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Questioning Family Farms' Readiness to Adopt Digital Solutions †

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Abstract: This paper explores the adoption of digital solutions by Italian farmers. The hypothesis is that digital technology adoption relies on an articulated set of socioeconomic variables that deserve attention. To test this hypothesis, we analyzed data from the last census of Italian agriculture. The analysis showed significant differences in the adoption of digital technologies, which can be viewed from territorial, structural, and sociodemographic points of view. This casts some doubt on the fairness of the digital transition in rural areas, calling for the strengthening of rural policies at the beginning of the new programming period in 2023–2027.

Keywords: digital agriculture; Italian farms; context-related analysis; smart farming; technology adoption; innovation

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1. Introduction

This paper analyzes the readiness of farmers to adopt digital technologies in Italian farms. More precisely, we aim to explore how multiple contexts (business, personal/social, spatial) interplay and affect farmers' readiness to adopt digital solutions. This aspect is investigated through the lens of "omnibus context", by evidencing the relevance of multiple contexts in innovation adoption [1].

Innovation adoption is a complex process involving various dimensions. Concerning digitalization, a growing body of literature has analyzed these factors by emphasizing the disruptive character of digitalization and the related risks of non-neutrality [2–4], which call for more responsible digital innovations [5]. Set against the background of potential beneficiaries, the concept of readiness plays a significant role in the adoption process of digital solutions in agricultural practices in that it emerges as a prerequisite for digitalization, emphasizing the broad gap between the current state of farmers and the ideal farmer 4.0 [4]. As pointed out in Heiman et al. [6] thresholds model of diffusion, microeconomic behavior, heterogeneity, and dynamics are the critical variables that explain innovation adoption. This paper focuses on the second dimension by analyzing heterogeneity in the readiness to adopt digital solutions among Italian farms. To do that, we performed a context-related analysis, taking into account the various dimensions of the "omnibus" context emphasized in the seminal works of Welter and Baker: business, social, and spatial [1,7].

2. Methodology

To test heterogeneity and neutrality issues, we refer to the readiness of farmers in adopting an innovation. This concept is analyzed with reference to digital solutions and is grounded on secondary data provided by the Italian Census of Agriculture of the National

Institute of Statistics. More precisely, data were extracted from section F of the questionnaire (use of information or digital technologies by farms). A "looking behind the data" approach was adopted through an "omnibus" lens of analysis referring to the broad perspective of the context [7], which focuses on context-related variables: business (farm size, standard output, commercialization), social (farmer's age, level of education) and spatial (regional level). To verify the eventual relationships between the context variables and digitalization, a χ^2 test was carried out to test the following hypotheses:

H0: $\chi^2 = 0$ (no association between context variables and digital technologies).

H1: $\chi^2 \neq 0$ (there is an association between context variables and the adoption of digital technologies).

The Chi-squared test was calculated through the following formula:

$$\chi^2 = \sum \frac{(\textit{Observed frequencies} - \textit{Expected frequencies})^2}{\textit{Expected frequencies}}$$

3. Results

Data from the Italian Agricultural Census demonstrate, on the one hand, the increase in the percentage of farms that have adopted digital technologies (from 3.8% to 25.8%) and, on the other hand, the relevance of context in shaping different trajectories of digitalization.

3.1. Business Context

As far as the business context is concerned, the utilized agricultural area, standard output, and marketing channels are considered. Table 1 allows us to reject the null hypothesis: as a matter of fact, large and economically viable farms are more digitalized than small-scale farms. Regarding marketing channels, farms directly selling to other farms or producers' organizations are more equipped with digital technologies.

Table 1. Business context: contingencies.

UAA *		**Standard Output (€)**		**Marketing Channels**	
	Digitalized		**Digitalized**		**Digitalized**
<1 ha	−23,439.26109	<4000	−53,212.28313	direct selling	18,405.31721
1–4.99	−31,060.08915	4000–15,000	−18,421.39692	other farms	380.0263797
5–9.99	6243.864275	15,000–50,000	15,856.57355	food industries	−2662.394058
10–19.99	13,098.33523	50,000–500,000	46,163.80925	trade companies	−19,229.80497
20–49.99	17,973.52573	>500,000	9613.297256	producers' organ.	3106.855436
50–99.99	9954.075728				
>100 ha	7229.549277				
χ^2	118,320.64	χ^2	204,114.61	χ^2	13,710.74
normalized χ^2	0.104429163	normalized χ^2	0.180150458	normalized χ^2	0.015388227
Cramer's V	0.323155013	Cramer's V	0.424441349	Cramer's V	0.124049294

* UAA: Utilized Agricultural Area.

