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The Smarterfarmer Project

Farms and the Digital Frontier:

Mapping the Digital Landscape of Farming in Denmark

Farmers' Perspectives on Digital Technologies

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Chapter 3 – Farmers’ Perspectives on Digital Technologies

When adopting new technologies, the literature on technology adoption in general highlights two factors as particularly important: perceiving clear benefits from *using* these technologies and perceived *usability* (Adams et al. 1992). In this chapter, we examine how farmers and farm managers evaluate their digital technologies across these two aspects and explore the differences that may influence how digitalisation in agriculture is perceived in practice.

a. Perceived Usefulness

The integration of FMIS and PA technologies offers a wide range of potential benefits, helping farmers monitor and optimise their farm operations and resource use. To better understand how farmers and farm managers perceive the impact of digital technologies, we asked them to what extent they agree that their digital technologies contribute positively to their farming operation. Specifically, they were asked to assess their usefulness in terms of:

- helping them run their farming operation (i.e., Operational Support),
- contributing to the farm’s economic performance, and
- helping to manage the operation’s environmental impact.

Responses were recorded on a five-point scale, where 1 indicates strong disagreement, and 5 indicates strong agreement that their digital technologies deliver the stated benefits.

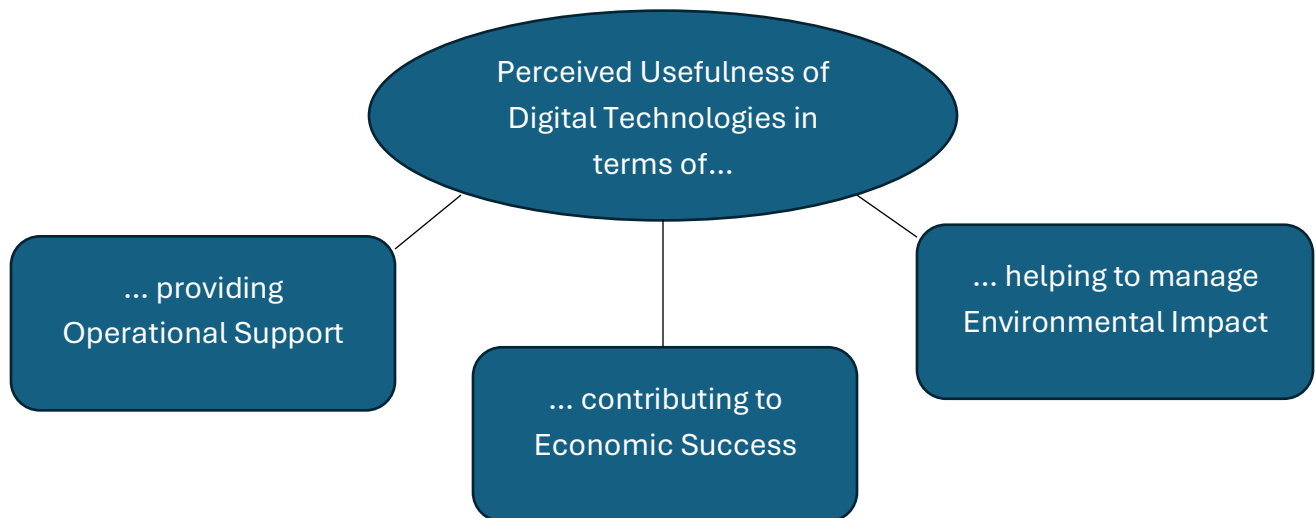


Figure 1: Evaluation Criteria for the Usefulness of Digital Technologies

Across all digital-adopter farms, respondents generally rated the contribution of their digital technologies favorably (Figure 2). On average, farmers and farm managers gave the highest rating to the usefulness of digital technologies in terms of providing operational support, with a mean score of 3.8 out of 5. This was followed by the perceived contribution to ecological performance, which received an average rating of 3.6. The lowest average rating was given to the economic benefits, which scored 3.4 out of 5 on average. This suggests that while farmers and farm managers generally recognize the operational value of digital technologies, such as streamlining production or business processes or simplifying farming activities, they may not yet perceive a direct financial benefit. For instance, savings in resources might not be immediately apparent, or digital technologies may still be viewed primarily as a cost factor that has yet to pay off.

