Report on dynamics of transition pathways and socio-technical lock-ins in arable farming

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LEGUMINOSE
the way to a green transition

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Summary

LEGUMINOSE (Legume-cereal intercropping for sustainable agriculture across Europe) is a research and innovation project funded by the European Commission (EC) under the Horizon Europe research program with the aim to identify the obstacles to intercropping and enhance farmers' acceptance by providing knowledge and demonstrations that promote economic, environmental, and social benefits of legume-cereal intercropping. The project is based on the premise that intercropping has the potential to reduce pesticides and improve plant-microbe mediated element cycling, soil health, and crop quality and health.

Summary of Deliverable

The purpose of this report (D2.4) is to provide a synthesis of transition pathway dynamics and socio-technical lock-ins in arable farming through the development of a structural equation model representing 7 European countries (Czech Republic, Denmark, Germany, Italy, Poland, Spain, and the United Kingdom) as well as Egypt and Pakistan.

The current report (D2.4) is part of a series of reports under LEGUMINOSE WP2. Other deliverables of the WP include Establishment of Dynamic Partnership Map (D2.1), Report on barriers and opportunities towards intercropping (2.2), Report on opportunities for intercropping species mixtures (D2.3).

Disclaimer

List of abbreviations

Technical	D	Deliverable
	EC	European Commission
	LL	Living Lab
	WP	Work Package
Partners (including sub-contractors)	APR	Agritec Plant Research S.R.O., Czech Republic
	AU	Aarhus Universitet, Denmark
	CIA	Confederazione Italiana Agricoltori Toscana, Italy
	CSIC	Agencia Estatal Consejo Superior De Investigaciones Cientificas, Spain
	DSV	Deutsche Saatveredelung AG, Germany
	ECOLOGICA	ECOLOGICA For Environmental Consultants and Studies Co. L.L.C., United Arab Emirates (sub-contractor of UNIFI)
	GCUF	Government College University Faisalabad, Pakistan
	IAPAS	Instytut Agrofizyki Polskiej Akademii Nauk, Poland
	LUH	Gottfried Wilhelm Leibniz Universitaet Hannover, Germany
	UNIFI	Universita Degli Studi Di Firenze, Italy
	UPA	Union de Pequeños Agricultores y Ganaderos, Spain
	UREAD	University of Reading, UK
	SA	The Soil Association, UK
Countries	DE	Germany
	DK	Denmark
	ES	Spain
	IT	Italy
	PL	Poland
	CZ	Czech Republic
	UK	United Kingdom
	EG	Egypt
	PK	Pakistan

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1 Introduction

The purpose of this report is to identify the dynamics of transition pathways and socio-technical lock-ins in arable farming related to intercrop adoption. The report is part of a series of reports of WP2 of the LEGUMINOSE project that assess the foundations for intercropping in farming systems across Europe and beyond. These reports include the D2.1 *Map of Establishment of Dynamic Innovation Partnership (DIP),* that establishes the foundations for selection of participants in a stakeholder forum. Further the D2.2 *Report on barriers and opportunities towards intercropping,* which provided an analysis of survey data to identify farmer characteristics as well as a wide range of decision-making factors. Finally, the D2.3 *Report on opportunities for Intercropping species mixtures,* which assesses the opportunities, strategies and enabling conditions for legume-cereal intercropping. Although each with a different focus, these reports are all based on feedback from stakeholders in various forms. The primary focus is to gather and improve the understanding of the enabling conditions for upscaling the adoption of intercropping.

Previous work with focus groups across partner countries in LEGUMINOSE WP2 established that, although legume-cereal intercropping is a promising cropping system for improving soil health and cropping system resilience a series of barriers hinders adoption. At the farm system level, key enabling factors for intercropping were identified as knowledge of best management practices (e.g. quality seed mixes), economic profitability, community-based advisory systems, and appropriate technology (e.g. farm equipment) (Stone et al. 2023 [forthcoming]). Better community networks, training and communication across the supply chain could also support young people to become intercropping farmers, a current weakness highlighted across some countries. Further, outreach and engagement with farmers through living labs (LL) are a promising platform to deliver some of the knowledge and technology required to increase adoption of intercropping in Europe and other countries where monocropping remains the dominant cropping system. However, farmers individual decision-making regarding intercropping is nested within wider food system dynamics, which also conditions individual agency. At the food system level, developing supply chains and supportive policies are key factors that will enable the expansion of intercropping (Stone et al. 2023).

1.1 Purpose

The purpose of the WP2 of LEGUMINOSE is to identify the knowledge gap between research and on-farm intercropping practices, to support subsequent research, experimental activities, and work dissemination.

The purpose of this report is to develop a stocktake of potential barriers for farmers' acceptance of intercropping and to understand how they link to the characteristics of farming systems. A qualitative inquiry among farmers at each location was initially carried out to identify needs and attitudes towards intercropping. These insights support implementation of quantitative analysis to better understand farmer's behaviour towards the adoption of agronomic innovation.

Barriers to adoption of innovation are studied by means of Structural Equation Models and Latent Class Regression in this report. This framework provides useful information for the implementation of policies in support of innovation uptake. Furthermore, it will offer insights for enhancing communication, dissemination strategies and stakeholder engagement that can be used to develop local awareness campaigns and design policy instruments to support the uptake of intercropping among farmers.

1.2 Structure

Chapter 1 provides an introduction to the report.

Chapter 2 provides brief review of literature about transition pathways in arable farming and the main points from previous deliverables of the WP.

Chapter 3 presents the methodology applied in the compilation of results for this report.

Chapter 4 presents a synthesis of results from a structural equation model built from data collected in a survey of farmers which collected perspectives on barriers and opportunities to integrating intercropping on their farming systems. The chapter is organised in three sections each representing different considerations for intercropping across the national partners.

Chapter 5 summarises the main conclusions.

2 Transition pathways in arable farming

Despite the environmental and economic benefits of intercropping supported by studies in the European context, legume-cereal intercropping has not been widely adopted in Europe, particularly in large-scale industrialized cropping systems (Bybee-Finley & Ryan, 2018). Legumes have low fertilizer requirements, a relatively high protein content and could potentially increase protein self-sufficiency and environmental impact reductions in support of the European Union's "Green Deal" (Ferreira et al., 2021). Enhancing legume production in the European Union (EU) has become a political objective. The EU's Common Agricultural Policy (CAP) regulations currently include legume as part of the greening restriction, for the provision of Ecological Focus Areas (EFA), to encourage adaptation by farmers (Bonke et al. 2021). Yet legumes are grown on just two percent of arable land in the EU (Ditzler et al., 2021). To increase the adoption of legume-cereal intercropping, it is important to understand the complex social, technical, and political barriers across Europe and beyond (Mamine & Farès, 2020). Identifying strategies for increased adoption are also important to support enabling environments for intercropping and could provide a framework to enable other green transitions. It is particularly important to understand considerations and perceptions of supply chain stakeholders from farm to fork to uncover barriers and trade-offs, enabling the design of mutually beneficial strategies across scales (Haysom et al., 2019).

