SGA Newcomer Award 2024

1st rank

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Abstract
Climate change and its numerous consequences is a reality we are currently facing, which threatens our way of life on various levels. In this matter, our agri-food system accounts for 31% of global anthropogenic emissions (Tubiello et al., 2022), which leaves little doubt about the role of our dietary patterns as a critical driver for climate change. Therefore, although changing habits is a challenge, changing our consumption patterns and breaking psychological barriers (e.g., habits) that hinder a transition towards sustainable food consumption is imperative. On the one hand, multiple external factors related to the product or the purchasing situation but also internal factors such as our habits, knowledge and values impact these choices (Visshers et al., 2009). On the other hand, various consumer-targeted policy instruments that vary in effectiveness and intrusiveness can guide our consumption patterns and overcome internal and external factors. Yet, for a successful implementation, these instruments need to be accepted (Nilsson et al., 2016).

As our consumption patterns are complex but should become more sustainable and as a deeper understanding regarding the acceptance of sustainable food policy is currently lacking, this thesis aims to determine consumers' acceptance of sustainable food policy instruments. Further, the relevance of various individual predictors of acceptance is identified, allowing to deduce implementation recommendations for policy makers. In this sense, 18 policy instruments were selected to measure sustainable food policy acceptance. The selected instruments represented a combination between all categories of policy instruments that varied in

intrusiveness and effectiveness (i.e. information-based, nudges, subsidy, tax and regulation) and products (e.g. meat, dairy, vegetable and non-specific) on which they can be applied. A Swiss sample consisting of German-speaking participants (N = 435), was asked to indicate (using an online survey) on what level they agree with the different instruments proposed. Further, to investigate the effect of various predictors on the acceptance of policy instruments, the survey included sociodemographic factors as well as psychological variables related to consumption behaviors and knowledge. A principal component analysis was performed to structure the data and to explain as high a proportion as possible of the total variance in the variables. Further, to indicate which independent variables explained the most variance in acceptance of policy instruments for sustainable consumption, a multivariate regression analysis was performed.

Governmental and non-governmental interventions are important means to encourage consumers to change their food-related behaviors but their effectiveness and successful implementation relies significantly on the extent of acceptance it receives from the public (Diepeveen et al., 2013; Nilsson et al., 2016). Looking at the overall acceptance of the different categories of policy instrument observed in our study, we observe that less intrusive instruments have a higher acceptance than more intrusive instruments. The high acceptance of less intrusive policy instruments (information-based and nudges) observed in this study shows that, although the effectiveness of these instruments is among the lowest (Ammann et al., 2023), their acceptance is higher when compared to more intrusive instruments (market-based and regulatory). Further, information-based policy instruments also create awareness and thus increase the acceptance of more intrusive instruments (Röös et al., 2014). However, although nudges are highly accepted, they can raise the issue of legitimacy and lack of transparency as they influence peoples' choices while they are not fully aware of it (Ivanković & Engelen, 2019). Indeed, in the case of a nudge, the consumer is not informed of the measure applied to him which can be perceived as manipulation (Wilkinson, 2012) and could explain why informative instruments had a slightly higher acceptance than nudges. In contrast, the observed decreasing acceptance of more intrusive policy instruments could be related to their impact on the freedom of choice of individuals.

Looking at the two subcategories of market-based instruments taxes and subsidies separately, taxes are the policy instrument with the lowest acceptance. However, we observed that the acceptance of subsidy is higher than that of regulations, which is higher than that of taxes. Therefore, although taxes and subsidies are both market-based instruments considering them as separate instruments is fundamental as their acceptance varies. Further, although regulatory instruments are more intrusive than market-based instruments, the acceptance of regulatory instruments was higher than that of taxes in this study. This is explained by the central role of prices when it comes to food choices, making price discounting instruments more attractive for consumers than a tax (Steenhuis et al., 2011).

We identified several predictors related to individual acceptance of policy instruments to increase sustainable food consumption. Among the observed variables, internal factors explained more than 40% of the variance in acceptance. Among those variables, health consciousness, food-related environmental knowledge and the new ecological paradigm were the strongest predictors supporting the acceptance of sustainable food policy, followed by some of the sociodemographic factors. For instance, acceptance increased with age (younger), political orientation (left) and eating habits (lower meat and dairy consumption). Further, a higher health consciousness increased the acceptance of policy instruments in our sample. A synergy between health consciousness and more sustainable consumption habits of consumers could be the reason behind this increase. Further, participants with more knowledge related to sustainable food have a higher education background and could therefore be more prone to be aware of the consequence of our food consumption patterns on the climate. Looking at students, Doplet et al. (2019) found similar results.