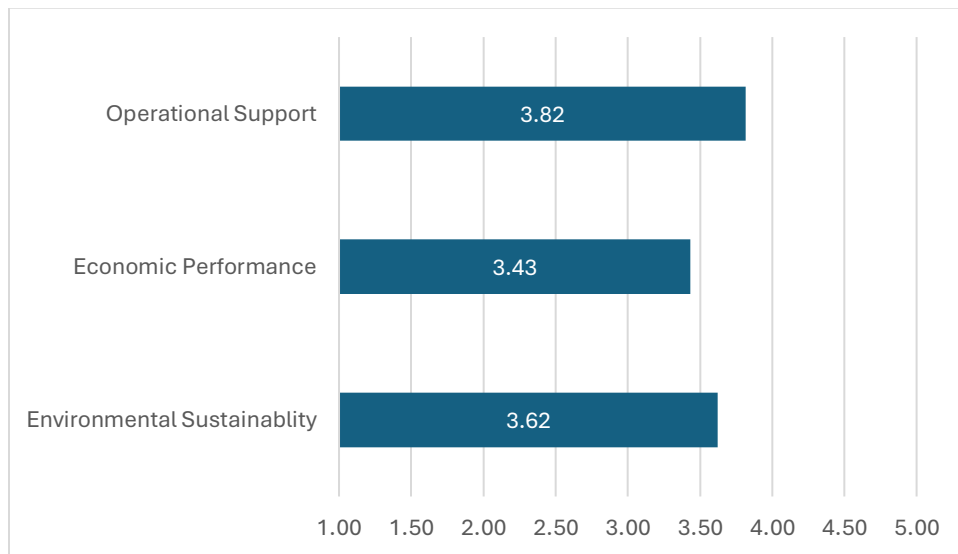


Figure 2: Rated Usefulness of Digital Technologies

However, there are notable differences in ratings across farm types.

a. Production Type

When looking at production type alone, livestock-producing farms tend to assess their digital setup more favorably in terms of their operational usefulness than their primarily arable counterparts. Over 80% of livestock farm respondents agree or strongly agree that their digital technologies support farm operations, with an average usefulness rating of 3.9. In comparison, primarily arable farms report an average rating of 3.7, and about 10% fewer respondents agree that their digital setup helps them run their farms (Figure 3). Among livestock farms, pig producers report the highest levels of agreement (85%), followed by

cattle farms (77%). This pattern suggests that digital technologies in livestock farming may be more aligned with operational processes than in arable farming.

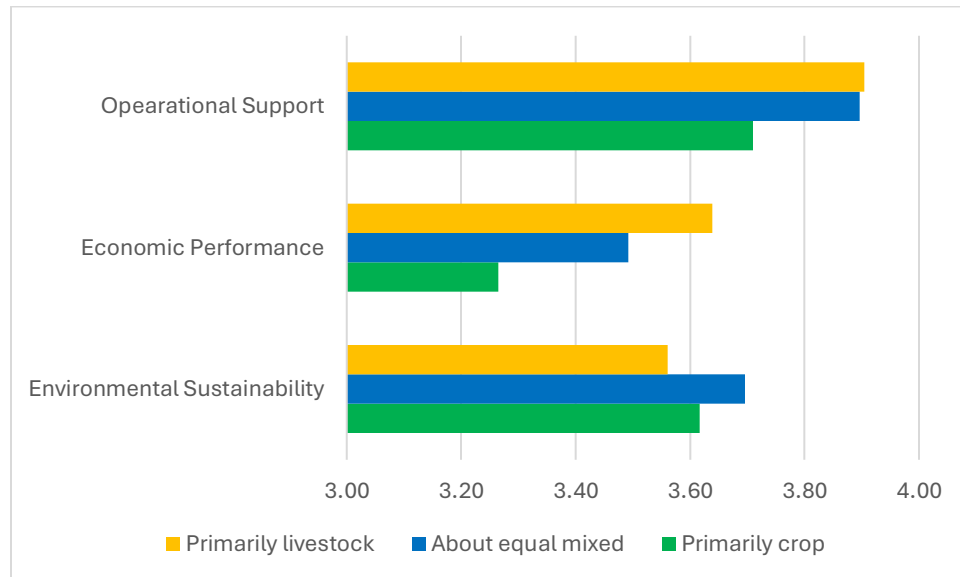


Figure 3: Rated Usefulness by Production Type

However, when we consider other farm characteristics such as size, location, or overall level of digital advancement, the differences between production types largely disappear. In other words, when comparing farms with similar profiles, production type alone does not significantly influence how useful farmers perceive their digital technologies to be. This suggests that it's not so much whether a farm is livestock- or crop-oriented that matters, but rather how far along they are in their digital journey, how productive their operations are, or how well their systems are integrated.

That said, there is a substantial correlation between economic size and livestock production, which implies that the type of production may still shape digital experiences indirectly, for instance, through influencing the kinds of technologies adopted, the possible level of investment or the complexity of operations. In this sense, the nature of livestock production may still play a role in shaping digital outcomes, even if it is not the primary factor when controlling for other variables.

The difference in how respondents perceive the impact of their digital technologies becomes more pronounced when focusing on their economic contribution. Without considering other factors, 63% of respondents from primarily livestock farms rated the economic impact of their digital technologies positively, particularly among pig and cattle

producers. In contrast, only 40% of respondents from primarily arable farms expressed a similarly positive view.

This divide is also reflected in the average ratings: arable farms report a score closer to neutral (3.3), suggesting a more cautious perception of digitalization's financial benefits. By comparison, mixed farms average 3.5, and primarily livestock farms 3.7, indicating a more favorable economic assessment among those groups. This pattern also holds when taking other factors into account: There is a significant positive relationship between livestock-producing farms and the perceived economic utility of the digital technologies in use.