Many theories and models describing agricultural technology adoption have been used to support understanding and pathways toward adoption, which can be useful in the context of adopting new practices to support green transitions. Dissanayake et al. (2022) conducted a literature review on technology adoption in agriculture using a collective approach model of the adoption of technology with the theory of planned behavior to identify four critical factors: (1) the adopters' (e.g. farmer or food system stakeholders) perceptions of usefulness, ease of use, compatibility; (2) the technology itself (e.g. intercropping, other transition toward a sustainable food system); (3) institutional factors; and (4) availability of capital sources (economic factors). Importantly, the personal attributes of adopters, as well as social factors, influence the adoption of innovations across the food system (Dissanayake et al., 2022). In the context of legume-cereal intercropping, our study highlighted that many characteristics influencing the intention to adopt for stakeholders were uncertain. For example, questions around intercropping compatibility, ease of use, relative advantage, and result demonstrability at farm and food system scales and untested economic and institutional support networks increased the perception of risk for adopters. A useful framework to understand intercropping pathways is the innovation adoption curve. Currently, intercropping is an example of an innovative production system in the innovator phase (Dissanayake et al., 2022) – to support adoption of intercropping for early and late majority adopters, we argue that it is critical to build five-point strategies to address farm, food, advice, governance, and networking in tandem. Similarly, it could be useful to organize pathways for green transitions using the community capitals framework to identify place-based SWOT and strategies (Flora et al., 2012; Flora et al., 2016).

Agri-food system transitions require stakeholder alignment in terms of challenges and solutions. One study analysing visions for the Dutch agri-food system found that environmental and social challenges were usually well-aligned, but the transition or solution required was often misaligned, especially for economic issues where grow oriented paradigms conflict with more holistic paradigms such as agroecology and hinder effective change (Wojtynia et al., 2021). Weituschat et al. (2022) used crop diversification as a case to understand how technological, economic, institutional, political, social, and cognitive lock-ins slow transitions toward sustainability. This study found three traps that slow sustainable transitions through historic misalignment (normative environmental goals disconnected from food security), incentive misalignment (gain-oriented goals unsupported), and disregarding discomfort (hedonic goals uncompensated). Our study found that a key strength of intercropping is the possibility of normative environmental gains without reducing yield on a field scale. However, lack of incentives (increased risk) and discomfort (lacking information) are barriers that must be addressed to enable wider adoption of intercropping. Organizing strategies that consider farm, food, advice, governance, and networking systems could help to overcome barriers, supporting green transitions in Europe and beyond. Incorporating these comprehensive strategies could facilitate green transitions in European food systems and beyond, building intercropping communication and knowledge exchange networks between European and non-European countries, supporting enabling environments for green food system transitions globally.

3 Methodology

The D2.4 *Report on dynamics of transition pathways and socio-technical lock-ins in arable farmin*g is a thorough assessment of the survey data presented in D2.2 using Structural Equation Modelling (SEM). Building on the D2.2, additional data treatment enabled the survey data to be utilized as input for the SEM. Three separate SEM's were created to examine the data: (1) a global SEM was developed to model average responses across all datasets; (2) a regional model, grouping European countries into North (DK, DE, UK), Central (CZ, PL) and South (ES, IT) to uncover regional differences; (3) a model for countries outside of Europe (PK, EG) was developed.

Using SEM to analyse farmers' opportunities and barriers for adopting intercropping across Europe and beyond supports the examination of complex relationships among variables (Schumacker and Lomax, 2010). By incorporating both observed and latent variables, we can gain a more holistic understanding of the factors influencing farmers' decisions to adopt intercropping. Further, SEM enables us to model the interdependencies and causal pathways, providing insights into how different variables are interconnected. This is valuable in understanding the strength and direction of the associations between various factors affecting intercropping adoption.

3.1 Survey development and dissemination

Before the survey was administered, AU requested that consortium partners identify existing studies, which together with the initial review of existing projects and research by AU partners provided a basis for the survey design (initiated as part of T2.4). A joint meeting of all partners was conducted to present the survey draft and receive and integrate input and suggestions. A survey template for this concise survey (~10-15 min) was provided to each partner country and was administered on a country basis (Table 1). The survey included five sections: (1) background information; (2) crop choice; (3) crop management; (4) intercropping; (5) general feedback. The survey contained qualitative as well as quantitative elements, thus providing different types of complementary information, offering a rich picture on farmers perspectives of a transition to intercropping (Creswell, 2014).

Table 1 - The participating countries with partners who conducted the surveys in each country identified.

Country	Partner
Czech Republic	APR
Denmark	AU
Germany	LUH & DSV
Italy	UNIFI & CIA
Poland	IAPAS
Spain	UPA & CSIC
United Kingdom	SA & UREAD
Egypt	UNIFI & ECOLOGICA (subcontractor)
Pakistan	GCUF

The survey template was made available in English and was completed by participants in English or using a translated version with the same questions and categories, the full survey template is available in Appendix A. The survey included a combination of open questions (with optional written input) and closed questions (with multiple choice options). The template also included a GDPR statement and an informed consent form.

3.2 Data collection

Identifying a useful sample of farmers was central to accomplishing our study aims. Given the diversity of farms and opportunities for accessing farms, partners were able to decide the best approach to reach farmers in their country, either online, by phone or face to face. Each partner country identified a sampling frame appropriately sized to reach at least 200 respondents. As response rates for e-mail surveys are typically low, more participants needed to be identified in this approach. Best practices for establishing points of contact and sending reminders were also considered. The respondents surveyed did not need to be intercropping at present but were selected to represent the prevailing production systems across the surveyed countries. Since some partner countries cover a large geographical area, farming practices would be incoherent, so particular regions within these countries were selected to participate in this survey.

Farmer surveys were conducted in each of the nine countries with total participation of 2051 with an average of 228 respondents per country (median 180). The number of respondents by country ranged from 818 in Denmark to 44 in the United Kingdom (Figure 1). The sampling frame was established on a country basis. Given the variation of farming systems across the surveyed countries, partners employed various approaches to gather data. For the most part, the survey was administered as an email survey, either through a direct contact or as a pop-up survey on a homepage or in a newsletter. The web-based format naturally gives preference to farmers that are younger, and less resource constrained, hence it may be more likely that the farmers responding are more open to engaging with academic research than average farmers and more open to adopting innovation, although this participation bias is difficult to account for. This variation in the number of informants and their related stakeholder categories is a minor shortcoming reflecting that the perspective and methods of stakeholder consultation varied slightly across countries. In Spain and the United Kingdom, farmers mentioned on several occasions that the survey was too long, and this could have affected obtaining more responses.

