Extended Abstract
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Paper/Poster Title	**Ex-ante assessment of policies supporting precision agriculture in small-scaled farming systems**

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Abstract	***200 words max***
Reducing nitrogen losses and the associated negative impact on the environment is a major challenge in agricultural production. Precision agricultural technologies are supposed to help solving this challenge. Since the adoption rate of such technologies in small-scale farming systems is still rather low, additional policy measures are needed to support their adoption. In this study, we investigate the efficiency of such measures using an agent-based modelling framework that combines cognitive and dispositional farmers' characteristics with a bio-economic optimization model. We simulate the effect of different policies on the adoption decisions of farmers in a Swiss case study. We use census, choice experiment and survey data from Swiss crop farmers to calibrate the agent-based model. Our results help to better assess the impact of different policy measures on the adoption decisions regarding site-specific fertilization and to inform policy makers on the most efficient measures.	

Keywords	precision farming, technology adoption, agent-based modelling, variable rate technologies
JEL Code	Q16, Q18

Introduction	***100 – 250 words***
Improvements in nitrogen use efficiency and the associated reduction of negative environmental impacts due to nitrogen losses, is one of the main challenges of agricultural production. Precision agriculture technologies are expected to help address this challenge by providing timely, detailed, and site-specific production information (Schimmelpfennig and Ebel, 2016). Although technologies for site-specific nitrogen application have been available on the market for several years, their application rate in small-scaled farming systems is lower than expected (e.g., Finger et al., 2019; Groher et al. 2020). One reason is the profitability of the technology in small-scaled farming systems (Späti et al. 2021). Thus, to increase nitrogen use efficiency through the adoption of site-specific nitrogen fertilization technologies, appropriate policy measures are needed. However, little research has been done on the impact of potential policy measures to increase nitrogen use efficiency considering the heterogeneity of farm and farmers' characteristics (e.g., cognitive, social, and dispositional factors). To fill this gap, we here combine census, survey, and choice experiment data with an agent-based modeling approach for an ex-ante assessment of different policy measures (i.e., tax on nitrogen, subsidy technology, or direct payment) supporting adoption of technologies aiming to increase nitrogen use	

efficiency in small-scaled farming systems. More specifically, we simulate the effect of farmers individual and heterogeneous adoption decisions of site-specific nitrogen fertilization technologies in wheat production under different policy settings and quantify the total N reduction due to the adoption of the technologies as well as the efficiency of the policy measure (i.e., Fr./kg N saved).

Methodology	***100 – 250 words***

To simulate farmers' adoption decisions regarding site-specific fertilization under different policy scenarios, we use an agent-based modelling framework FARMIND (Huber et al., 2021). We use information on farmers' risk preferences, attitudes, and perceptions regarding variable rate technologies as well as choice experiment data from a survey with 418 crop farmers in Switzerland to calibrate the ABM (Späti et. al., 2022). FARMIND integrates the cumulative prospect theory and social interactions with a bio-economic optimization model simulating the costs and benefits from the adoption of variable rate technologies under heterogeneous field conditions in our case study region (Späti et al. 2021). The modelling framework is used to simulate the effect of a nitrogen tax, a subsidy for the technology and an action-based direct payments that remunerates farmer for applying the technology on their farm.

Results	***100 – 250 words***

Preliminary results show that the economic benefit, from the application of the technology and the associated reduction in nitrogen use depend on the underlying field heterogeneity. The additional income generated by the application of the technology varies from a few francs per hectare at low heterogeneity to around 50 CHF with high heterogeneity in the underlying soil conditions. The average willingness to pay determined in the choice experiment is 156 Swiss francs for a variable rate technology that reduces nitrogen by 20% and 208 Swiss francs for a reduction potential of 40% of nitrogen input. However, individual farmers deviate from these average values. We use the agent-based modelling framework to quantify these effects on total N reduction from the technology uptake given heterogenous farm and farmers' characteristics.

Discussion and Conclusion	***100 – 250 words***

Our analysis contributes to a better understanding of the factors that influence farmers' decisions to adopt more environmentally friendly technologies in small-scale farming systems. The agent-based modelling framework allows us to simulate how different policy measures affect the adoption of technologies for site-specific nitrogen fertilization. By simulating different scenarios, we can identify the most efficient policies that support the adoption of variable rate technologies and thus promote more sustainable agricultural production. Our results may help to design more efficient policies to support adoption of site-specific fertilization technologies, and thus reduce nitrogen losses and the associated negative impact on the environment.

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