farming (CAE 01492)	1	64	0,91	1,488	0,186	0,53	1,28	0	6
	2	4	0,00	0,000	0,000	0,00	0,00	0	0
	3	1	4,00					4	4
	4	7	0,86	0,690	0,261	0,22	1,50	0	2
	5	8	0,25	0,463	0,164	-0,14	0,64	0	1
	6	2	0,00	0,000	0,000	0,00	0,00	0	0
	Total	86	0,81	1,376	0,148	0,52	1,11	0	6
Dairy industry (CAE 105)	1	64	0,56	1,022	0,128	0,31	0,82	0	6
	2	4	1,25	1,258	0,629	-0,75	3,25	0	3
	3	1	0,00					0	0
	4	7	2,57	1,512	0,571	1,17	3,97	0	4
	5	8	0,63	0,744	0,263	0,00	1,25	0	2
	6	2	7,50	3,536	2,500	-24,27	39,27	5	10
	Total	86	0,92	1,596	0,172	0,58	1,26	0	10
Manufacture of grain mill products (CAE 106)	1	64	0,22	0,576	0,072	0,07	0,36	0	2
	2	4	1,00	1,414	0,707	-1,25	3,25	0	3
	3	1	1,00					1	1
	4	7	2,00	2,887	1,091	-0,67	4,67	0	8
	5	8	1,00	1,309	0,463	-0,09	2,09	0	4
	6	2	2,50	0,707	0,500	-3,85	8,85	2	3
	Total	86	0,53	1,195	0,129	0,28	0,79	0	8
Manufacture of bakery products (CAE 107)	1	64	11,20	7,428	0,929	9,35	13,06	1	27
	2	4	34,50	13,626	6,813	12,82	56,18	16	47
	3	1	66,00					66	66
	4	7	83,00	12,596	4,761	71,35	94,65	67	100
	5	8	46,00	6,908	2,442	40,23	51,77	37	57
	6	2	121,50	17,678	12,500	-37,33	280,33	109	134
	Total	86	24,57	27,768	2,994	18,62	30,52	1	134

ANOVA						
		Sum of Squares	df	Mean Square	Z	Sig.
Dairy cattle farming (CAE 01410)	Between Groups	26156,754	5	5231,351	81,510	0,000
	Within Groups	5134,467	80	64,181		
	Total	31291,221	85			
Rabbit farming (CAE 01492)	Between Groups	17,229	5	3,446	1,917	0,101
	Within Groups	143,795	80	1,797		
	Total	161,023	85			
Dairy industry (CAE 105)	Between Groups	115,841	5	23,168	18,426	0,000
	Within Groups	100,589	80	1,257		
	Total	216,430	85			
Manufacture of grain mill products (CAE 106)	Between Groups	31,958	5	6,392	5,717	0,000
	Within Groups	89,438	80	1,118		
	Total	121,395	85			
Manufacture of bakery products (CAE 107)	Between Groups	59909,222	5	11981,844	170,201	0,000
	Within Groups	5631,859	80	70,398		
	Total	65541,081	85			

R<sup>2</sup>=88,6%

Source: Own elaboration by IBM SPSS and with data from INE (2023a)

**Table 2.A. Cluster Statistics for Viticulture (CAE0121) and Wine Industry (CAE 1102) Activities**

Descriptives									
CAE	Cluster	N	Mean	Std. Dev.	Std. Error	95% Confidence Interval for Mean		Mín.	Máx.
						Lower Bound	Upper Bound		
Viticulture (CAE0121)	1	79	120,949	149,104	16,776	87,552	154	2	588
	2	7	1058,000	181,597	68,637	890,051	1226	873	1 399
	Total	86	197,221	298,587	32,197	133,204	261	2	1 399
Wine Industry (CAE 1102)	1	79	6,291	8,700	0,979	4,342	8	0	42
	2	7	24,143	12,006	4,538	13,039	35	9	39
	Total	86	7,744	10,186	1,098	5,560	10	0	42

ANOVA						
		Sum of Squares	df	Mean Square	Z	Sig.
Viticulture (CAE0121)	Between Groups	5646155,005	1	5646155,005	245,489	0,000
	Within Groups	1931965,797	84	22999,593		
	Total	7578120,802	85			
Wine Industry (CAE 1102)	Between Groups	2049,211	1	2049,211	25,429	0,000
	Within Groups	6769,161	84	80,585		
	Total	8818,372	85			

R<sup>2</sup>=74,4%

Source: Own elaboration by IBM SPSS and with data from INE (2023a)