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Using input-output to disentangle the farm income problem: an integrated macro-micro level analysis

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Sommario

Despite its long-standing presence in the debate, the "farm income problem", namely the gap between agricultural incomes and the incomes of the other sectors, has been usually tackled separately by either macroeconomic approaches or microeconomic studies. In this work we integrate both approaches. Firstly, by employing input-output techniques to evaluate both the profitability and the positioning of Tuscan agriculture in agri-food value chains. Secondly, we build up a novel microeconomic dataset of Tuscan firms and assess how macroeconomic indicators are mirrored by the performances of firms serving the agri-food value chain. The results show that the structure of the food value chain impacts agricultural firm profitability.

JEL codes: Q12, Q18, R15
Keywords: farm income problem, input-output analysis, agri-food value chains

1. INTRODUCTION[1]

The European motto "*from farm to fork*", aimed at reducing the length of the food value chains to bring more healthy and sustainable food to consumers, is contradicted by the evidence of the regional fragmentation of the food value chains and the distance between farmers and consumers. Typically, agriculture is an upstream sector, producing raw materials, and its profitability is conditioned by several exogenous factors (e.g., climate conditions, international prices). However, even in the case of final agricultural goods (fruits and vegetables), the high number of commercial intermediaries, as well as the market power exerted by the latter ones, negatively affect either the margins of profitability of farmers or the final prices paid by consumers (Petriccione, 2011; Pezzoli, 2011).
The overall scope of agriculture is far beyond the production of food and entails environmental safeguard, the *presidium* of fragile inner areas, and the provision of several ecosystem services. We are aware that other relevant rural activities actively contribute to the growth and development of rural areas and that hyper-specialization and intensive agriculture are hardly the right answers to the multifaceted concerns about territorial development (Gasselin and Sautier, 2023; Torre, 2020). However, if, among other things, the Common Agricultural Policy (CAP) aims at giving its contribution to the development of smart lively rural areas, we believe that the long-standing issues of the "farm income problem" and the farming economic sustainability are still crucial to avoid the dismantling of the sector.
The main aim of this paper is to find out whether, in the very specific case of Tuscany, the farm income problem still exists, and it is influenced by the positioning of agricultural firms in the agri-food value

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chain. Our study focuses on the remuneration of the factors in agriculture vis-à-vis the other industries involved in the provision of food. According to the existing literature, the farm income problem has been tackled from different perspectives and levels of analysis. We propose a macro-micro framework that, once defined and estimated the food value-chain, measures how the value added is distributed among the factors of each sector involved in the production of food, in order to understand if agriculture is under-remunerated with respect to its contribution. Therefore, the farm income problem is not evaluated at the level of available incomes for farm households but as the share of the "cake" able to grant margins of profitability similar to the other sectors.
The relevance for the regional sciences is twofold. On the one hand, the Tuscan agricultural sector is a fragmented small sector, composed of a limited number of big companies, controlling most of the cultivated area and hiring the largest share of available workers, and numerous small and very small farms, with limited access to resources and markets. However, the local development of many remote areas of the region depends on them, because of the integration with other valuable activities and their contribution to the reputation and promotion of the region worldwide. More generally, their existence is relevant *per se* because they provide crucial ecosystem services by carrying out their usual activities.
Secondly, we use an interregional input-output table (IRIOT) for Italian regions so as to reconstruct the trade flows between regions and estimate the distribution of value added across sectors in the Tuscan agri-food chain, highlighting the positioning of agriculture and singling out factor remuneration of both production and post-production phases. In this respect, there is a lack of studies that undertake an interregional perspective in addressing issues related to regional development (exceptions are represented by, e.g., Christensen et al., 2022; Capello et al., 2023; Van Oort and Thissen, 2021; Bentivogli et al., 2019; see also Salotti, 2022). This is mainly due to the lack of data about interregional trade flows. In this respect, the interregional input-output tables produced by IRPET (see, e.g., Paniccià and Rosignoli, 2018) offer a unique source of information to study how Italian regional production systems are integrated among each other and in diverse value chains, among which those activated by household demand for food stand[2]. Moreover, in this work we integrate the macroeconomic evaluation with a microeconomic assessment rooted in firm balance sheets. Indeed, recognizing that assessing firm heterogeneity represents one of the major challenges for regional science (see, e.g., Mazzola and Pellegrini, 2021), we build up a novel microeconomic dataset of Tuscan firms and assess how macro-economic indicators are mirrored by the performances of firms serving the agri-food value chain.
The paper is structured as follows. After a brief discussion about the farm income problem (section 2), section 3 provides the methodological framework for both the macro-level analysis and the micro-level analysis. Section 4 describes the main data-sources used and section 5 the main results achieved. Finally, we present some points of discussion and conclusive remarks.

2. THE FARM INCOME PROBLEM

The so-called "farm income problem" (e.g., Gardner, 1992), namely the gap between agricultural incomes and the incomes of the other sectors which suggests the need to bring farmers' earnings to converge with the levels of the other sectors, has justified the European economic support to farmers over time (Sotte, 2022). The reasons identified at the basis of this gap are the low elasticity of demand to income and food supply, always conditioned by climate variability and other exogenous factors, the variability and instability of prices, and the relatively low returns on investments in technology (USDA, 2007; Mishra, 2002).
Is there still a "farm income problem"? Studies from Gardner onwards have underlined that the gap between farmers' income and the incomes of other sectors has narrowed over time. A recent longitudinal empirical study by Marino et al. (2021), who used the EU-SILC survey on the well-being of European citizens in the decade 2005-2015, highlights that, except for Central Europe, farming families are not poorer than others, especially those with primary agricultural income.

[2] An alternative source of information is represented by EUREGIO input-output table (Thissen at al., 2018), which integrates in the same input-output structure the economies of all European NUTS2 regions. With respect to the interregional input-output table used in this work, however, EU-regio provides information for a lower number of sectors (14 vs. 43). Furthermore, it is not integrated with COICOP household expenditure functions which are of paramount importance for estimating the degree of integration of agricultural in food value chains.

The variability of the results depends on the approach used, whether on the production or on the consumption side, on the variables used to measure income and related indicators, and on the available sources of data, which are always fragmented and dispersed in the case of agricultural analysis (Hill, 2018).
For instance, one way of tackling the farm income problem consists in evaluating the gap between the incomes of farmers with respect to the ones earned by other households in the economy (see, e.g., Marino et al., 2021). In a macroeconomic framework, this is usually done via analyses of social accounting matrices (SAM; e.g., Mainar-Causapé et al., 2020), in which the perspectives of farmers as producers as well as part of the household institutional sector are considered, thus offering a complete and consistent picture of the issue within a single economic framework.
Our study concentrates instead on the remuneration of factors in agriculture intending to find out if agriculture is under-remunerated, compared to other sectors of the economy, and if it depends on its backward positioning in food value chains. The under-remuneration contributes to the farm income problem by reducing the total amount of profits to be distributed among farmers. Indeed, as far as the farm income problem persists, relevant motivations may be connected to the internal problems of the agricultural sector (e.g., different productivity or efficiency) but the originality of the study is its focus on the structure of the food value chains.
Accordingly, one of the main aims of the 2023-2027 CAP is to improve the positioning of farmers along the agri-food value chain, so as to increase their incomes and limit the asymmetric transmission of prices along the value chain (Cagliero et al., 2019). Indeed, in times of constant prices and stable supply, the issue is less crucial, even if some imbalances along the supply chain might persist (Pecci, 2011; Zaghi e Bono, 2011). However, the triggering of inflation and the increasing probability of supply crises at the global level, due to the diffusion of unpredictable natural disasters associated with climate change, have recentralized the issue of redressing these imbalances, since farmers risk to be "squeezed" between the mounting costs of inputs and the inability to increase their profits.
Moreover, the growing complexity of the agricultural world and its heterogeneity make it even more difficult to estimate the remuneration of factors (Finger and El Benni, 2021). A variety of business models are observed in the agricultural world that move on a broad continuum, ranging from micro and small companies, mainly dedicated to self-consumption and integration of the primary income, to the more market-oriented big companies, with a large concentration of physical, financial, and human assets. For example, in the case of Tuscany, half of the utilized agricultural area (UAA) is cropped by 5% of the biggest companies and 100% of employees are hired by only 16% of the farms (IRPET, 2022; IRPET, 2022a).
Profitability can also vary based on the capacity to differentiate production. Generally speaking, agricultural products are intrinsically more homogenous compared to food products. However, the margins of differentiation of the so-called "fictitious differentiation" - i.e., based on some additive characteristics determined by marketing, including advertising, branding, labeling, and any other element that can confer specificity and non-approval to the product - has increased over time (Saccomandi, 1999), because of the ever-increasing focus on the territories of origin, quality, health, safety and production methods characterized by environmental or social sustainability.
To verify if agriculture in Tuscany is under-remunerated vis-à-vis the other sectors involved in the food value chains, the analysis at the macro-level is performed via an interregional input-output table, which allows the identification of the food value chains, as well as of the actors involved and their positioning along them (see also, e.g., Nucera et al., 2016; Finizia and Merciai, 2012). When going micro, instead, we focus on the evaluation of the profitability of agricultural firms vis-à-vis the firms in other sectors involved in the supply of food and provide a first assessment of whether the former one is affected by the position of farmers in the value chain.
The agri-food value chain is defined as the set of "distinct and separable technological stages of production associated with the use of a certain resource or with obtaining a specific product. The productive-technological supply chains serve to highlight the interrelationships existing between the various production phases, the technological stages relating to the use of the agricultural product and the relative markets" (Saccomandi, 1999: pp. 36-37). This definition can be complemented by the framework provided by Gereffi and Fernandez-Stark (2016), which define a value chain as "the set of activities that companies and workers carry out to bring a product from its conception to its final use and beyond. This includes research and development (R&D), design, manufacturing, marketing, distribution and final consumption support" (p. 7). In such a definition, the role of consumption in