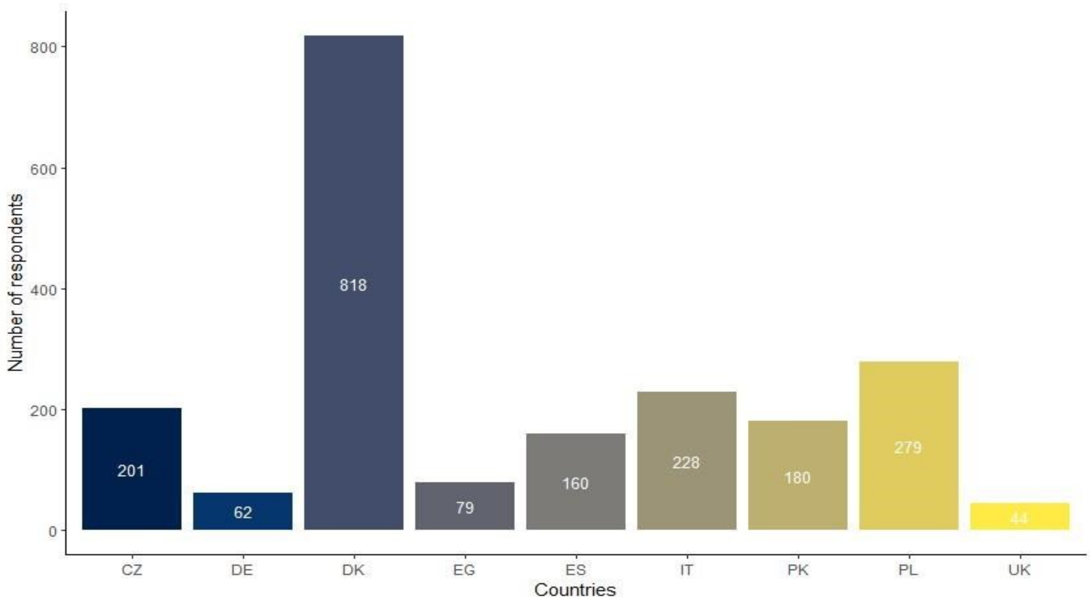

Figure 1 - The total survey participation by country with number of responses for each national survey listed in white.

3.3 Survey demographics

The most common age groups for respondents surveyed were the two oldest 41-60 years old (n= 981), followed by greater than 60 years old (n= 575). The smallest was the less than 25 age group (n= 80) and 26-40 years old was the second smallest (n= 383). The gender most producers identified with was as a man at 90.1% (n=1848), followed by as a woman at 9.0% (n=184), only twelve respondents identified as another option or chose not to disclose. The majority of respondents (62.6%, n= 1284) worked full time on the farm, 33% worked part time on the farm, and 3.3% selected other or chose not to disclose their occupational status.

3.4 Survey data treatment

The survey used as input for SEM development included 28 questions. The questions represented five constructs related to intercropping farms and strategies: (1) farm characteristics; (2) crop choice; (3) crop management; (4) opportunities; (5) barriers (Appendix A). Data collected in the survey was designed to provide an input to the SEM. Aside from the farm characteristics (1), each model construct (2-5) was addressed by a specific question asked on a Likert scale from 1 to 5. This numerical survey data that including the Likert scale questions were input into the SEM model without additional processing.
A more complex set of questions, variables and data types were included to represent the Farm construct. These inputs included characteristics about the farmer (e.g. age group), the farm in general (e.g. soil type), farm practices (e.g. conservation agriculture) and the food system context (e.g. market type). Questions to build the Farm construct were selected based on their measurability, use in other farm assessments, and their potential relevance to intercropping. The survey data that were non-numeric were processed in different ways for different data types (Table 2). When there were only two categories, binaries (0-1) were created. Binaries were also created when additional categories in the combined (all nine country) dataset were less than n= 100 (< 4.9%). For ranked categories, the low end of each category was used to create a scale. For example, for the total arable land 0 was used to represent the farms that were less than 50 ha, and 50 was used to represent the size category from 50-100. For unranked categories such as resource access one category was set to zero

(e.g. no access) while the additional categories were added on a scale (external partner: 1, on farm access: 2). Only the farm construct contained categorical variables, the rest of the constructs contained only numerical, primarily Likert scale variables. Variables consisting of multiple choices (e.g. livestock) were turned into a series of binary variables. To account for the compositional nature of these answers, the option indicating "none of the above" (e.g. "no livestock") was omitted from the analysis, as it was already included in the model in the combination of the other answers (e.g. if cattle & dairy, pigs, poultry, and other livestock all had a value of 0).

Table 2 – A list of categorical survey data in the Farm construct.

Binary	Gender Fulltime Farm practices (no-till, conservation agriculture, integrated pest management, mechanical weed control) Farm type (conventional, organic) Livestock (cattle & dairy, pigs, poultry, other livestock) Market type (sold or used on-farm)
Rank	Age – 4 levels Arable land area – 5 levels Advance planning – 4 levels Intercrop experience – 5 levels Intercrop likelihood – 5 levels
Categorical	Soil type – Sandy soil = 0, 5 levels Fertilizer type – Mineral fertilizer only = 0, 4 levels Irrigation – No, not relevant in my region = 0, 3 levels Resource access – No = 0, 2 levels

Two grouped (regional) models were developed based on their geographic locations (Table 3). The Regional Europe SEM includes North Europe, Central Europe and South Europe. The Outside Europe model included the two non-European countries in the partnership. The regional grouped varied in size from 259 to 924 survey responses.

Table 3 – Groups within the regional structural equation models.

Region	Country	Number of responses
North Europe	Denmark Germany United Kingdom	924
Central Europe	Czech Republic Poland	480
South Europe	Italy Spain	388
Outside Europe	Egypt Pakistan	259

3.5 Structural equation model development

SEM models were generated using the "lavaan" package (version 0.6.16, Rosseel 2012) in R. The model is a latent variable model, it measures covariance and error around individual inputs of each construct and builds pathway from exogenous variables (crop choice, crop management, farm characteristics) to endogenous variables (barriers and opportunities). The model consists of two components: the measurement model and the structural model. The measurement model contains the description of latent constructs, detailing which measured variables inform each construct. The structural model was developed to test how three aspects of intercropping strategy (crop choice, crop management, farm characteristics), influence the farmers perception of intercropping barriers and opportunities. The structural pathways thus lead from each of the three latent constructs (farm characteristics, crop choice, crop management) to both opportunities and barriers. Strength and magnitude of the estimated pathways can reveal which of these components has most influence on the perception of intercropping. The loadings of measured variables to constructs, as well as the paths of the structural model are available in Appendices B – D.

All models were fitted with diagonal weighted least squares (DWLS) estimator, which allows a better estimation of categorical variables, and all covariances between latent constructs were fixed to 0. The initial model was assessed for goodness of fit. To improve the fit, we assessed the multicollinearity and redundancy of each measured variable within its construct, and within the entire model, respectively. To this end, we calculated variance inflation factors (VIF) for variables within constructs and removed the variables with a VIF score >3. Variables with too little variation were discarded to avoid redundancy. We then assessed the misfit between correlations estimated by the model and observed correlations, and if problems were detected, we reassessed the structural model by inspecting the modification indices for the model. Through this process, two structural pathways, predicted to strongly improve the model, were added: One for crop management predicting crop choice, and another one for predicting the perception of barriers via perception of opportunities.

The global SEM model was constructed using all 2051 observations. The model fit was assessed with multiple indices; the Comparative Fit Index (CFI) was 0.971, the Tucker-Lewis index (TLI) was 0.969, Root Mean Square Error of Approximation (RMSEA) was 0.44. All these indices indicated a good fit. The model had 586 degrees of freedom.

A grouped model based on regions within Europe was also a good fit, with a CFI of 0.968, TLI of 0.966, and RMSEA of 0.045. This model had 1758 degrees of freedom. The SEM model for countries outside of Europe had the smallest sample size, but the fit of the model was still acceptable with a CFI of 0.941, TLI of 0.937, and RMSEA of 0.076. This model had 519 degrees of freedom. The regional groupings were created to achieve the statistical power necessary to create a reliable model. Thus, the countries with larger numbers of responses (e.g. Denmark) have greater effect on the regional models.