Participants in their sample with higher knowledge, independently of the level of education, showed higher pro-environmental behaviors. Thus, higher knowledge about the environmental impact of food shows higher pro-environmental behavior (Dopelt et al., 2019) and so the capability of consumers to increase their sustainable food consumption with the help of the correct policies.

When implementing policy instruments, it is fundamental to consider an instrument's intrusiveness on top of other factors like its effectiveness (e.g., in terms of GHG emission reduction). Therefore, less intrusive instruments, such as Information-based instruments, should be implemented first. Although, when using them, care must be taken not to overload the consumer with too many combined labels (Moon et al., 2016), too much text (Yang et al., 2021), and instead use simple guidelines that can help the consumer recognize sustainable products (Lazzarini et al., 2018) while using precise wording to avoid confusion (Gadema & Oglethorpe, 2011; Moon et al., 2016). Nudges are widely accepted by the population in this study, which is also the case for most European countries (Reisch & Sunstein, 2023. Further, they can be applied in various environments (e.g., canteen, shops). Food-related environmental knowledge, health consciousness and pro-ecological worldviews could be used to increase sustainable consumption. Increasing food related environmental knowledge and promoting sustainable food choices could therefore bring about a change in consumption.

Also, an increase in food-related environmental knowledge also correlates with pro-environmentally friendly food purchasing behavior (Hartmann et al., 2021) and thus could convert a purchase intention into action. In addition, raising consumer awareness of the health benefits of more sustainable consumption could be beneficial for our health and for reaching our environmental goals (e.g., (Tilman & Clark, 2014; Tukker et al., 2011; Westhoek et al., 2014). Pro-environmental behaviors are needed for consumers and society to maintain a sustainable lifestyle (Kim & Lee, 2022). For young adults, their close circle and leaders' opinions (e.g., authorities) play an essential role in shaping their pro-environmental eating habits (Wierzbiński et al., 2021). Authorities' input on this subject could help future generations of consumers better perceive the beneficial effects of sustainable consumption leading to increases in pro-environmental behavior and, thus, the acceptance of policy instruments in Switzerland. Next to the dependance of consumers' acceptance for a successful implementation, further interest groups (e.g., the food industry, government, politicians…) have to support these measures, too, as they are often responsible for the implementation. In this study, participants indicated that all stakeholders had the same level of responsibility for increasing sustainable consumption and that they trusted these actors identically to increase sustainable consumption. This indicates that to consumers all actors are highly relevant for increasing sustainable consumption.

In fine, considering the intrusiveness and effectiveness of a policy for a successful implementation is not sufficient as the acceptance is key for a successful implementation. Bearing in mind the different needs of various sociodemographic consumer groups, policy makers should in a first step focus on less intrusive policy instruments while avoiding taxes. Making use of the different predictors (e.g. health consciousness, knowledge or pro-ecological values) to increase acceptance could foster sustainable behavior beyond food choices and increase consumers' knowledge on its impact on the environment and their health. As consumers shape the demand, are compelling actors, who set norms as citizens of democratic countries, their acceptance, motivation and capacity for a change have to be considered and further explored. In conclusion, our results suggest that focusing on less intrusive instruments and fostering positive attitudes towards health and the environment while promoting environmental-related knowledge could be ways to increase the overall acceptance of policy interventions and sustainable consumption.

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The Economics and Policy of VRT for Sustainable Weed Management in Swiss Wheat Production

Viviane Fahrni, ETH Zürich, 2023

Introduction

Pesticide use poses potential risks to human health and to the environment but is crucial in many agricultural systems to provide food security (Möhring et al. 2020). As public awareness about the negative effects of pesticides grows, reducing pesticide use is increasingly being discussed by policy makers and food industry (Böcker, Möhring, and Finger 2019; Möhring et al. 2020). For example, Switzerland as well as the European Union (in its Farm to Fork strategy) have decided to reduce pesticide risks by 50% in the coming years.