activating the set of activities aimed at producing food is highlighted, together with the post-production stages.
Given the structure of the value chain, factor remuneration at different stages has been assessed by economic research from different perspectives and methodologies. In this respect, the power of actors in the pre- and post-production phases in capturing value added in global value chains is widely recognized (the so-called *smile curve*; see, e.g., Mudambi, 2008; Rungi and Prete, 2018). Studies have also pointed out how the structure of the agri-food value chain, and in particular the presence of powerful wholesalers and food processing firms, can affect the gains for farmers (see, e.g., Lee et al., 2012; Gereffi and Christian, 2010).
Our work is also indebted to other studies in the literature. Indeed, the input-output techniques have been used to both find out the linkages between the sectors of the agri-food systems (see, in a SAM-based perspective, Rocchi et al., 2020; Viccaro et al. 2018) and evaluate the distribution of the value added among the sectors (Nucera et al., 2016; Finizia and Merciai, 2012). To our knowledge, the present study is the first one examining the connection between the positioning of a regional agricultural sector in the food value chains and the farm income problem from an interregional perspective.

3. THE METHODOLOGICAL FRAMEWORK

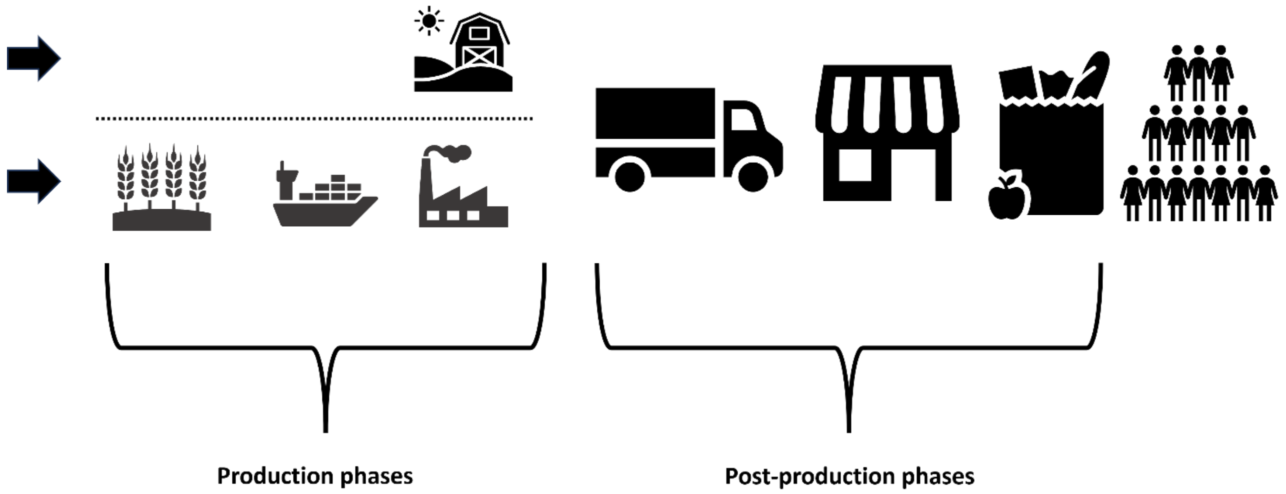
3.1 The macroeconomic input-output perspective

To reframe the farm income problem in a food value chain perspective from the macroeconomic point of view, we need both a methodology and the data able to consistently measure the problem, define and estimate a food value chain, and connect the two. In other words, our aim is, first, to estimate the farm income compared to other sectors involved in the food supply chain. Once estimated the extent of the farm income problem, we want to link it to the structure of the food value chain; and, in particular, to the (lack of) ability of the agricultural sector to extract value added from the final price paid by final consumers.
As to the measuring of the extent of the farm income problem, regional accounts allow to compute value added, gross profits and wages, together with units of labor (employees and self-employed units) at the sectoral level, so that the farm income can be compared with that arising in the other sectors potentially involved in the value chain (e.g., the food processing industry)[3]. In this respect, a low value added per unit of labor and/or a low gross operating margin per unit of independent labor might signal a low productivity level and a low propensity to invest (via low capital depreciation) of the agricultural sector vis-à-vis the other industries involved in the provision of food. However, value added also depends on the capability of a sector to negotiate a "fair" price for its output with its clients positioned forward in the value chain, which depends on the inner characteristics of both the sectors and the supply chain. For example, the higher the level of both fragmentation of the agricultural sector and concentration of the forward sectors, the higher the probability of small agricultural firms being "squeezed" and under-remunerated.
To understand if the characteristics of the food supply chain negatively affect the relative remuneration of the agricultural sector, we need to consider production as a coordinated network in which different sectors intervene to produce and distribute specific final goods (in our case food). In other words, once defined the composition of the food value chain(s), we analyze the positioning of agriculture vis-à-vis the other sectors in terms of factors' remuneration.
Let us start with a definition of a food value chain that is consistent with that of the well-known vertically integrated sector (Pasinetti, 1973)[4]. In particular, we define it as the bundle of production and distribution steps activated in order to satisfy the final demand for food arising in a specific area, either a region or a country.

[3] Of course, gross operating margin alone is not a perfect measure of farm income. On the one hand, it includes further items than income, the most important being capital remuneration (i.e., depreciation). In this respect, higher margins might correspond to a sectoral higher propensity to invest. Second, income considered here only relates to primary income distribution. Indeed, our study must be read as complementary with SAM-based works in which farmers as an institutional sector and their incomes emerge.
[4] See also Viccaro et al. (2018).

Figure 1 graphically depicts what is meant in the context of this work. In response to the household demand for food, firms belonging to different sectors produce final goods to directly meet consumer needs. According to Figure 1, the food consumption basket is directly “served” by firms belonging both to the agricultural sector and to the food processing industry. At the same time, firms' production processes might require raw materials as well as intermediate goods and services provided by other plants, which do not necessarily belong to the same industry. This gives rise to a second production step. The process may be further extended, as firms engaged in the second step also demand intermediate inputs and may activate additional production steps. The value chain associated with food demand is therefore defined by the set of firms (and production activities) involved in all the production processes originating from it. Apart from production phases, Figure 1 also points out that producers and consumers are linked to each other via post-production steps, represented by, e.g., transportation and commercial services. The final price paid by consumers, net of indirect taxes, is the sum of value added contributions of all the actors involved in the value chain. And in our framework the positioning of agriculture vis-à-vis the other sectors involved in the food value chain will take into account all the production and post-production steps activated to satisfy the household demand for food.