4 Results

Three structural equation models were developed to represent all data collected (Global model), as well as two grouped models one representing Europe regionally and another one for the two countries outside of Europe (Table 4). The global model has a strong positive association between Farm and Opportunities, and an insignificant association between Farm and Barriers. The Regional Europe model included negative associations in the Central and North. This indicates that not including some livestock types, not using conservation practices (no-till, conservation agriculture, integrated pest management, mechanical weeding) and not having clay soils all increased perceptions of Barriers and Opportunities in these regions. Farm had a positive association with Barriers and Opportunities in the South. This indicates that having livestock, conservation practices and sandy soil increased perceptions of barriers and opportunities. In the Outside Europe model Barriers were negatively associated with Farm while Opportunities were positively associated, this indicates that Farm variables have different relationships with Barriers as compared to Opportunities in these countries (Egypt, Pakistan).

In the global model, Crop choice had an insignificant influence on Barriers as Crop management was the best predictor of barrier perceptions. Crop choice had a larger impact on Opportunities in the global model while crop management was only slightly associated. In the regional models all European regions and the Outside Europe model had negative associations between Crop choice and Barriers. Aside from South Europe all regional models had positive associations between Crop choice and Opportunities. Crop management and Barriers also had positive associations in the regional models aside from South Europe. Crop management and Opportunities were positive across all regions in the Europe model but were negative in the Outside Europe model.

Table 4 – Comparisons of latent classes across the three SEM developed: Global, Regional Europe and Outside Europe. The Europe, regional model includes the same countries with the Southern region containing Spain, Italy, Central containing Czech Republic and Poland and North containing Denmark, Germany and United Kingdom. The Outside Europe model we have grouped Egypt and Pakistan.

Response	Predictor	Global Model	Europe, regional			Outside Europe
			South	Central	North	
Barriers	Farm	1.13 +/-0.59 .	0.24 +/-0.06 ***	-0.67 +/-0.15 ***	-0.37+/- 0.05 ***	-1.628 +/-1.697
	Crop choice	0.01 +/-0.08	-0.17 +/-0.06 **	-0.12 +/-0.07 .	-0.06+/- 0.03 *	-0.139 +/- 0.103
	Crop management	0.26 +/-0.07 ***	-0.02 +/-0.07	0.32 +/-0.10 ***	0.18+/- 0.03 ***	0.063 +/- 0.06
Opportunities	Farm	0.74 +/-0.18 ***	0.22 +/-0.03 ***	-0.43 +/-0.06 ***	-0.22+/- 0.03 ***	2.316 +/- 0.418 ***
	Crop choice	0.28 +/-0.03 ***	-0.002 +/-0.03	0.03 +/-0.04	0.19 +/- 0.02 ***	0.462 +/- 0.852
	Crop management	0.05 +/-0.02 *	0.30 +/-0.04 ***	0.34 +/-0.05 ***	0.06 +/- 0.02***	-0.275 +/- 0.645
Crop choice	Crop management	0.57 +/-0.04 ***	0.68 +/-0.08 ***	0.88 +/-0.14 ***	0.29 +/- 0.04 ***	0.752 +/- 0.132 ***
Barriers	Opportunities	0.63 +/-0.19 ***	0.81 +/-0.05 ***	0.63 +/-0.07 ***	1.06 +/- 0.03 ***	2.597 +/- 0.756 ***

4.1 Global structural equation model

In the Global SEM, survey data from all countries were included to identify potential strategies connecting crop management, crop choice and farm characteristics to opportunities and barriers of intercropping (Figure 2). The overall pathways showed that the Farm construct was most strongly associated with Barriers (1.129, p= 0.054) as compared to Opportunities (0.736, p= 0.000). The Crop management construct was also more strongly associated with Barriers (0.260, p=0.000). Conversely, the Crop choice construct was most strongly associated with Opportunities (0.280, p= 0.000) than Barriers (0.008, p= 0.920).

Of the seven components within the Crop management construct in the Global model, the most critical variable informing the strength of opportunities and barriers were the continuous monitoring of crops during the season (0.907, p= 0.000). Additional important variables were the use of decision support tools (0.771, p= 0.000) following a fixed spraying schedule (0.759, p= 0.000). Within the Farm construct, three characteristics were significantly informing responses to opportunities and barriers. The first was the presence of livestock on farming systems: poultry, other livestock, pigs. The second was the use of conservation practices – both Integrated Pest Management and Conservation Agriculture. The third and final was the farm soil type categorized by its texture. Within the Crop choice construct, the most significant component was selecting crops that are disease resistant followed by crops that are competitive against weeds and building humus. Both Crop management and Crop choice are more strongly associated with the Opportunities. Crop management is more weakly associated with Barriers while Crop choice was negatively associated with Barriers. This indicates that an increase in the importance of selecting crops based on disease resistance, weed competition and to build humus (Crop choice) reduces the importance of perceived barriers to intercropping.

The Farm construct in the European SEM contained 9 components, the strongest variables were soil type (-0.309, p= 0.000), followed by the practice of mechanical weeding (-0.098, p= 0.000). The Farm construct included many negative associations, this indicates that not utilizing conservation practices, having soil types with less sand are associated with increases in the Opportunities and Barriers perceived.

The Opportunities that were most impactful were crop diversity and climate footprint. Weed and pest/disease control were also important opportunities of intercropping. The least impactful components of the Opportunities were yield stability and soil structure. The most impactful Barriers were yield uncertainty, crop advisor knowledge and the availability of time to integrate intercropping onto farm systems. The least impactful Barriers were subsidies and markets.