These results suggest that digital technologies may currently be better aligned with the economic structures and value chains of livestock production, where standardized processes and continuous data monitoring are more easily integrated into day-to-day operations. In contrast, the more variable, seasonal, and weather-dependent nature of crop production may limit the perceived economic benefits of digital tools in primarily arable settings—at least in their current form.

Regarding digital technologies' contribution to environmental stewardship, respondents across all production types reported comparable ratings for environmental impact when we do not control for other factors. While farms with about equal mixed production show a slightly higher average score, this difference is not statistically significant. This suggests that farmers - regardless of whether they focus on crops, livestock, or both - tend to perceive the ecological benefits of digital tools in a relatively consistent manner.

However, when other factors are taken into account, a positive relationship emerges between environmental usefulness ratings and primarily crop-producing farms, particularly compared to their livestock-specialized counterparts. This indicates that, among farms with otherwise similar characteristics, arable farms are more likely to perceive environmental benefits from their digital technologies. One possible explanation is that digital technologies in crop production, such as precision spraying, variable rate fertilization, and soil monitoring, are more directly linked to reducing input use and mitigating environmental impacts. In contrast, digital technologies in livestock production may be more commonly geared toward improving economic performance, such as optimizing feed efficiency, enhancing animal health or increasing productivity, which may make their environmental benefits less immediately visible or less directly perceived.

b. Production Size

In terms of economic size, respondents from larger farms tend to rate their digital setup more favorably in terms of provided operational support and economic contribution when

not considering other factors (**Error! Reference source not found.**¹). The most pronounced difference appears in the perceived economic contribution of digital technologies: nearly 70% of farms in the top third of the sample assessed the economic impact of their digital technologies positively. In contrast, only around 30% of farms in the bottom third agreed that their digital technologies contribute to their farm’s economic success, with the remainder expressing either neutral or negative views. The positive association is further supported when looking at other size indicators, such as average workforce size, estimated turnover, registered working hours, cultivated hectares, and number of animals.

Moreover, the positive relationship between digital technologies’ operational and economic usefulness ratings remains significant even when other factors are considered (except for the current level of digital advancement; See next section). This suggests that larger operations may be better positioned to realize financial and operational benefits from digital technologies. This may be due to their greater ability to invest in integrated systems that offer advanced decision support or automation, as well as the fact that economies of scale make such investments more cost-effective and impactful.

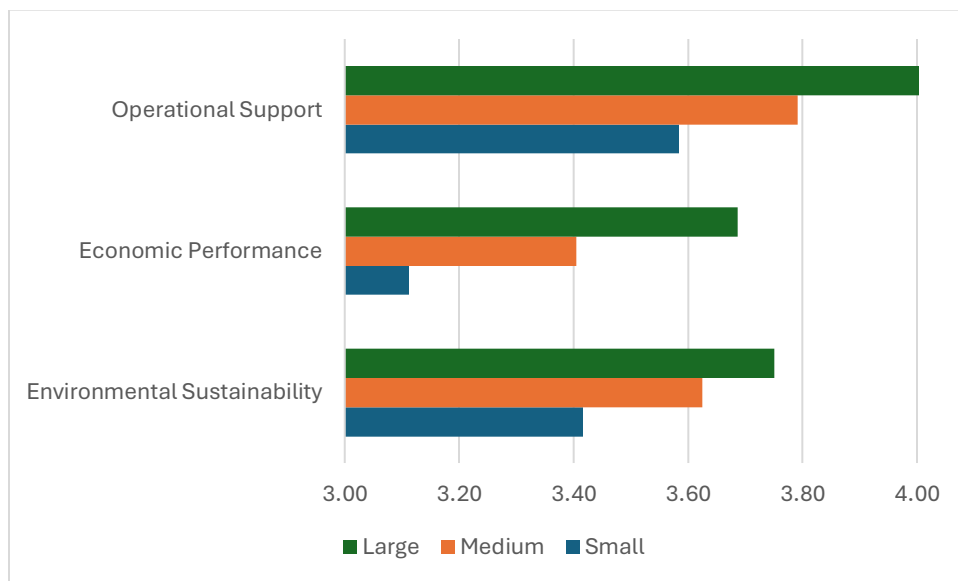


Figure 4: Rated Usefulness by relative Economic Size

Because economic size correlates with livestock production, these patterns suggest that digital technologies may be more mature or better aligned in particular with the operational

¹ For illustrative purposes, we categorized farms into small, medium, and large based on their 2023 total standard output

demands of larger-scale livestock farms. Large livestock-oriented operations perceive the strongest benefits from using their digital technologies (Table 1), suggesting that these technologies may currently deliver greater operational and economic value when applied at scale or in more intensive production systems.