Figure 1.
Graphical representation of a food value chain



Within the interregional input-output structure of the data, we can algebraically define the food value chain as the combination of two components: i) a food demand shock originating from a given area; ii) the set of production processes activated to respond to it. Let $Fd_{z,s}$ be an *(MxN)x1* final food demand shock vector[5] affecting region *s,* and *A* the matrix of input coefficients obtained by dividing the intermediate input demand of each sector (*i*) in every region (*j*) by its total output (Y_{ij})[6]. In terms of production, a food value chain can be defined as:

$$Fd_{z,s} + AFd_{z,s} + A(A)Fd_{z,s} + A(A^2)Fd_{z,s} + \cdots + A(A^{n-1})Fd_{z,s} = (I-A)^{-1}Fd_{z,s} = Y_{z,s} \quad (1)$$

with $n \to \infty$ defining the iteration step. The left-hand side of the equation reports the chain of production steps activated by the food final demand shock as a power series approximation. First, the shock itself, which is accommodated by a particular industry, or set of industries; then the first round of demand for intermediate inputs required to accommodate the final demand shock; subsequently, the production of intermediate inputs needed to produce the intermediates demanded in the previous round; and so on.
From equation (1) we can then recover sectoral/regional value added, profits and wages activated in order to serve the final demand shock as:

[5] The number of rows (*MxN)* in an inter-regional framework is equal to the number of regions (M) times the number of sectors (N).
[6] Letting *T* be the matrix representing the flows of intermediate inputs and *Y* a diagonal matrix containing the output of each sector in every region on its main diagonal, the input coefficient matrix *A* is obtained by post-multiplying *T* by the inverse of *Y*, i.e., $A = TY^{-1}$.

$$\hat{X} \cdot (I - A)^{-1} \cdot Fd_{z,s} \quad (2)$$

with $\hat{X}$ being a diagonal matrix containing along its main diagonal either the value added coefficients, or the gross operating margin coefficients, or the labor cost coefficients, depending on the object of the analysis.

Since, according to such a perspective, a given sector of the economy can be activated by different final demand needs (e.g., clothing, education, health, etc.), we can describe each industry according to the shares of different final demand needs in generating its value added (and components). Moreover, we can assess how much of the value added is generated by directly serving the final demand shock and how much is instead due to its role as a supplier of intermediate inputs.

Given the definition of the food value chain just provided, we can highlight two main production networks aimed at providing food in which agriculture is involved. In the first one, agriculture furnishes intermediate inputs to the food processing industry, which in turn provides the final goods. In the second one, agriculture directly produces the final good demanded by the households. In the analysis of the results, we consider these two prodromic cases and analyze how both production and post-production factors are remunerated for each euro spent by final consumers.

Concentrating upon the production side of the value chain, these two value chains can be obtained from:

$$\hat{X} \cdot (I - A)^{-1} \quad (3)$$

Being the IRIOT at basic prices, each column of the matrix in equation (3) returns the sectoral remuneration in the production steps required to provide the bundle of goods it produces, being intermediates or final. In the cases of Tuscan agriculture and the Tuscan food processing industry, the two value chains will be represented by the corresponding columns in the matrix in equation (3).

However, concerning the definition of the food value chain as a bundle of both production and post-production steps, equation (3) only focuses on the production side and hides the roles played by commercial services and transports in connecting final good producers, both farmers and the food processing industry, and consumers. In other words, interpreting final good expenditures as the sum of sectoral value added contributions, there is a wedge between the price paid by the final consumers and that received by the final good producer defined in equation (3). Such a wedge includes, among other things, commercial and transportation margins. Such margins, directly paid by consumers to the providers in tables at basic prices, can be incorporated into the analysis starting from an IO table at purchasing prices.

In order to reconstruct the different prices paid on food products by households depending on the sector selling the final goods, we started with national Supply and Use tables at purchasing prices and applied the methodology described in ISMEA (2013). Moreover, we adjusted the margins to regional tables by considering as further constraints the amounts devoted to net indirect taxes, energy services, transportation margins, and commercial margins applied to the regional demand for food in the IRIO table described in Figure 2. Once estimated the above-mentioned margins, we did add them up to agricultural and industrially processed final goods stemming from equation (3) and normalized the sum of each of the two column vectors to 100. With such a transformation we could derive, for both vertically integrated sectors, the price finally paid by final consumers on final goods as the sum of the value added contributions (interpreted as shares) of both, the production and post-production phases:

$$P_i = \sum_x VA_{i,x,prod} + \sum_x VA_{i,x,post} = 100 \quad (4)$$

Where P_i is the price paid by the household paid on food produced by sector *i*; $\sum_x VA_{i,x,prod}$ is the sum of value added contributions of different sectors (indexed by *x*) in production phases; $\sum_x VA_{i,x,post}$ is the sum of the value added contributions of different sectors (also indexed by *x*) in post-production phases.

By complementing the analysis of production stages of the value chain (eq. 3) with post-production phases (stemming from eq. 4), we can disentangle two aspects of the farm income problem. On the one hand, we can consider the profitability of farming in terms of value added, gross operating margins and labor cost out of each euro of production (eq. 3). On the other one, we can uncover the gap between how much consumers are willing to pay for the final goods and what is left to the farmers (eq. 4).

3.2 The microeconomic perspective

After having connected the farm income problem to the positioning of agriculture in the food value chain from a macroeconomic input-output perspective, we embed firms into the analysis. The general objective of this work is indeed to analyze the microeconomic heterogeneity of profitability of agricultural enterprises vis-à-vis the other sectors in charge of producing and distributing food and to connect it to the structure of the value chain. To do that, we first need to construct profitability indicators as far as possible consistent with the macroeconomic analysis developed through the input-output table, notably: production, intermediate costs, value added and, as components of the latter, gross operating profits, and labor cost.

In this respect, it is not possible to reconstruct the full microeconomic counterpart of equation (3) because we don't have information about microeconomic interrelations among firms. However, from the perspective of the agricultural vs. food processing industrial firm, we can make use of balance sheets data to construct the ratio between, alternatively, value added, gross operating margins or labor cost and output (or sales). These indicators will constitute a proxy of how much each single firm is able to extract, in terms of value added or profits, from a 1 euro of production. Moreover, gross operating profits (divided by independent laborers in the firm) return a measure of the average income earned by farmers.

As stated in Section 3.1, equation (3) only returns information about the production phases of the value chain. However, an analysis of the positioning of firms in the food production network would require to distinguish firms according to the characteristics of their clients. In this respect, constructing the microeconomic equivalent of equation (4) necessitates of microeconomic data about the relations between producers and distributors. Given the unavailability of such information in the standard microeconomic database, we rely upon the information stemming from a survey on agricultural firms realized in 2019 (see Turchetti and Chini, 2019) through which we investigate the performances in terms of profitability of agricultural firms depending on the preferred distribution channels. In particular, we separated firms directly selling their products to households (also through farmer organizations and cooperatives) from those instead working to serve longer value chains, and thus selling to food processing firms or wholesale and retailing. Since each firm, in principle, can differentiate among different distribution channels, we classified them into two groups according to the higher share between the two channels under the constraint that at least 30% of the output was destined for that distribution channel.

4. DATA

According to the definition of the food value chain given in section 3, the input-output framework appears to be well suited to analyze the positioning of different sectors within it. In this respect, our analysis starts from the interregional input-output table at basic prices estimated by IRPET[7].

A graphical representation of the IRPET interregional input-output table is reported in Figure 2 (reference year: 2018). The interregional input output table (IRIOT) contains information for 43 sectors and 20 Italian administrative regions (plus extra-regio). Each row of the matrix indicates the destination of the production generated by a sector *j* located in a region s distinguishing, in terms of intermediate uses, the region and the sector demanding such inputs; in terms of final uses, the region and the specific final demand component. Moreover, the last two columns identify changes in inventories and foreign exports.

Reading the IRIOT by column provides information about production requirements in terms of intermediate inputs and productive factors services of each single sector/region. Evidently, in IRIOT, the origin of the intermediate inputs is distinguished by sector and geographical area of origin (apart from imports). The total of each single column of the intermediate part of IRIOT is the sectoral total output as the sum of demand for intermediate inputs, value added at basic prices and net indirect taxes.