Herbicides are key pesticides: When gone untreated, weeds cause a wheat yield loss of around 23% worldwide and despite various crop protection measures, weeds account for an actual loss of wheat yield of around 7.7% (Oerke 2006). This makes weeds the most damaging pest group in wheat production (Milberg and Hallgren 2004; Oerke 2006; Jabran et al. 2017) and herbicides are the preferred weed management strategy worldwide (Jabran et al. 2017). Weeds grow in spatially heterogenous distributions, aggregated in clusters often described as patches of weeds, or along stripes following the direction of cultivation (Marshall 1988; Milberg and Hallgren 2004; R. Gerhards and Oebel 2006; Krohmann, Gerhards, and Kühbauch 2006; Heijting et al. 2007; R. Gerhards 2018).

Designed to manage infield heterogeneity, precision agriculture and more specifically variable rate technologies (VRTs) show promising potential to bring the right amount of inputs, such as herbicides, to the right place at the right time (Gebbers and Adamchuk 2010; Walter et al. 2017;

Barnes et al. 2019). For site-specific pre- and post-sowing weed management a range of technologies exists for both mechanical weeding solutions and variable rate herbicide application where output rate can be changed by pressure, pulse, and specialized nozzles (Sökefeld 2010; Roland Gerhards et al. 2022). Sensing technologies, such as drones, satellites, or tractor mounted sensors, provide different image resolutions and come at price points ranging up to tens of thousands of francs (Späti, Huber, and Finger 2021).

Despite the estimation that smart farming can make agriculture more profitable for farmers (Walter et al. 2017) the actual adoption of VRTs especially in European agriculture is falling behind expectations (Mintert et al. 2016). Barriers to the uptake of VRTs can among others be farm size, high initial capital investment, added maintenance costs, lack of specialized knowledge about data analysis, low perceived benefits, and uncertainty (Griffin and Lowenberg-DeBoer 2005; Schimmelpfennig 2016; Tamirat, Pedersen, and Lind 2018; Barnes et al. 2019).

Uncertainty and low perceived benefits of a set of technologies with such promising potential call for an analysis to clarify under which circumstances these technologies are economically viable for farmers and how their environmental benefits could be supported by policy. This thesis addresses the question: What is the potential for saving herbicide when a field with heterogenous weed pressure is seen through imaging technologies at different resolutions? And what is the effect of this herbicide application on realized yield and net return for each of the resolutions?

There is little evidence as yet demonstrating widespread economic and environmental benefits of precision management technology (Schimmelpfennig 2016; Basso and Antle 2020). Due to the numerous uses and scenarios, such as farm activity, heterogeneity, and environmental conditions, it is difficult to generally quantify the benefits of precision farming (PF) (Gebbers and Adamchuk 2010). Overall, PF reduces greenhouse gas emissions, losses of critical inputs to the environment, and effluents from agricultural systems to water bodies, but the magnitude of these effects are often not well known or highly variable (Walter et al. 2017; Finger et al. 2019; Balafoutis et al. 2017). Reviews through the years describe that findings about the profitability of VRTs are ambiguous depending on economic environment, field conditions, choice of crop, considered inputs and precision technology used (Balafoutis et al., 2017; Lowenberg-DeBoer, 2018) and that also uptake of PF is heterogenous across time, space and technology (Finger et al. 2019).

The research gap is a study comparing different sensing technologies for the same application in one crop and across various field conditions, bringing together economic, agronomical, and technical aspects. Modelling and analysis in this thesis give insight into the potential environmental and economic benefits of VRT resolutions for Swiss wheat production under heterogenous field conditions and can inform future policy decisions.

Method

In this master's thesis a bioeconomic model to simulate herbicide application through VRT in wheat production in Switzerland is established. To this end the wellestablished rectangular hyperbolic yield loss model (Cousens 1985) is expanded into a damage abatement function by integrating a herbicide efficacy equation (Pannell 1990) which is then put in an economic framework. With this model the differences between five imaging technology resolutions with regards to optimal herbicide use, yield and revenue are simulated (exante). A simulated field of 1 ha is split into 2x2 m, 10x10m, 20x20 m, 50x50 m and a uniform 100x100 m resolution. Weeds are modelled to appear on the field in different distributions at different heterogeneity levels. The baseline scenario considers current wheat and pesticide prices and is compared to two tax scenarios (50% and 100% tax on pesticide). Model simulations are run in R. Sensitivity of the model results is analyzed by Latin hypercube sampling (Thiele, Kurth, and Grimm 2014).