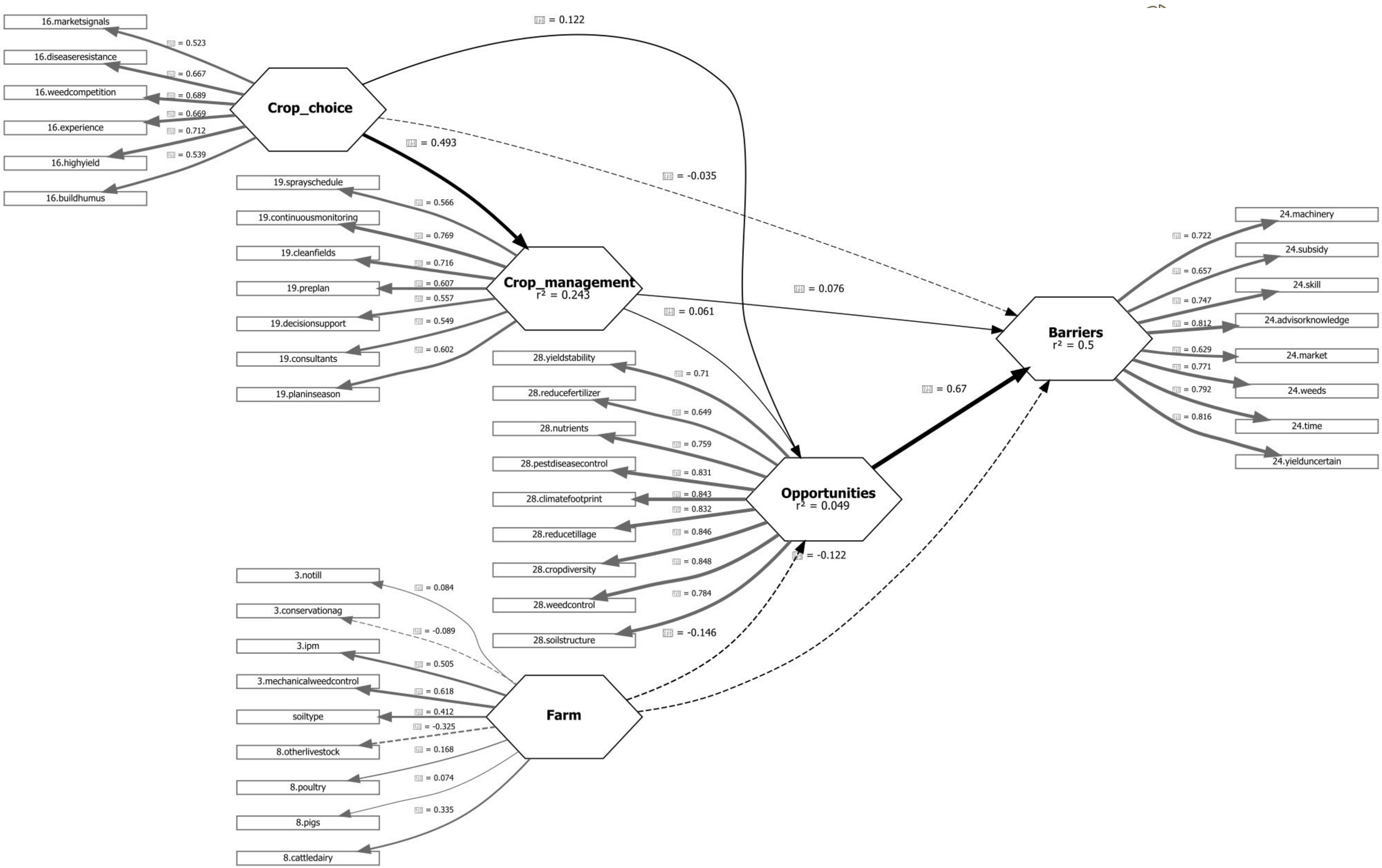

Figure 2 – Global structural equation model.

4.2 Regional European structural equation model

In the Regional Europe SEM, survey data from European countries were grouped based on region (Table 3), to identify potential strategies connecting crop management, crop choice and farm characteristics to opportunities and barriers of intercropping. North, Central and South Europe had different pathways between constructs. The North and Central models had the same positive and negative associations between constructs while the South Europe model had more differences, with negative associations for Barriers and Crop management and Opportunities and Crop choice which are positive in the other two regions.

In North Europe the most important barriers were yield uncertainty followed by lack of time and then weed management (Figure 3). The most important opportunities were provision of nutrients for crops in subsequent growing seasons followed by weed control. The most important variable in the Farm construct was soil type. The only negative variable in the Farm construct was the inclusion of other livestock types. The most important variable in the Crop choice construct was selecting for disease resistance and in Crop management was clean fields.

In South Europe the most important barriers were yield uncertainty tied with weed management and followed by lack of time (Figure 4). The most important opportunities were crop diversity followed by reduced tillage and provision of nutrients for crops in subsequent growing seasons. The most important variable in the Farm construct was a negative association with soil type. In addition to soil type, the negative variables in the Farm construct were integrated pest management, mechanical weeding, and the inclusion of poultry and cows (dairy/cattle) livestock types. The most important variable in the Crop choice construct was selecting for disease resistance and in Crop management it was using decision support tools.

In Central Europe the most important barriers were yield uncertainty followed by weed management and self-perceived skills to practice intercropping (Figure 5). The most important opportunities were crop diversity followed by climate footprint. The most important variable in the Farm construct was soil type. Negative Farm variables included no-till and keeping poultry and pigs. The most important variable in the Crop choice construct was building humus and in Crop management it was using decision support tools.

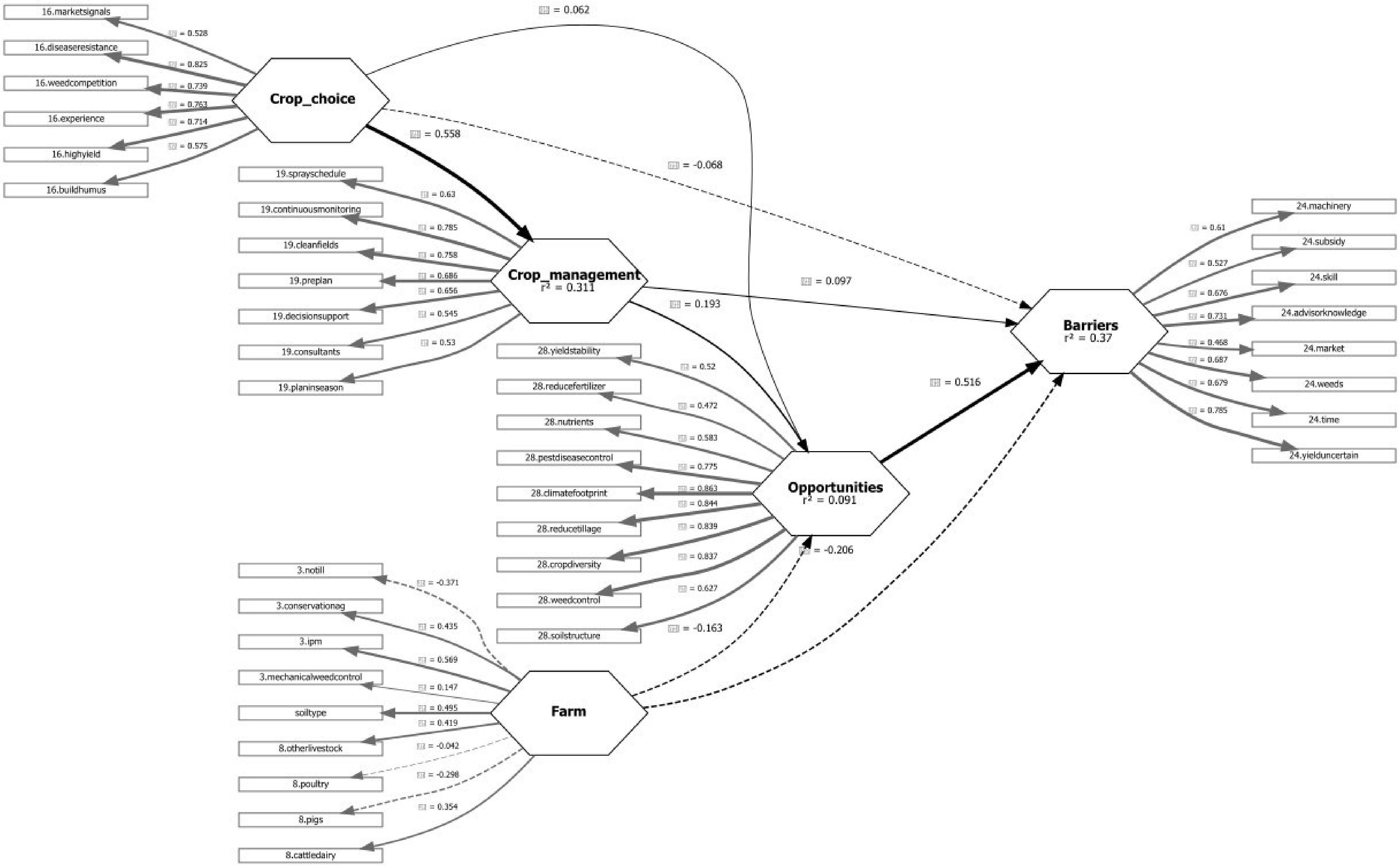

Figure 3 – North Europe structural equation model.