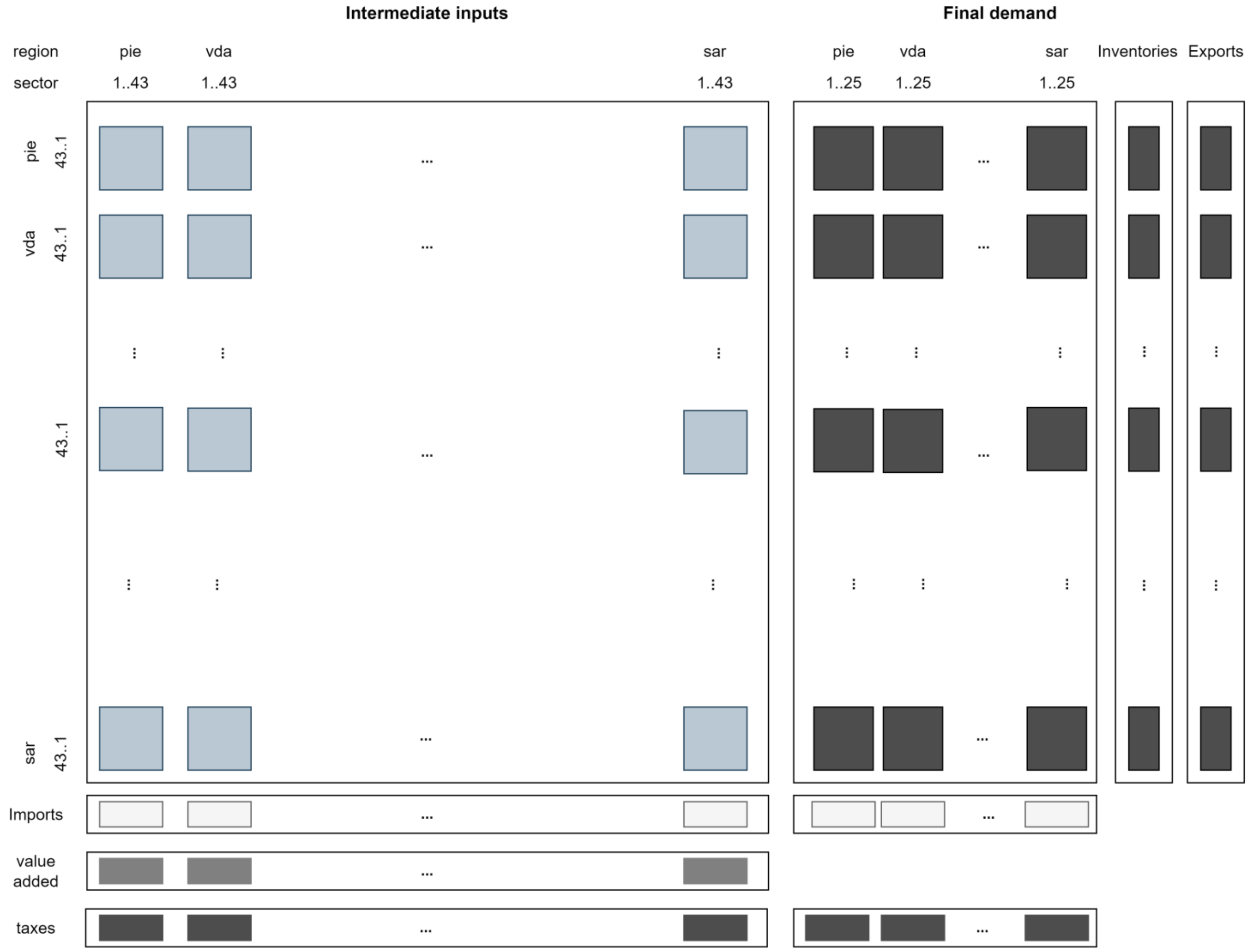
The accounting structure of the table can be summarized by the following identity, for each *j*-th sector and *r*-th region:

[7] See Paniccià and Rosignoli (2018) for the methodology use for estimated those tables and Bentivogli et al. (2019) in order to review the IRIO model specification.

$$\sum_{s=1}^{N}\sum_{i=1}^{M}x_{ij}^{sr}+va_j^r+tax_j^r+imports_j^r\equiv\sum_{s=1}^{N}\sum_{i=1}^{M}x_{ji}^{rs}+\sum_{s=1}^{N}\sum_{z=1}^{Z}Fd_{s,z}^{rs}+inv_j^s+exports_j^s \qquad (5)$$

Where: N = number of regions; M = number of sectors; Z = number of final demand components; x = intermediate goods and services; va = value added at basic prices; Fd = final demand; tax = indirect taxes; *imports* = intermediate input imports; *inv* = changes in inventories of final products; *exports* = international exports.
Final demand components at the regional level in the IRIOT foresee household consumption divided into 12 COICOP expenditure functions[8]; public administration consumption divided into 10 expenditure functions[9]; fixed capital formation; non-profits institutions serving households; valuables.

Figure 2.
A graphical representation of the IRPET interregional input output table (IRIOT). 2018



Further data used in the macroeconomic side of the analysis is given by Istat Regional Accounts, from which we retrieved information about value added components and employment in terms of labor units, and by the Italian Supply and Use Table at purchasing prices, also released by Istat, which we exploit to single out the value added connected to post-production phases.
In order to estimate the profitability indicator at micro-level, we firstly define the observed population of this study by using the open dataset of the Tuscan Regional Agency for Agricultural Disbursements

[8] The 12 (2-digits) COICOP household expenditure functions include: 1) food and non-alcoholic beverages; 2) alcoholic beverages, tobacco and narcotics; 3) clothing and footwear; 4) housing, water, electricity, gas and other fuels; 5) furnishings, household equipment and routine household maintenance; 6) health; 7) transport; 8) communication; 9) recreation and culture; 10) education; 11) restaurants and hotels; 12) miscellaneous goods and services.
[9] The 10 Public Administration expenditure functions include: 1) general public services; 2) defence; 3) public order and safety; 4) economic affairs; 5) environmental protection; 6) housing and community amenities; 7) health; 8) recreation, culture and religion; 9) education; 10) social protection.

(ARTEA), which contains the shape files of the crop plans, the so-called *Piani Colturali Grafici (PCG)*, that farms periodically submit to the agency[10]. The reference period is three years (2017/2019) and the number of farms for each year is approximately 35,000 (Tab. A1 in the Appendix). Subsequently, we verified the presence of these companies in the tax archives, tracing about three-quarters of them for a total of over 85% of UAA.
To complete the panel with other variables of interest, we used statistical archives from ISTAT (namely, Asia-Local Units, Asia-Frame and Asia-Agriculture Archives) identifying firm size in terms of employees and turnover class and attributing a NACE REV. 2 code[11].
We also used the ISTAT archives to integrate the panel with companies from other sectors. In the three years 2017-2019, we managed to trace a total of 430,000 companies, of which 5.9% belonged to the agricultural sector. To this group, we added 2,767 companies appearing in the ISTAT archives with NACE REV. 2 code corresponding to agriculture but not present in the PCG[12].
To reconstruct the microeconomic counterpart of equation (3) balance sheet information for agricultural firms had then to be retrieved. Information about firm performances in terms of output, value added and profits, mainly stems from tax records. Starting from the tax declarations relating to the payment of the regional tax on productive activities (IRAP: *Imposta regionale sulle attività produttive*), on the one hand, to the tax declarations relating to the agricultural income of persons and companies, and to the income from employment of individuals, on the other, we have reconstructed various archives which were subsequently analyzed, separately and/or jointly in this work[13].
The most complete source of balance sheet information in tax archives at our disposal is represented by IRAP declarations. However, the share of agricultural enterprises subject to it and which fill in the items we need is relatively limited. This is why, in addition to the more comprehensive archive in terms of information, we have reconstructed databases that are less exhaustive in terms of economic items but more complete in terms of the number of companies subject to declaration.
Through the IRAP declarations and the declarations of income from employment of individuals we have reconstructed two databases for the declaring subjects. The first one presents fields relating to the company's value added, labor cost and, by subtraction, gross operating margin. The second, which contains information about only those subjects for whom more information is available, presents data about turnover, production, intermediate costs, and value added in its two components of labor costs and gross operating margin.
To create the first of the two databases, we made use of the IRAP declarations of all the subjects who completed the declaration in the years of interest. For each economic subject, the value added was obtained, alternatively, by the difference between production and intermediate costs or by the sum of its components, according to the parts of the declaration that were filled in. Once estimated the value added of the individual economic entity, we computed the value of the labor cost, alternatively, as the sum of the deductions of income from employment, as the sum of the declared labor cost, or as the sum of the income from employment (appropriately revalued to take into account of the contributions paid) of all those subjects who have indicated the company in question as a withholding agent in income declarations.
The second of the two databases, richer in information but relating to a smaller number of subjects, shows positive items (turnover, production) and negative items (intermediate costs incurred within the period) to calculate the value added (obtained therefore as a subtraction between production and intermediate costs) and contains an estimate of the division of value added between labor costs and