Production Type	Economic Size	Operational Support Rating	Economic Performance Rating	Environmental Sustainability Rating
Primarily crop	Small	3,5	3,1	3,4
	Medium	3,7	3,3	3,6
	Large	3,9	3,5	3,8
About equal mixed	Small	3,8	3,2	3,4
	Medium	3,9	3,6	3,8
	Large	4,0	3,7	3,9
Primarily livestock	Small	3,6	3,4	3,4
	Medium	4,0	3,7	3,6
	Large	4,1	3,8	3,7

Table 1: Usefulness Ratings across Production Types and Relative Economic Sizes

Notably, when it comes to the perceived environmental usefulness of digital technologies, we find no significant relationship with farm size once other factors - especially the level of digital advancement - are considered. This suggests that while larger farms may initially appear more positive about the environmental impact of digital tools, it is likely their more advanced digital capabilities, rather than their size alone, that drive these perceptions. In other words, when comparing farms with similar production types and levels of digital maturity, larger farms are not significantly more likely than smaller ones to perceive environmental benefits from digitalization.

c. Digital Advancement

When looking at the current level of digital advancement, we observe that respondents from farms that are more engaged with digitalization tend to rate their digital technologies more favorably. Usefulness ratings across all assessed criteria are positively associated with more extensive use of PA technologies, also when controlling for other farm characteristics. This suggests that greater digital integration progressively unlocks more of the potential offered by these technologies - or, conversely, that farmers who already

perceived digital technologies as useful were more likely to adopt and integrate them in the first place.

When examining the relationship between perceived operational, economic, and environmental usefulness and the *specific precision agriculture technologies used* across surveyed farms, we generally find positive associations. For crop-related PA technologies, the strongest correlations appear between most technologies and the usefulness ratings related to environmental sustainability - in line with their intended purpose. The only exceptions are field robots and crop sensors, which show no significant correlation. However, as discussed in Chapter 1, these are among the most advanced and least widely adopted technologies, suggesting their value may not yet be fully realized.

Similarly, usefulness ratings related to operational support and economic contribution also show significant positive associations with most crop-related PA technologies - again, excluding field robots and crop sensors. However, these correlations are slightly weaker than those observed for environmental usefulness. Among all crop PA technologies, section control for fertilizer application shows the strongest and most consistent association across all assessments, although the differences between technologies are relatively small.

For livestock-related PA technologies, similar patterns emerge. The use of all surveyed technologies is positively associated with overall usefulness ratings. In contrast to crop-related PA technologies, the strongest associations for livestock-related PA technologies were observed in relation to the perceived economic contribution of digital technologies.

Moreover, both a *strong strategic orientation toward digitalization and advanced operational digital capabilities are not only linked to higher perceived usefulness but also exhibit the strongest association among all the factors analyzed – also when accounting for other farm characteristics*. This aligns with expectations: farmers and farm managers who see digital technologies as beneficial may be more inclined to embrace them and build their operations around them.

Network effects may play a key role in this regard. Respondents who indicated that digital systems used by external partners - such as suppliers, service providers, or customers - influenced their decision to invest in digital technologies also tended to rate more positively for operational, economic, and environmental impact of their digital technologies. This suggests that digitalization provides stronger benefits when farms are part of a connected ecosystem, where technologies and data systems are aligned across the value chain. Integration with external actors may not only encourage adoption, but also enhance usability, efficiency, and perceived value, amplifying the overall impact of digital tools on farm performance.

Regarding operational advancement, those who are more confident in their ability to operate and apply digital technologies are more likely to experience meaningful benefits - whether because they use the tools more effectively, or because their proficiency leads them to see the value more clearly.

An interesting pattern emerges when looking at the bottom of the digital ladder: non-adopters of digital technologies tend to hold significantly more negative views about their potential value compared to adopters (**Error! Reference source not found.**). A majority of non-adopters either remained neutral or disagreed with the idea that digital technologies provide operational, economic, or ecological value for their farm. While, on average, adopters rate the usefulness of their digital technologies above the neutral midpoint of the scale (i.e., higher than 3), non-adopters expressed generally unfavorable expectations.

This contrast highlights a potential perception gap between adopters and non-adopters regarding the benefits of digitalization in agriculture. On the one hand, this gap may reflect real limitations, as digital technologies might indeed be less relevant or accessible for certain non-adopter farms - such as smaller operations with limited productivity potential or those facing age-related challenges (see Chapter 1). On the other hand, it may point to the presence of skepticism or bias among non-adopters, possibly rooted in unfamiliarity, mistrust, or past negative experiences with technology. Understanding whether this perception gap stems from structural constraints or attitudinal resistance is important for designing effective support strategies and policies aimed at promoting inclusive digital transformation in agriculture.