3.2. Social Context

For this category, we took into account farmers' age and their level of education. Table 2 shows the results, confirming the connection between the selected variables, more precisely, by indicating the following: (a) younger farmers are more equipped with digital technologies than their elderly counterparts; (b) the higher the level of education, the higher the rate of digitalization in the farms.

Table 2. Social context: contingencies.

Farmer's Age		Level of Education	
	digitalized	No education	−0.1261882
<40	18,612.745	Primary school certificate	−0.1076158
41–64	23,308.333	Secondary school certificate	−0.0316419
≥65	−41,921.078	Professional (agricultural) qualification diploma	0.1816126
		Professional (not agricultural) qualification diploma	0.0645273
		High school specialized (agriculture) diploma	0.2048297
		High school Diploma	0.0384361
		University degree in agriculture	0.3292959
		University degree	0.0860448
χ^2	58575.165	χ^2	76,320.052
normalized χ^2	0.0518122	normalized χ^2	0.0675083
Cramer's V	0.227623	Cramer's V	0.2598236

3.3. Spatial Context

The spatial context was here analyzed through the regional distribution of innovation in the Italian regions, which allows a digital gap among regions to emerge. As evident from Table 3, we can reject the null hypothesis and confirm the association between the selected variables. The digital divide between northern and central-southern Italy (with the exception of Tuscany) emerges.

Table 3. Spatial context: contingencies.

Northern Italy	Digitalized	Central Italy	Digitalized	Southern Italy	Digitalized
Piedmont	8196.55208	Tuscany	3805.572	Abruzzo	−3511.128
Valle D'Aosta	385.60472	Umbria	−124.20022	Molise	−1536.2406
Lombardy	10,357.3808	Marche	−384.33698	Campania	−5605.2783
Veneto	8298.92492	Lazio	−2809.738	Apulia	−19,642.919
Friuli Venezia Giulia	2237.31579			Basilicata	−2835.9181
Liguria	501.470861			Calabria	−9059.9993
Emilia Romagna	8353.71655			Sicily	−11,795.249
Bolzano	8715.99573			Sardinia	1305.3146
Trento	5147.15973				
		χ^2	128,435.44		
		normalized χ^2	0.1133564		
		Cramer's V	0.3366845		

Table 4 provides a synthesis of the empirical analysis through the lens of heterogeneity and neutrality in digital technology adoption. High levels of heterogeneity mark the endowment of digital technologies, which mostly penalize smaller farms, conducted by aged farmers prevailingly located in central and southern Italy.

Table 4. Synthesis of the results.

	Heterogeneity	Neutrality	Who Is Excluded?
Business context	Yes	No	Small-size farms
Social context	Yes	No	Aged and low educated farmers
Spatial context	Yes	No	Central (but Tuscany) and southern regions

4. Discussion and Conclusions

The analysis represents a first step towards a broader investigation concerning digitalization in the Italian farming sector and, as such, has limitations due to the lack of available data from the Italian census of agriculture. That is why we have conducted a study based on an "omnibus" context while waiting for more detailed data supporting a discrete context work. Moreover, an analysis of the other two elements of Heiman et al.'s [6] threshold model ("microlevel behavior" and "dynamics") is required to excavate the complex process of innovation adoption. Despite these limits, we can agree with the recent literature emphasizing that heterogeneity and non-neutrality issues characterize digital technology adoption [2]. This paper confirms that the digital gap mainly affects smallholder, aged farmers located in southern and (surprisingly) central Italy. The results of the analysis cast some doubts on the potential capacity to fill the ambitious objectives expected in the long-term vision for rural areas 2040, where is the following is posited: the further development of rural areas is dependent on them being well connected between each other and to peri-urban and urban areas [8]. Based on our results, it seems difficult to answer the following question: how long is expected to be the "Long-Term Vision"?

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