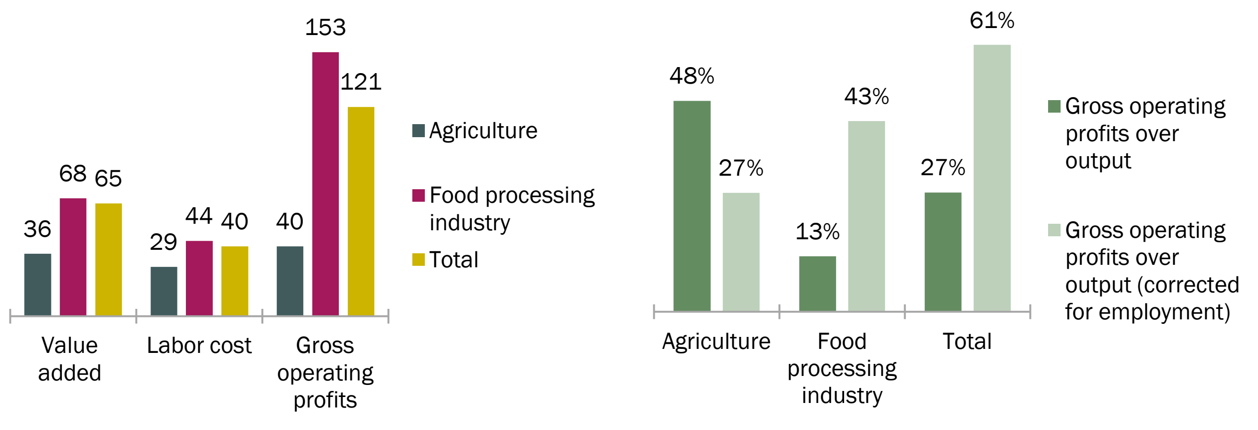
[10] All farmers who intend to demand the economic support within the common agricultural policy (CAP) framework are obliged to present periodically their crop plans. The archive is representative of both the total of active Tuscany farms and the total agricultural area. The data have been preliminarily processed to join the yearly datasets at NUTS2 level in a unique dataset; then we eliminate the records relating to technical-economic units (UTE) not eligible for the utilized agricultural area (UAA).
[11] Table A2 in the Appendix shows some characteristics by turnover class. Three quarters of the companies fall into the top three turnover classes and use about half of the surface area. The average company size in terms of UAA grows with the increase in turnover, as do the number of employees and the incidence of companies with at least one employee, which in the last two turnover classes is 100%.
[12] 86.5% is classified as sector A and for the vast majority as A01: Agricultural crops and production of animal products (81.7%); A02 follows: Forestry and logging (3.9%) and A03: Fishing and aquaculture, hunting and related services (1%) (Tab. A3 in the Appendix).
The remainders specialize in services and only a minority share in processing. 5.9% of farms have a NACE REV. 2 I: Accommodation and restaurant service activities, with a prevalence of accommodation activities, while 1.8% have a NACE REV. 2 G: Wholesale and retail trade.
[13] IRAP is due for the habitual exercise of activities aimed at the production or exchange of goods or the provision of services.

gross operating profits which essentially follows the procedure followed for the construction of the first of the two archives[14].
Tables A4 and A5 in the Appendix display some characteristics of IRAP vis-à-vis non IRAP firms. In particular, they are distributed differently among the various legal forms, with an over-representation of corporations and partnerships and an under-representation of sole proprietorships (Tab. A4). Moreover, IRAP companies represent about 60% of the surface area of our population and half of the total UAA. The average UAA is greater for IRAP firms, but the median is almost the same: the differences in terms of surface dimensions emerge in the long tail of the distribution due to the presence of very large companies, exceeding 1,500 hectares. Differences in terms of number of employees and share of companies with at least one employee are not that relevant (Tab. A5).
Finally, data about the different distribution channels on which agricultural firms rely upon in order to sell their products stems from a survey on agricultural firms realized by IRPET in 2019 through which we could investigate the performances in terms of profitability of agricultural firms depending on the preferred distribution channels[15].

5. RESULTS

The starting point of the analysis is represented by the lower remuneration of factors in agriculture vis-à-vis the rest of the economy; in particular, the other sectors potentially involved in the provision of food. That is shown in Figure 3. The latter one depicts, on the left-hand side, value added, labor cost and gross operating margin of Tuscan agriculture vs. the food processing industry. All the measures are divided by labor units (total in the case of value added, i.e., productivity; employees in the case of labor cost; self-employed workers in the case of gross operating margin). As it can be easily observed, agriculture lags far behind, especially in terms of gross operating profits. At the same time, on the right-hand side, gross profits are shown as a percentage of total output. Without correcting for employment, agriculture displays a higher profitability with respect to the food processing industry.

Figure 3.
The farm income problem in Tuscany in terms of remuneration of factors. Value added, labor cost and gross operating profits in absolute terms (left; thousand euros per worker). Gross operating profits on total output (right; %)

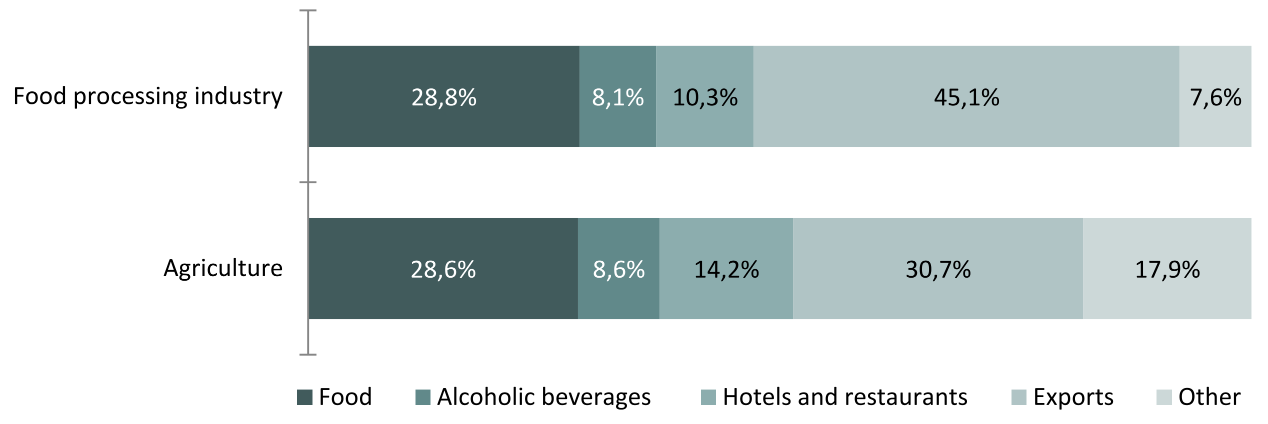


Source: Elaborations on Istat Regional Accounts (2018)

[14] Having reconstructed the first two databases not only for agricultural enterprises but also for all other economic subjects and having available for the latter financial statement information from other statistical sources, we were able to validate the obtained estimates by observing the distributions of the various indicators of interest for companies present both in the tax archives and in the official ones available. As far as agricultural incomes are concerned, we instead added the income items deriving from the RA cadres (agricultural income) of the tax returns of physical persons, partnerships and corporations. Both from the IRAP declarations and from the income declarations of sole proprietorships and companies we have also obtained information relating to the NACE sector of the companies.
[15] The analysis of results from the survey together with the questionnaire can be found in Turchetti and Chini (2019). The survey was submitted to 304 agricultural firms from a population composed by farms which submitted a PGC between 2016 and 2018. The matching with our dataset of agricultural firms returned information for 214 farms. We reweighted the sample according to responses with respect to our population of firms.