Results

High spatial resolutions lead to high savings in herbicide use compared with standard rates and uniform application. The median values of optimal herbicide use show an upwards trend from higher to lower resolutions with the lowest median value being achieved by the 10x10 m resolution. The findings indicate that both the 2x2 m and the 10x10 m resolution are sufficient to achieve a 50% herbicide reduction compared to standard and uniform applications for the simulated heterogeneity. Higher spatial resolution technology leads to higher yields compared to lower resolution and uniform application, within a range of < 7% of the achievable yield. Higher spatial resolution technology leads to higher net returns compared to lower resolution and uniform application, but the difference is moderate. For the two tax scenarios the general trends are the same as for the baseline scenario. Median values of optimal amounts of herbicide are lower than in the baseline scenario under the 50% tax and lowest under the 100% tax for all resolutions. The amounts of yield lost for different resolutions under the tax scenarios are small (≈ 1%). This has implications for food security: All resolutions provide adequate yields despite herbicide input reductions. It also indicates that the choice of VRT resolution has a bigger impact on yields and food security than a tax scenario. As the tax increases the cost for herbicide total net return levels of all resolutions decrease by less than 30 CHF/ha from the baseline scenario to scenario b, and by less than 50 CHF/ha from the baseline to scenario c. Similar to the trend in yields, this indicates that the choice of VRT resolution has a bigger impact on net return than a tax scenario.

Conclusion and Policy implications

In this master's thesis a bioeconomic model simulating heterogenous field conditions for chemical weed management in wheat production was established to compare the environmental benefits and profitability of variable rate technology resolutions. For high resolution technologies savings in herbicide inputs of 50% could be found for the given heterogeneity range. A 50% herbicide tax was sufficient to incentivize significant reductions with a medium resolution technology option. Yield levels can be maintained with all technology options but vary more with lower resolutions, implying a higher production risk for farmers. Differences in net revenue between technology options in three scenarios range between 190 CHF/ha and 154 CHF/ha and are higher than results from an antecedent study on nitrogen fertilization.

Despite its limitations this work shows that substantial herbicide savings are achievable through spatially explicit information. Going forward the established model can be used by decision makers to analyze whether a technology option is financially viable for a given set of heterogenous field conditions. Tax schemes successfully incentivize the decrease of input use, albeit moderately. High herbicide saving potential and merely moderately higher net returns for higher technology resolutions represent a classic mismatch between public (environmental) and private (farmers) benefits. There are several entry points to facilitating and incentivizing the VRT uptake. Sharing infrastructure between farms via machine pools or contractors is one option (Späti et al., 2021). Providing the right boundary conditions such as high-speed internet access, a clear legislative framework, connectivity of devices, as well as investing in information, training, and education are also key (Finger et al., 2019).

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Swiss apple farmers' risk preferences, perceptions and pest management strategies

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Abstract

Global agriculture relies heavily on the use of pesticides. While pesticides are beneficial for production outcomes such as ensuring yield and plant protection, several negative side effects have been found (e.g., environmental pollution or adverse health effects) (Carvalho, 2006; Larsen, Gaines, & Deschenes, 2017; Stehle & Schulz, 2015; Valiuskaite, Uselis, Kviklys, Lanauskas, & Rasiukeviciute, 2017). Growing concerns about the negative side effects have increased the political effort to reduce pesticide application (Hu, Cao, Chen, & Li, 2022; Pretty, 2018; Schaub, Huber, & Finger, 2020). However, it has proven difficult to implement effective policies and there is little evidence that the policies implemented have led to an actual reduction of the risks and quantities of pesticides applied (Mohring et al., 2020; Pan, He, & Kong, 2020; Wanger et al., 2020). While farmers' decisions regarding pesticides are largely driven by economic evaluations like monetary costs and benefits, these do not fully explain famers' pest management choices. Behavioral factors have been found to be important for farmers' adoption of more sustainable agricultural practices and reduction of pesticide use (Finger & Mohring, 2022; Y. Wang & Finger, 2023). For example, behavioral characteristics such as risk preferences[1] and risk perceptions[2] were found to be important factors influencing farmers' decisions to apply pesticides (Dessart, Barreiro-Hurle, & van Bavel, 2019). However, the effects of these factors have not been studied intensively.