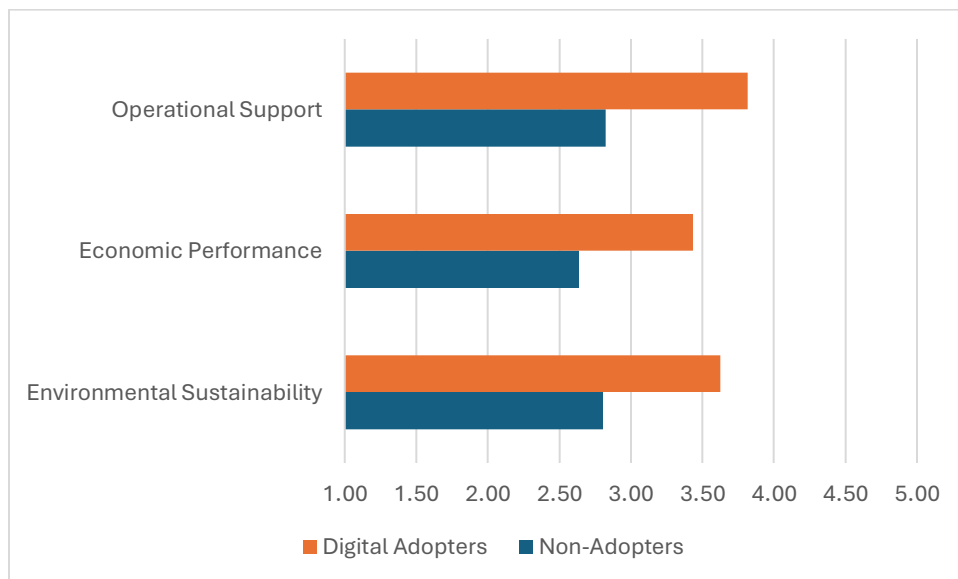


Figure 5: Digital Technology Assessment of Non-Adopters vs. Digital Adopters

d. Other Characteristics

When looking at age without considering other factors, we find a negative correlation, indicating that older respondents tend to rate the usefulness of digital technologies somewhat lower than their younger counterparts. For illustration, Figure 6 shows that farmers above the average age of 54 reported lower average usefulness ratings, while those below that age assessed digital technologies more positively.

However, when comparing farms with otherwise similar characteristics, we observe that there is no significant association between age and perceived usefulness, especially when digital advancement is considered. While older farmers tend to assess digital technologies less favorably overall, our analysis suggests that age itself is not the decisive factor. When digital maturity is held constant, age no longer plays a role in shaping perceptions of usefulness.

Instead, the findings point to lower digital engagement among older farmers as the underlying driver of more cautious or negative assessments. Age may still play an indirect role - for example, through differences in investment behavior, technological familiarity, or future planning horizons - which could influence the likelihood of adopting and engaging with digital technologies in the first place.

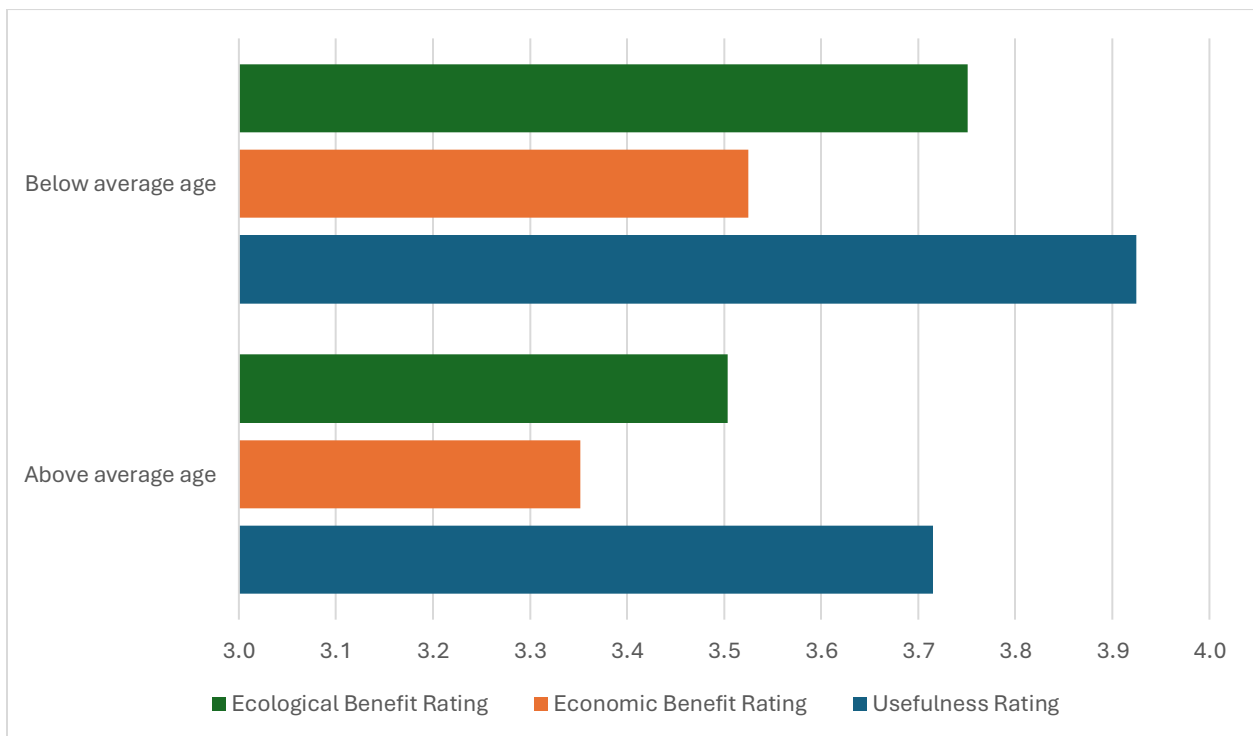


Figure 6: Usefulness Ratings by age group (Avg: 54 years)