When correcting for employment (i.e., dividing the gross operating profits by self-employed units of labor and output by total labor units), we do observe a gap between agriculture and the food processing industry, as well as compared to the rest of the regional economic system. However, as it is clear from comparing the two Figures, the distance between the food processing industry and agriculture is rather lower in this second case. The ratio between the two sectors is 1.61 in this latter case compared to 3.78 in the former one. Data reported in Figure 3 might signal a lower productivity level and a lower level of mechanization of agriculture compared to, e.g., the food processing industry. The scope of the present work is to provide a complementary explanation based on the positioning of agriculture in the food value chain.
In this respect, after estimating the food value chain, together with other production networks based on different final needs, we first compare agriculture and the food processing industry in terms of the different final demand sources of their own value added. Indeed, apart from that for food, other components of final demand contribute to generate the value added of the strategic sectors for food provision. For instance, final demand for alcoholic beverages and for hotels and restaurants. In this respect, we can break down the value added of agriculture and the food processing industry, according to the relative shares of the different value chains they work for. More precisely, we distinguish three needs within the expenditure items of Italian families: food, alcoholic beverages and expenses for hotels and restaurants. These are three items of expenditure that can well represent, for agriculture and food, the set of productions that fall within the food chain. In addition to these, we identify the production intended to serve foreign demand, and then group the others into a residual supply chain.
Assuming the value added of each of these sectors to be 100, Figure 4 shows the relative importance of different value chains in generating sectoral value added. In both sectors, foreign demand is the one that contributes the most to activation, although more for the food industry (45.1% vs. 30.7%). This is not surprising considering the importance for Tuscan exports of sectors such as wine, olive, horticulture and the confectionery and bakery products industry.
The demand for food from Tuscany and the rest of Italy generates almost 30% of the value added in both sectors. Regarding agriculture, which is typically a basic sector, around 40% of this share is activated by intermediate demand, therefore aimed at transformation, while the rest is sold directly to meet the final demand.
Figure 4 also highlights the strong link in Tuscany between agri-food production and hotel and restaurant services, which generate 14.2% of agricultural value added and 10.3% of that of the food industry.

Figure 4.
The sources of value added for food processing and agriculture in Tuscany

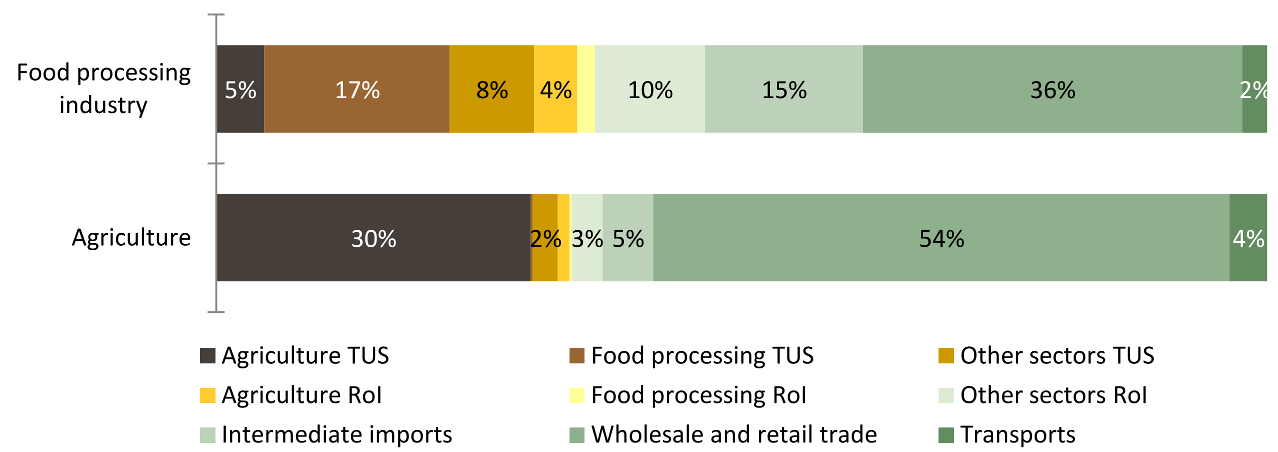


Source: Elaborations on IRPET IRIO table 2018

Once estimated the relevance of food final demand in generating value added of Tuscan agriculture and the food processing industry, we want to study how value added is distributed over it. From the point of view of the consumer who buys a finished product, the price of the latter can be considered as the sum of all the contributions (in terms of value added) to its creation. As shown in equation (4), It includes the remuneration of the commercial activity, of the final producer, and of all those who have carried out the necessary intermediate productions.

Assuming 100 the price paid by the consumer, through the system of input-output tables of IRPET we can thus estimate the distribution of factor remuneration in terms of value added along the production chain. As shown in Section 3, we have "added" post-production intermediation activities, namely commercial and transport margins, to the "production" chain in order to evaluate the distance between the price paid by consumers (which includes trade and transport margins) and the price paid to actual producers (which is net of them).
Figure 5 shows the breakdown of the value added of the agri-food chain, depending on whether the final good is produced by Tuscan agriculture vs. the food processing industry. The share of commercial margins for both sectors is immediately evident, and in the case of agriculture it is even higher (54%). Such results are consistent with previous studies (see, e.g., Finizia and Merciai, 2012). In other words, the price of agricultural products more than doubles in the post-production phases of the food value chain, although the characteristics of the raw material, as shown in section 2, should be central in the determination of the value, as proxied by the final price, of a product.
The value added of agriculture for the direct purchase of agricultural products is about 30%, while when agricultural products are processed and then sold as food products, the margin left to the agricultural sector for factor remuneration is significantly lower (5%). Whereas this might be due to a scarce integration of Tuscan agriculture in the food value chain activating the Tuscan food processing industry, the multiplication of actors positioned forward in the supply chain can further compress farmer remuneration. Indeed, as a study by Nomisma already noted in the 1990s, the Italian agri-food value chains suffer from consolidated imbalances (lack of competition, concentration of distribution, excessive presence of commercial intermediaries), which are often unloaded on farms, reducing their profit margin, or on consumers, by increasing the selling prices of products (Pezzoli, 2011; Petriccione et al., 2011). Consequently, it is said that the increase in consumer prices may not depend on inefficiencies of farms, but, in some measure, on external costs relating to the structure of the entire agri-food chain.
The gross operating margin of Tuscan agriculture, after deducting labor cost, is about two thirds of these two residual shares.
Taking 100 expenditure on food consumption, the value added of the food industry is around 17% and the supply chain is considerably more fragmented in terms of the sectors that participate in it.

Figure 5.
value added remuneration of different sectors being 100 final expenditures on food alternatively produced by food processing industry and agriculture



Source: Elaborations on IRPET IRIO table 2018

Tuscan agriculture faces a high gap between the price paid by consumers and the remuneration of its contribution. Net of the low efficiency, which might partly characterize the agricultural and food activities but also other sectors, the high profitability margins of the downstream sectors, necessarily force the former ones to reduce their profitability margins or the production itself.
We now tackle the issue of the farm income problem from a microeconomic perspective. We estimate profits using gross operating profits (GOP) and profitability using GOP on sales as an indicator. This cannot be done on all companies but only on those subject to IRAP, which are a smaller group of the observed population (see table A4 in the appendix).