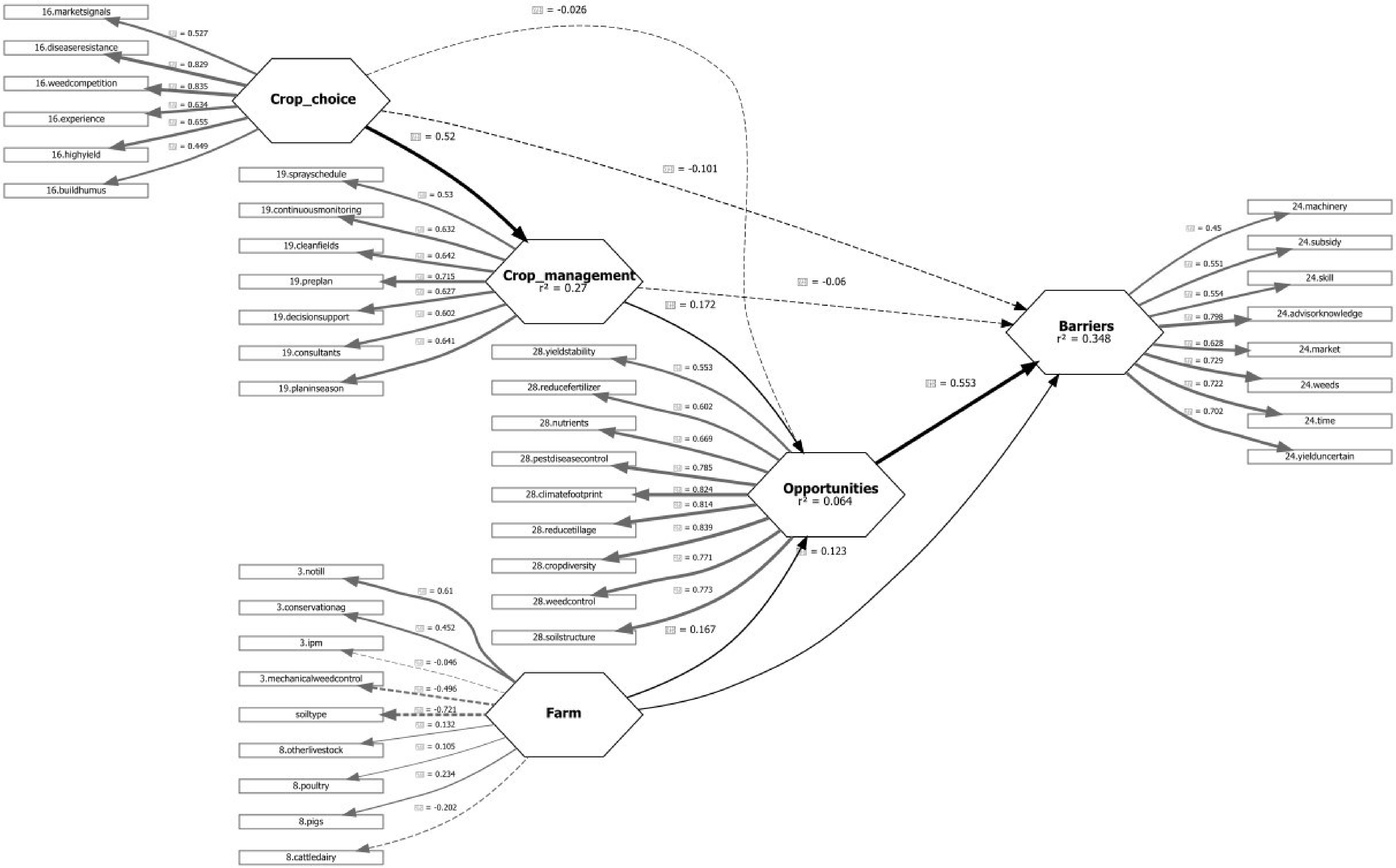

Figure 4 – South Europe structural equation model.

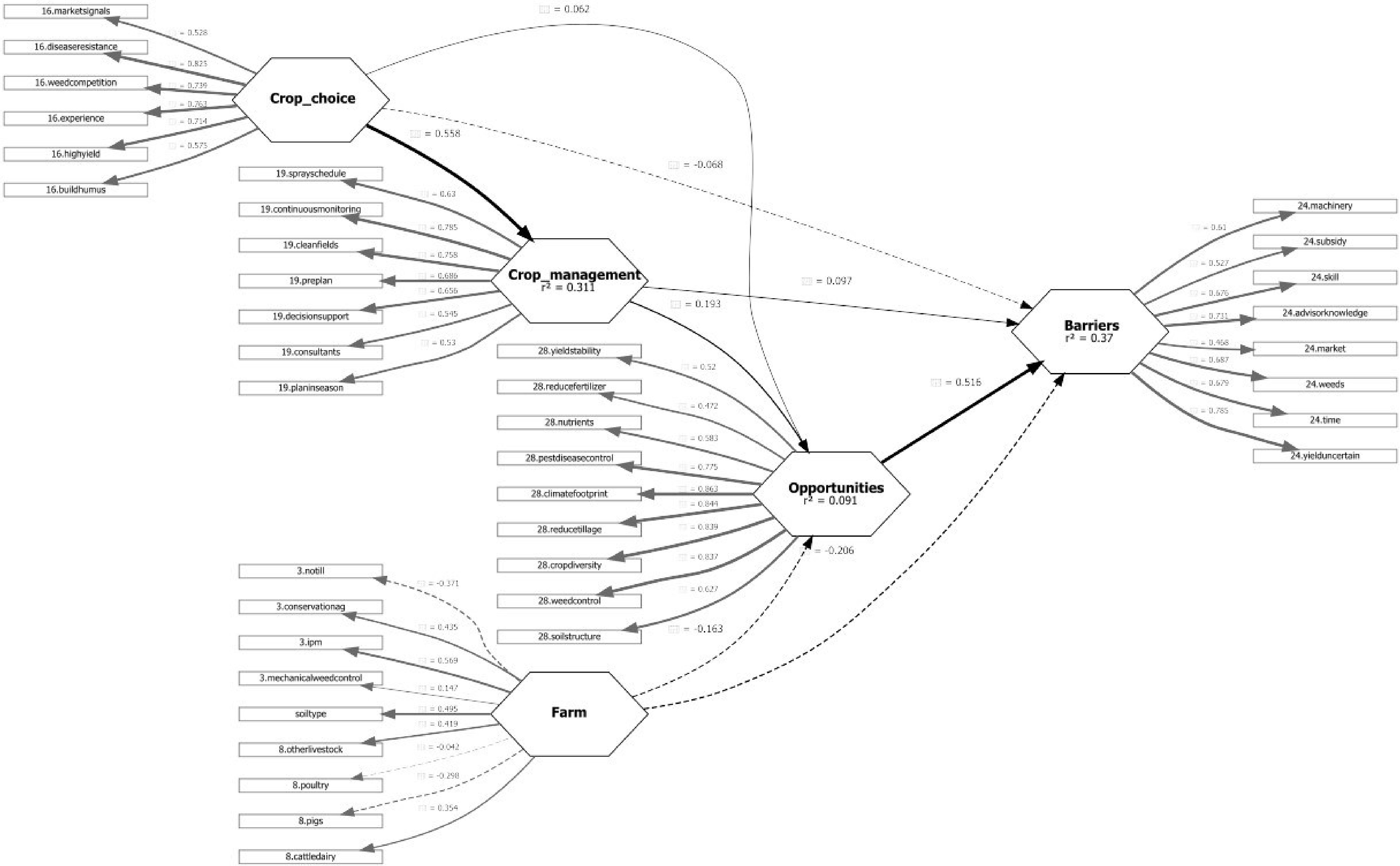

Figure 5 – Central Europe structural equation model.