Lastly, we find weak but identifiable indications that farms located on Zealand, relative to the rest of the country, perceive the digital technologies they use as more useful in terms of operational support, even when controlling for other farm characteristics. However, this location effect disappears once digital advancement indicators are included in the analysis - suggesting that it is higher levels of digital maturity, rather than location itself, that explain the more favorable assessments on Zealand.

In contrast, when accounting for both farm characteristics and digital advancement, respondents from Southern Denmark report lower economic benefit ratings from their digital technologies. This may indicate that, even at comparable levels of digital development, regional differences in infrastructure, support services, or market integration may influence how farmers perceive the financial value of digital tools.

Other demographic factors—including gender, number of children, household income, education level, and marital status—show no statistically significant association with perceived usefulness ratings. Likewise, farm-level characteristics such as location, legal form, and organic status also reveal no meaningful correlations.

Overall, farmers and farm managers tend to view their digital technologies positively, particularly regarding their contributions to operational efficiency, economic performance, and environmental sustainability. These favorable perceptions are important, as they support continued and expanded adoption of digital technologies, which is widely seen as a key driver for advancing agricultural performance.

These ratings are largely explained by a farm's level of digital advancement. Farms that are more strategically, operationally, and technologically engaged in agricultural digitalization tend to attribute greater value to their digital technologies. However, as the analysis has shown, there are also notable differences across production types and other farm characteristics, such as size, region, and age. While digital advancement is a key driver of perceived value, these contextual factors can still shape how digital technologies are adopted, implemented, and ultimately assessed by farmers.

However, there appears to be room for improvement in enabling small-scale farms to better realize economic and operational benefits from digital tools. Digitalization currently seems to deliver the greatest value in large-scale operations, particularly those specialized in livestock farming. In this sense, digitalization currently appears to favor scale, standardization, and controlled production environments.

To ensure inclusivity and broader adoption across the agricultural sector - including among diverse farm types and practices - greater attention is needed to make digital solutions more adaptable, accessible, and responsive to varying operational contexts.

a. Perceived Usability

Another important factor influencing technology use is perceived usability. To explore this, we asked respondents to evaluate how easy they find the digital technologies they currently employ. In addition, since digitalization offers the greatest potential when different technologies and systems are seamlessly integrated, we also asked respondents to assess how well their digital technologies connect and function together.



Figure 7: Evaluation Criteria for the Usability of Digital Technologies

Overall, farmers and farm managers were less unanimous in their usability ratings compared to their earlier assessments of usefulness. On average, they rated the ease of use of their digital technologies at 3.4 out of 5. While 76% of respondents agreed that their digital technologies are useful in supporting their farming operations, fewer than half agreed that these technologies are easy to use. Regarding interoperability, the average rating was 3.3 out of 5, with a similarly limited proportion of respondents expressing agreement.

This suggests that, although digital technologies are widely seen as beneficial in principle, many users might face challenges in terms of how intuitive and integrated these tools are in practice, and that adoption and impact could be further improved by addressing user experience and system compatibility.