An initial estimate of the profits in the three years 2017/2019 confirms that the gap between agriculture and the rest of the economy in terms of profits is significant: the average profit of agriculture is around 25,000 Euro, i.e., 7.5% with respect to the other sectors. As expected, the comparison is limited by the heterogeneous composition of the rest of the production system, whereby the dispersion around the mean is greater and conditioned by many outliers. If we consider the median profit, it is equal to approximately 3,000 Euro, or 17.2% of the rest of the Tuscan economy (Tab. 1).
If we compare agriculture with the other sectors of the agri-food chain, some significant differences are observed, even if the gap remains and, in some cases, is even wider. For example, the average profit of agriculture is 3.1% of that of beverages, which has rather high margins, especially in the long tail of distribution (Tab. 1). All the other sectors of the supply chain show lower profits than those of beverages and lower heterogeneity. The gap compared to agriculture remains high, but it is observed that in the case of the food sector the agricultural median GOP is particularly low. Therefore, even the smallest food companies recover higher profits in absolute terms, both if compared with agriculture and with other sectors.
Finally, another element to take into consideration is the difference between retail and wholesale. Wholesale intermediaries have higher profits not only compared to agriculture, a sector upstream in the supply chain, but also compared to the retail sale of foodstuffs.

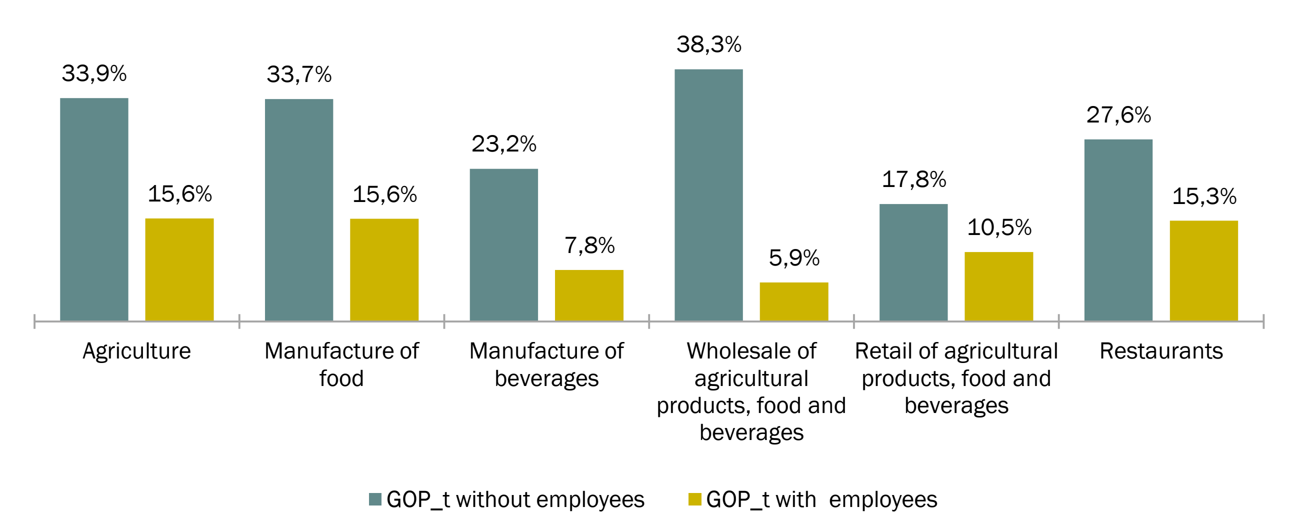
Table 1.
Sectoral mean and median profit and share of agriculture with respect to other sectors (Tuscany; mean 2017-2019)

	Mean	**Median**	**% agricultural mean profit**	**% agricultural median profit**
Agriculture	24.842,7	2.878,8		
Manufacture of food	116.754,6	32.590,9	21,3	8,8
Manufacture of beverages	800.876,5	21.060,7	3,1	13,7
Restaurants	95.136,6	23.472,6	26,1	12,3
Wholesale of agricultural products, food and beverages	93.401,4	25.723,8	26,6	11,2
Retail of agricultural products, food and beverages	51.522,1	16.813,3	48,2	17,1

Source: Elaborations on Tax archives, PCG e ASIA-agricoltura

We have then calculated the share of GOP on turnover (i.e., profitability) and see whether lower profits in correspond to a lower profitability. We broke down the analysis by companies with and without employees. There are 3,661 IRAP farms with employees, therefore one third of the total. In the absence of employees, by definition, profitability is higher, as the cost of labor decreases. As can be seen in Figure 6, there are no significant differences compared to other sectors, while the profitability gap between companies with and without employees emerges.

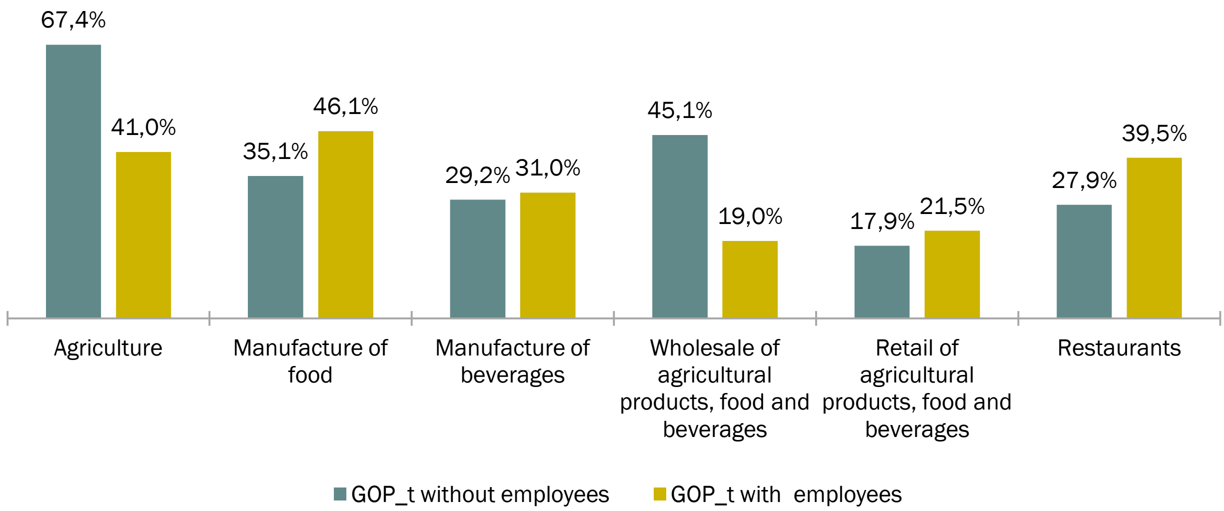
Figure 6.
Median profitability in firms with/without employees (Tuscany; mean 2017-2019)



Source: Elaborations on Tax archives, PCG, ASIA-agricoltura and Asia-imprese

Are the results driven by the extent of labor utilization within different sectors? In order to check for this, we replicate the macroeconomic result stemming from Fig. 3 by correcting both the GOP and sales for labor utilization. In particular, we divide gross operating profits by the number of self-employed workers at the firm level and sales by the firm number of workers (both self-employed and employees). The results are shown in Figure 7. After the correction profitability of agricultural firms without employees is even higher with respect to that displayed by other sectors involved in the food supply chain. At the same time, consistently with what observed at the macro-level, the correction for employment leaves agricultural firms with employees with a lower profitability with respect to firms specialized in the food processing industry[16].

Figure 7.
Median profitability in firms with/without employees correcting for employment (Tuscany; mean 2017-2019)



Source: Elaborations on Tax archives, PCG, ASIA-agricoltura and Asia-imprese

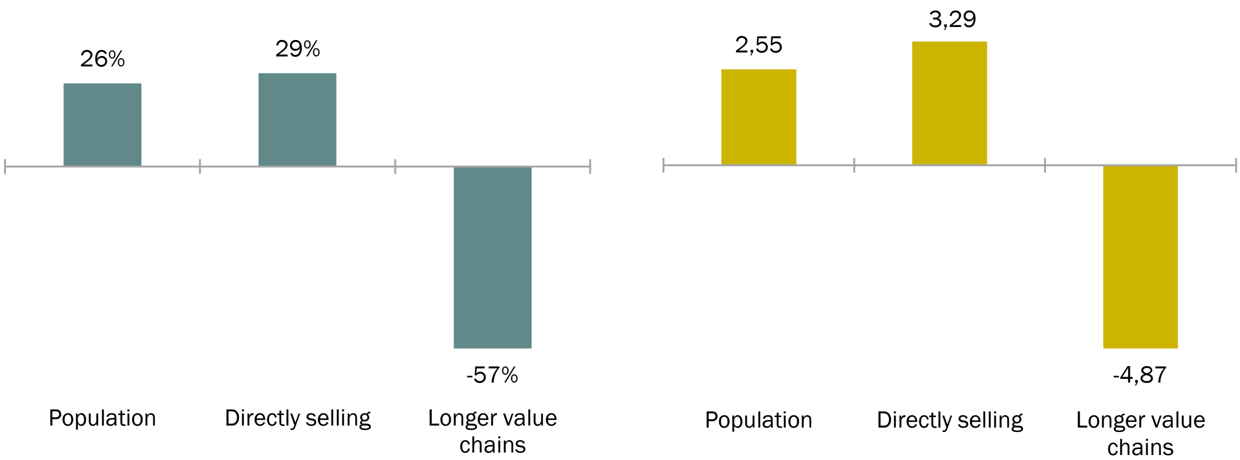
Thus, as a primary result, we observe that while, in terms of profits, there is still a gap between the part of Tuscan agriculture that we observe and the other sectors, profitability is far more comparable with the rest of the economy. Such micro-evidence is consistent with what has been found on the macroeconomic side of the analysis.