4.3 Outside Europe structural equation model

In the outside Europe SEM, survey data from the two countries located outside Europe (Egypt and Pakistan) were included to identify potential strategies connecting crop management, crop choice and farm characteristics to opportunities and barriers of intercropping. We excluded the measured variables of pigs as livestock, as well as the use of no till practice, as the two variables were never present in these countries. The overall pathways showed that the Farm construct was most strongly associated with Opportunities (2.316, p= 0.054) as compared to Barriers (-1.628, p= 0.000). The Farm construct was also most strongly associated with both Opportunities (2.316, p= 0.000) and Barriers (-1.628, p= 0.338). There was an association between Crop management and Crop choice (0.752, p= 0.000) indicating that decisions within one construct influence the other. Similarly, Barriers were associated with Opportunities (2.597, p= 0.001). Of the seven components within the Crop management construct, the most critical variable informing the strength of opportunities and barriers were planning in season (1.312, p=0.000), following a fixed spraying schedule (1.000, p=0.000), while additional important variables were having clean fields and decision support (0.832, p=0.000). Within the seven Farm construct, four characteristics were significantly informing responses to opportunities and barriers. These included (1) soil type (-2.028, p=0.000); (2) mechanical weeding (-1.475, p=0.000); and (3) conservation practices – both Integrated Pest Management and Conservation Agriculture (1.343 and 1.000 respectively, p=0.000). Within the Crop choice construct, by far the most significant component was selecting crops that are disease resistant.

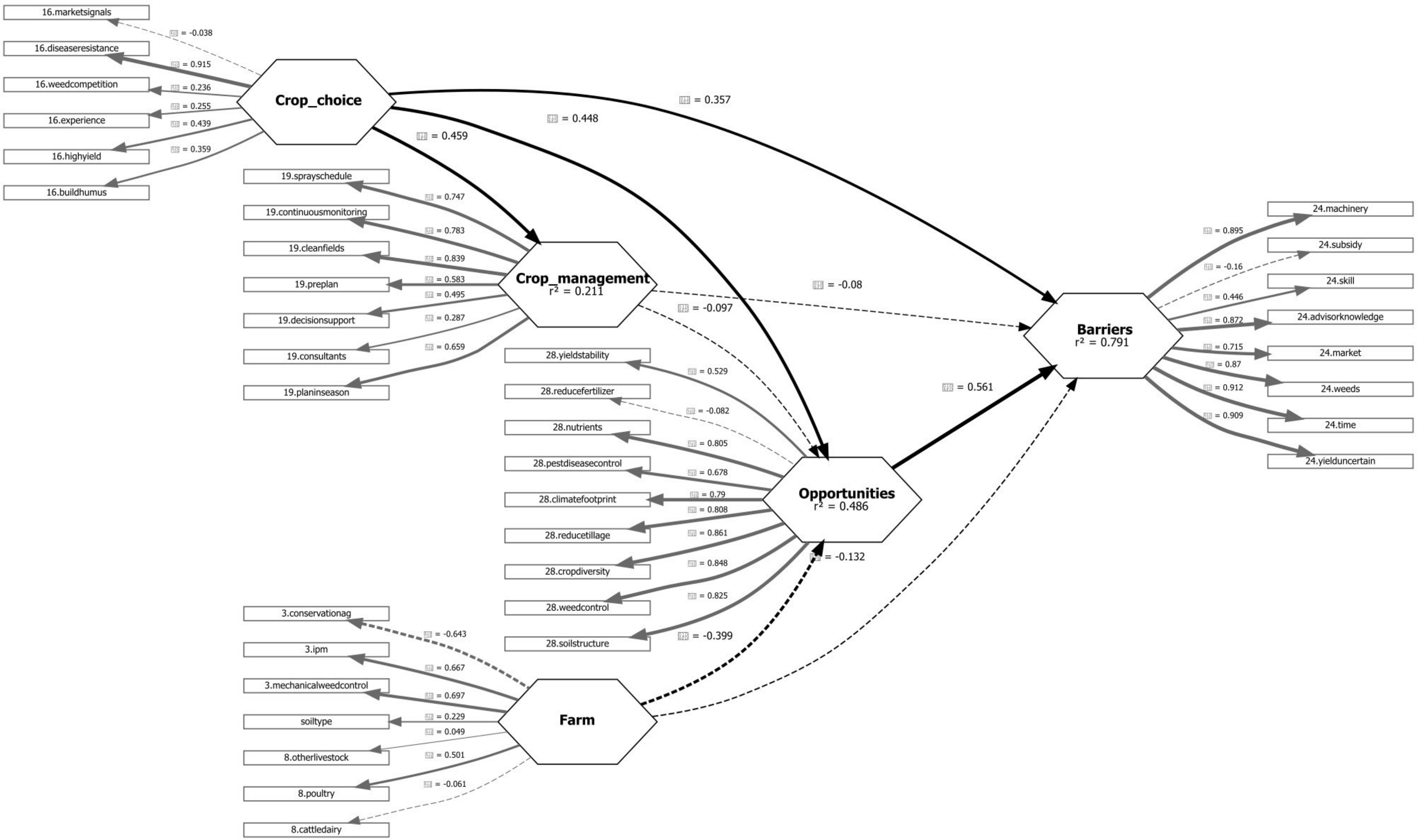

Figure 6 – Outside Europe structural equation model.

5 Conclusion

The structural equation models identified associations between opportunities and barriers to legume-cereal intercropping and farm characteristics and decision-making (crop choice, crop management). The global SEM model highlighted that across all models, opportunities inform barriers and crop choice informs crop management decisions. These associations could be harnessed by developing pathways toward greater intercrop adoption by addressing barriers and opportunities in tandem.

Although the variation across Europe and beyond in terms of the predictors of barriers and opportunities is modest (most strongly influenced by farming system characteristics). The variation observed has implications for planning interventions to support a transition to intercropping, the variation in SEM parameters across European regions and Pakistan and Egypt outside Europe underscores the need for targeted, regional-specific interventions that consider local factors, practices, and challenges. Understanding local factors influencing the success of intercropping systems is crucial for designing targeted and context-specific strategies and tailoring such strategies to the unique characteristics of each region will enhance the effectiveness of efforts to support a transition to intercropping.