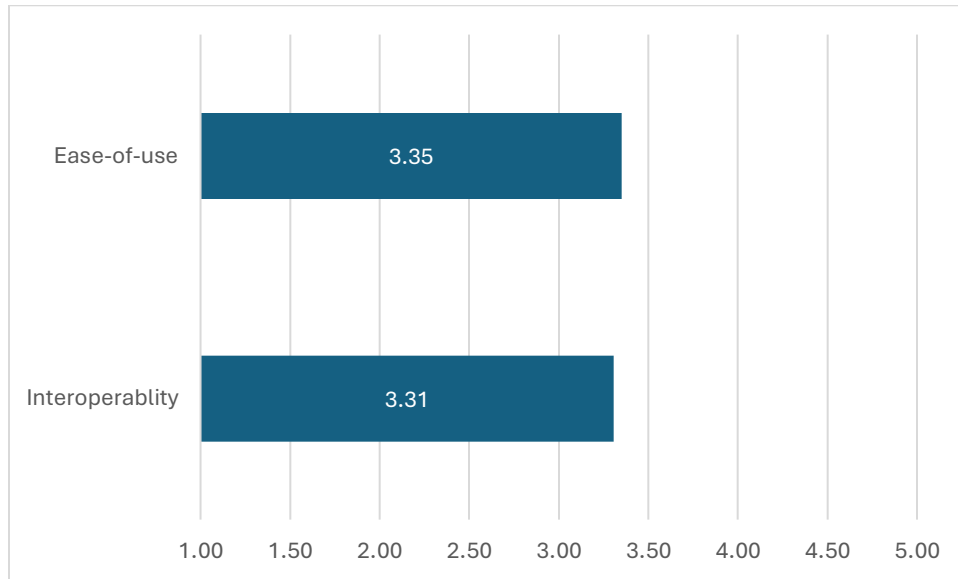


Figure 8: Perceived Usability of Digital Technologies

When only looking at production type, respondents from primarily arable farms tended to rate the ease of use and interoperability of their digital technologies lower than those from primarily livestock farms or mixed operations. The strongest positive associations are observed among respondents from farms specialized in livestock. Although the differences are relatively small, this may suggest that livestock-related technologies are generally more integrated and advanced in terms of user experience. Among livestock producers, poultry farmers stand out by giving the highest scores for interoperability (3.5). Pig farmers report the lowest interoperability ratings, matching those of primarily arable farmers, both averaging 3.3.

Regression analysis controlling for other factors also indicates a negative relationship between primarily arable farms and ease-of-use ratings. This suggests that, compared to other farm types, arable farmers are more likely to find digital technologies difficult to use, even when accounting for differences in farm size, location, and level of digital advancement. Similarly, crop farms appear more likely to rate the interoperability of their digital technologies lower, particularly when compared to respondents from livestock-specialized farms. One possible explanation is that digital technologies for crop production may be more fragmented, less mature in terms of user experience, or harder to integrate into existing workflows or production conditions than those used in livestock or mixed operations.

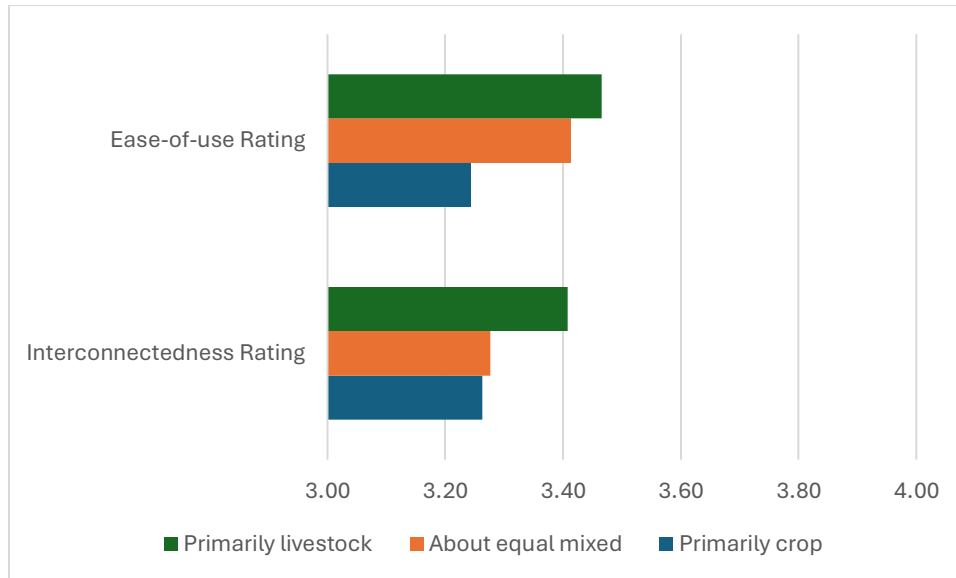


Figure 9: Rated Usability by Production Type

When looking at economic size, we observe that its influence is less pronounced than it was in relation to perceived usefulness. Not considering other farm characteristics, we find a positive association between farm size - measured by total standard output, as well as cultivated land, number of animals, workforce size, and registered working hours - and ratings of both ease of use and interoperability (Figure 10). However, these correlations are noticeably weaker compared to those found for the usefulness ratings. This suggests that challenges related to usability and system integration are relatively consistent across different farm sizes, with a potential difference being that larger farms may have more resources (such as staff, training, or technical support) to compensate for complexity or interoperability issues.

When controlling for other farm characteristics using regression analysis, this finding is strengthened: ease-of-use ratings do not significantly differ across farms of different economic sizes. This means that having a higher total output or turnover does not necessarily make digital technologies easier to use from the farmer’s perspective.

However, the analysis indicates that the size of cultivated farmland does appear to matter—there is a positive association between the number of hectares and ease-of-use ratings. This suggests that larger arable areas may create stronger incentives to use digital tools efficiently, possibly leading to greater familiarity or investment in user-friendly systems. In other words, while economic scale alone doesn't influence ease of use, managing larger areas of land may encourage more practical engagement with digital technologies, making them feel easier to operate over time.