[1] *Risk preference describes how much a person likes or dislikes taking risks (Sulewski & Kloczko-Gajewska, 2014)*

[2] *Risk perception describes the subjective perception of the objective severity of risks from various hazards (Meraner & Finger, 2019)*

Therefore, the present thesis analyzes survey data of 188 Swiss apple farmers collected by Zachmann et al. in 2022 and investigates the relationship between farmers' risk preferences and risk perceptions of the pesticide-related effects on apple production, farmer health and the environment, and their use of pesticides. Apples are of high economic relevance in Switzerland, have large production volumes and high quality standards which lead to application of large amounts of pesticides. Thus, the present thesis firstly quantified the pest management strategies used by Swiss apple farmers and their risk preferences and pesticide-effect perceptions. Secondly, using an OLS regression model this thesis analyzed the relationship between farmers' decision to apply pesticides and their risk preferences, and perceptions of the effects of pesticides on apple production, human health, and the environment.

The results of this thesis showed that the use of chemical-synthetic pesticides is Swiss apple farmers' preferred pest management method. However, the chemical-synthetic pesticides are mostly used in combination with other plant protection methods, such as promotion of beneficial insects and confusion techniques. This has also been found to be the most effective strategy to combat pests (Y. Q. Wang, Wang, & Zhu, 2018). On average Swiss apple famers are risk-averse (i.e., do not like taking risks/ low risk preference). Generally, risk aversion is common among farmers as their livelihood is threatened by many factors, such as unpredictability of yield and variable input prices. Therefore, farmers often choose chemical-synthetic pesticides due to their reliability (European Comission, 2017; Kabir & Rainis, 2015). Additionally, in the present thesis farmers' risk preferences were found to be domain specific. For example, farmers are generally less willing to take risks regarding market and prices and more willing to take risks concerning environmental protection. Consequently, risk preferences from one domain cannot be used as predictors for risk preferences in another domain and this fact should be considered when designing policies aimed at farmers' risk preferences (Finger, Wupper, & McCallum, 2022). Despite the importance of risk preferences, the OLS model showed no significant influence of risk preference on farmers' pesticide application decisions, which may be due to relatively large heterogeneity of risk preferences among the farmers surveyed. Swiss apple farmers have a significantly positive perception of the effects of pesticides on apple production whereas their perception of the effects of pesticides on farmer health and the environment are neutral. The positive perception of pesticide effects on the production seems logical due to the product-enhancing purpose of pesticides (Parveen, Nakagoshi, & Kimura, 2003). Analysis of the OLS regression model revealed that farmers who have a one point more positive perception of pesticide effects on production (on a 5-point scale) have a 12.7-14.2% higher probability to use chemical-synthetic and non-chemical-synthetic pesticides. Perceptions of pesticide effects on farmer health and the environment did not exhibit a significant relationship with farmers' choice to apply chemical-synthetic or non-chemical-synthetic pesticides. Therefore, it seems that perceptions of pesticide effects on human health and the environment are not relevant enough to alter farmers' pesticide behavior whereas positive production outcomes take a dominant role in farmers' decision making (Vatn, Kvakkestad, Steiro, & Hodge, 2020). Furthermore, the more positive farmers perceive the effects of pesticides to be on apple production the less willingly they may try alternative pest management methods (Pissonnier, Lavigne, Toubon, & Le Gal, 2016).

In conclusion, policies aiming at a reduction of pesticide use should emphasize the positive impact alternative pest management methods can have on production, instead of focusing on reduced health and environmental risks. It is important to highlight that alternative pest management methods potentially lead to lower production risks, lower costs, and potentially higher profit in apple production. However, the development and implementation of reliable alternative strategies should be supported simultaneously. Furthermore, risk- averse farmers may be more willing to lower their use of pesticides if the increased income volatility due to avoidance of pesticides is reduced by efficient insurances (Dessart et al., 2019). Due to the long-term nature of apple trees, long-term solutions should be considered such as financial support in the transition phase while farmers switch from conventional to more sustainable production methods as changes may take longer to be implemented and become profitable (Lee, 2021; Toma & Mathijs, 2007). Finally, educating farmers about the advantages and disadvantages of different production methods is key to empower them to take the right pest management decisions to secure their livelihoods but also achieve sustainable apple production.

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