The final step of our attempt of reconciling macro- and micro- evidence consists in assessing whether the distance between the price imposed on producers by commercial operators and the price faced by consumers plays a role in compressing profits of agricultural firms. In this respect, by exploiting the results from a survey on agricultural firms realized in 2019 we can disentangle the results on profitability for those firms directly selling their products to households from those instead working to serve longer value chains, and thus selling to food processing firms or wholesale and retailing.

In Figure 8 we report the results for these two types of firms with respect to gross operating margins on sales and per worker (median). The graph clearly captures how firms directly selling to consumers are able to obtain both higher profits and profitability, with those serving longer value chains displaying losses. Although preliminary because based on an analysis performed on a limited number of firms, such results point toward the idea that there is a profitability issue regarding those agricultural firms which serve longer value chains and which are not able to directly serve final demand.

[16] We recognize that the number of self-employed workers remains an imprecise measure of labor effort and some of the partial inconsistencies between micro-results (Figure 7) and macro evidence (Figure 3) might also be due to the inability to fully capture this aspect of farm activity.

Figure 8.
Profitability and profits of agricultural firms depending on their position on the value chain. GOP and sales (left) and GOP per worker (thousand euro; right)



Source: Elaborations on ISTAT, IRPET, PGC, Tax Archives

6. FINAL REMARKS

In this work we tackled the issue of the farm income problem in Tuscan agriculture vis-à-vis the other sectors in the agri-food value chain, combining a macro- and a micro- perspective. Through an input-output macroeconomic framework, we highlighted how a part of the farm income problem resides in the gap between the price paid by consumers and the return to agricultural producers. We also showed that most of this gap is generated by post-production activities, namely commercial services.

Results from the micro analysis are broadly in line with those stemming from the macro input-output evaluation. First, agricultural firms, although displaying profitability levels in line with those of the other sectors involved in the agri-food supply chain, are far behind when we look at profits. This might be because a relevant share of the price of food finally paid by consumers is formed forward in the value chain, in particular in post-production phases of the value chain, and this doesn't allow farmers to get a sufficiently high income from their activities. This guess is confirmed by the survey analysis: firms directly selling to consumers – i.e., also controlling the part of the value chain relating to commercial services – show higher profits and profitability with respect to those serving longer value chains. Although results are based on a limited number of respondents and must be confirmed by census data, they nevertheless show that scarce power exerted by agricultural firms in setting the price of food.

Based on these results, in the case of Tuscany the economic support of CAP is still justified by the troubles met by farmers to get an acceptable share of the price paid by consumers. Whether it is accepted that agriculture plays a crucial role not only as an economic sector but also in environmental protection, especially in remote areas, often plagued by higher natural risk (e.g., Modica et al., 2021), the issue of providing a fair remuneration to farmers is a *sine-qua-non* condition to achieve the aim of a more sustainable agriculture. Since this study brings evidence that the structure of agri-food value chains affects the distribution of incomes among the various sectors and it confirms that the longer the chain the lower the profits and profitability of farmers, any support aiming at either improving their position or shortening the value chain, may help them to improve their condition.

Considering the structure of the agricultural system in Tuscany, based on small business companies and family farms, the collective organization of both production and post-production stages would increase the bargaining power of farmers, especially vis-à-vis the commercial operators. According to Sorrentino et al. (2018) and Velázquez et al. (2017), not only the producers' organizations (POs) are able to counterbalance market inequalities along the value chain, but they also contribute to decrease the transactions costs of contracts. Moreover, it is recognized that collective actions turn to be useful to strengthen the overall efforts for a more sustainable agriculture (Cao et al., 2020).

APPENDIX

Table A1: Population of agricultural firms and presence in tax data (Tuscany; 2017-2019)

	PIANI COLTURALI GRAFICI (PCG)			PRESENT IN TAX ARCHIVES		
	2017	2018	2019	2017	2018	2019
Nr.	36.675	37.088	35.979	26.343	26.450	25.566
%				*71,8*	*71,3*	*71,1*
%				*88,8*	*87,9*	*86,5*
AVG. UAA (HA)	18,1	18,1	18,6	22,4	22,3	22,6
MEDIAN UAA (HA)	5,4	5,3	5,6	7,8	7,8	7,9

Source: Elaborations on PCG and Tax archives

Table A2: Agricultural firms by turnover class (Tuscany; 2017-2019)

Turnover class (*thousands*)	% firms	% UAA	Average size	Employment size	% of firms with at least 1 employee
<19	37,4	21,2	16,4	1,3	39,1
19-49	23,3	18,4	22,9	1,5	48,0
50-99	14,5	15,6	31,1	1,9	68,6
100-199	10,0	14,5	42,0	2,6	85,2
199-1000	9,9	19,6	57,0	5,1	100,0
>1000	4,9	10,7	63,5	12,9	100,0

Source: Elaborations on PCG, ASIA-AGRICOLTURA, ASIA-UL, ASIA-FRAME

Table A3: Firms in the observed population by NACE rev. 2 sector (Tuscany; 2017-2019)

NACE REV. 2	Desc. NACE REV. 2	Nr. of non-agricultural firms	Nr. of agricultural firms	Total	% agricultural firms on total	% of sector on total non agricultural firms	% of sector on total agricultural firms
1	Crop and animal production, hunting and related service activities	0	20.662	20.662	100,0	0,0	81,7
2	Forestry and logging	0	981	981	100,0	0,0	3,9
3	Fishing and aquaculture	0	249	249	100,0	0,0	1,0
10	Manufacture of food products	3.129	61	3.190	1,9	0,8	0,2
11	Manufacture of beverages	163	34	197	17,3	0,0	0,1
46	Wholesale trade	35.025	165	35.190	0,5	8,6	0,7
47	Retail trade	50.362	295	50.657	0,6	12,4	1,2
55	Accommodation	6.431	1.308	7.739	16,9	1,6	5,2
56	Food and beverage service activities	24.983	183	25.166	0,7	6,2	0,7
	Other sectors	285.375	1.367	286.742	0,5	70,4	5,4
	Total	**405.468**	**25.305**	**430.773**	**5,9**	**100,0**	**100,0**

Source: Elaborations on PCG, ASIA-AGRICOLTURA, ASIA-UL, ASIA-FRAME

Table A4: Agricultural firms: IRAP vs. non IRAP (Tuscany; 2017-2019)

	IRAP	Non-IRAP	Total
Nr	10.925	9.883	20.808
Of whom (%):			
Sole proprietorship	*65,7*	*78,9*	*73,2*
Partnership	*20,9*	*17,2*	*18,8*
Public companies	*12,3*	*3,7*	*7,4*
Other	*1,1*	*0,3*	*0,6*

Source: Elaborations on Tax archives, PCG e ASIA-agricoltura

Table A5: Characteristics of firms: IRAP vs. non IRAP (Tuscany; mean 2017-2019)

	IRAP	non-IRAP
Nr.	10925,3	9883,3
AVG. UAA	33,3	21,9
Median UAA	10,1	9,8
Value added	513M€	-
Workers	17697,6	23605,6
% of firms with employees	33,5	28,7

Source: Elaborations on Tax archives, PCG e ASIA-agricoltura

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