For interoperability, regression analysis indicates a negative association with production size when taking other factors into consideration. This suggests that larger farms, despite often being more digitally advanced, may face greater challenges with system integration. The likely reason is the greater number and complexity of technologies in use on large farms, which can lead to compatibility issues across platforms, machines, and data systems. As farms scale up and adopt more tools, ensuring that these systems work seamlessly together may become increasingly difficult - impacting the perceived interoperability of their digital technologies.

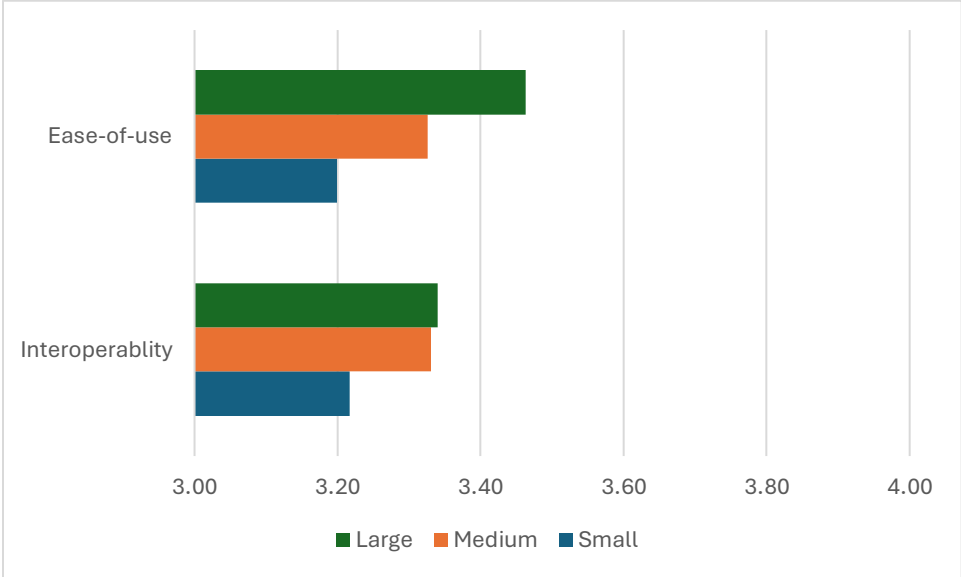


Figure 10: Rated Usefulness by relative Economic Size

Similar to the patterns observed for usefulness ratings, respondents whose farms score higher on digital advancement also tend to rate the ease of use and interoperability of their digital technologies more positively.

Unsurprisingly, for both usability aspects the strongest association is found with a farm’s digital operational capabilities - that is, how well farmers rate their own ability to work with digital technologies and data. This relationship also holds when taking other farm characteristics into account. This suggests that farms with high digital competence are better equipped to address challenges related to usability and system integration.

For ease of use, we also find a positive association with strategic digital orientation. This could mean that farms that have a clearer strategy or long-term vision for digitalization tend to find their digital technologies easier to use. A strategic approach likely leads to more deliberate choices in selecting, implementing, and training for digital technologies, which reduces friction and improves usability.

For interoperability, we find a positive association with the extent of (primary) PA technologies in use. This suggests that farms that actively use more PA technologies are more likely to experience or prioritize better integration across systems.

We also asked non-adopters how they perceive the ease of use of digital technologies in general. Similar to their ratings of usefulness, their assessments were largely negative. Only 18% of respondents agreed with the statement that digital technologies are easy to use, resulting in an average score of 2.6 out of 5. This points to a potentially important perceptual barrier that may prevent these farmers from engaging with or adopting agricultural digitalization. To address this, it will be essential to build trust through targeted support and training, promote simplified, plug-and-play solutions, and foster greater engagement through peer learning and hands-on demonstrations. These approaches can help reduce perceived complexity and show tangible value, especially for those hesitant or unfamiliar with digital tools.

In terms of other farm- or farmer-related characteristics, we find no other notable patterns for usability ratings.

In summary, there appears to be potential to advance agricultural digitalization by improving the usability of digital technologies - particularly in terms of ease of use and interoperability. Across all farm types and sizes, many respondents expressed neutral or negative perceptions in this area, suggesting that low perceived usability may slow down agriculture digitalization. While farmers value the benefits that technologies can bring, they are unlikely to embrace technologies that require excessive troubleshooting or are difficult to integrate into their existing operations. Although average ratings still lean toward the positive end of the scale, usability remains a critical factor for ensuring that digital technologies are adopted and used sustainably over the long term.

Our analysis indicates that an important remedy lies in strengthening farmers' strategic and operational digital capabilities, enabling them to make informed decisions about digital tools and integrate them more effectively into their daily operations.

Importantly, and with reference to the previous chapter, we think that if digitalization is to work for everyone, inclusiveness must be a priority. While farms may produce similar commodities, they differ significantly in who operates them, their capacities, and where they are on their digital journey. These differences must be acknowledged and addressed to ensure that the benefits of digitalization reach all types of farms.