In the North Europe SEM, Farm was most strongly associated with both Opportunities and Barriers. The farm characteristics that most negatively impacted Opportunities and Barriers were integrated pest management (IPM) and soil type, indicating that the greater the percentage of sand in soil and the more IPM is used the less the farm will be impacted by the opportunities and barriers. In this region different types of livestock also had different relationships to opportunities and barriers with poultry increasing the opportunities and barriers experienced and cattle decreasing them. Based on our analysis, farmers with cattle in North Europe could have an easier time adopting intercropping as compared to poultry producers on average. Crop management had a stronger positive pathway to barriers and opportunities as compared to Crop choice. Thus, in North Europe a strategy targeting and supporting crop management decisions could be the best approach to increase opportunities if barriers were addressed in tandem.

In the South Europe SEM, Crop choice and Crop management were both negatively associated with Barriers, while farm characteristics were positively associated with Opportunities. In all other models (Regional European, Global, Outside Europe) Farm was negatively associated with barriers and opportunities, however, the strongest variable within Farm was still soil type, the same as North Europe, and the same relationship held. Conversely, in South Europe practicing no till, and conservation agriculture increase opportunities and barriers experienced while not practicing mechanical weeding or using IPM have a similar relationship, increasing the opportunities and barriers. The strongest pathways in the South Europe model are between crop management and opportunities, followed by crop choice and barriers. Thus, a strategy that relates crop management with opportunities and crop choice with barriers could provide the most effective pathway toward intercrop adoption in South Europe.

In the Central Europe SEM, many pathways were similar to those in North Europe in terms of direction and strength. Similar to North Europe, Central Europe also had stronger positive pathways from Crop management to Barriers and Opportunities as compared to Crop choice. Given the similarities in the SEM between these two regions, developing similar strategies for increasing intercrop adoption could be an effective approach.

In the Outside Europe SEM, Crop choice was positively associated with both Opportunities and Barriers, while Crop management and Farm were negatively associated with both. In Egypt and Pakistan, a strategy emphasizing increases in Crop choice variables would

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effectively increase Opportunities, however attention would need to be paid to ensure that Barriers would not increase as this association is also positive. Crop management variables were much less impactful and strongly associated with Crop choice, similar to North and Central Europe. The negative relationship between Farm and both Opportunities and Barriers indicates that farmers keeping poultry and practicing conservation agriculture experience fewer barriers and opportunities to intercropping in these countries.

Combined interpretation of pathways with the loadings of construct variables could support a complex but useful image of the connections from crop choice, crop management, farm characteristics to barriers and opportunities for legume-cereal intercrop adoption. For example, within crop choice supporting the development of high yielding varieties and ratios of legume cereal mixes for intercropping and increasing weed competition of these mixes and experience levels for farmers are all important components of crop choice that dampen how strongly barriers are experienced at the farm scale. The global model had associations between increases in crop management variables such as continuous monitoring and clean fields with increased barriers experienced by farmers. Future exploration of the relationship between intercropping barriers and opportunities with variables such as keeping livestock by type and conservation practices could help to illuminate specific pathways to enable intercrop adoption across Europe and beyond. Furthermore, involving local stakeholders, including farmers, agricultural extension services, researchers, and policymakers, in the planning and implementation of interventions could harness the findings from this SEM on a regional basis. In the forthcoming LEGUMINOSE Living Labs that will be implemented in the coming years, the specific local characteristics of the survey, may help to guide researchers and stakeholders in selecting suitable interventions.

6 Reference list

Bonke, V., Michels, M., & Musshoff, O. (2021). Will farmers accept lower gross margins for the sustainable cultivation method of mixed cropping? First insights from Germany. Sustainability (Switzerland), 13(4), 1–14. https://doi.org/10.3390/su13041631

Bybee-Finley, K. A., & Ryan, M. R. (2018). Advancing intercropping research and practices in industrialized agricultural landscapes. In Agriculture (Switzerland) (Vol. 8, Issue 6). MDPI AG. https://doi.org/10.3390/agriculture8060080

Creswell, J. W. (2014). Research design: qualitative, quantitative, and mixed methods approaches (Fourth edition, international student edition ed.). Los Angeles, Calif.: SAGE.

Dissanayake, C. A. K., Jayathilake, W., Wickramasuriya, H. V. A., Dissanayake, U., Kopiyawattage, K. P. P., & Wasala, W. M. C. B. (2022). Theories and Models of Technology Adoption in Agricultural Sector. In Human Behavior and Emerging Technologies (Vol. 2022). Wiley-Hindawi. https://doi.org/10.1155/2022/9258317

Ditzler, L., van Apeldoorn, D. F., Pellegrini, F., Antichi, D., Bàrberi, P., & Rossing, W. A. H. (2021). Current research on the ecosystem service potential of legume inclusive cropping systems in Europe. A review. Agronomy for Sustainable Development, 41(2), 26. https://doi.org/10.1007/s13593-021-00678-z

Ferreira, H., Pinto, E., & Vasconcelos, M. W. (2021). Legumes as a Cornerstone of the Transition Toward More Sustainable Agri-Food Systems and Diets in Europe. In Frontiers in Sustainable Food Systems (Vol. 5). Frontiers Media S.A. https://doi.org/10.3389/fsufs.2021.694121

Flora, C. B., Flora, J. L., & Gasteyer, S. P. (2016). Community capitals and the rural landscape (5th Edition). Routledge.

Flora, C., Bregendahl, C., & Renting, H. (2012). Collaborative community-supported agriculture: balancing community capitals for producers and consumers. Journal of Sociology of Agriculture, 19(3), 329–346. http://ijsaf.org/archive/19/3/flora_bregendahl.pdf

Haysom, G., Olsson, E. G. A., Dymitrow, M., Opiyo, P., Buck, N. T., Oloko, M., Spring, C., Fermskog, K., Ingelhag, K., Kotze, S., & Agong, S. G. (2019). Food systems sustainability: An examination of different viewpoints on food system change. Sustainability (Switzerland), 11(12), 1–17. https://doi.org/10.3390/su10023337

Mamine, F., & Farès, M. (2020). Barriers and levers to developing wheat-pea intercropping in Europe: A review. In Sustainability (Switzerland) (Vol. 12, Issue 17). MDPI. https://doi.org/10.3390/SU12176962

Rosseel, Y. (2012). lavaan: An R Package for Structural Equation Modeling. Journal of Statistical Software, 48(2), 1-36. https://doi.org/10.18637/jss.v048.i02

Schumacker, R. E., & Lomax, R. G. (2010). A beginner's guide to structural equation modelling (Third edition). New York, NY: Routledge, Taylor & Francis Group.

Weituschat, C. S., Pascucci, S., Materia, V. C., Tamas, P., de Jong, R., & Trienekens, J. (2022). Goal frames and sustainability transitions: how cognitive lock-ins can impede crop diversification. Sustainability Science, 17(6), 2203–2219. https://doi.org/10.1007/s11625-022-01156-5

Wojtynia, N., van Dijk, J., Derks, M., Groot Koerkamp, P. W. G., & Hekkert, M. P. (2021). A new green revolution or agribusiness as usual? Uncovering alignment issues and potential transition complications in agri-food system transitions. Agronomy for Sustainable Development, 41(6). https://doi.org/10.1007/s13593-021-00734-8

Appendix A: Survey questions

1. You and your farm

Initially we would like to know a bit about you and your farm.

1. How much arable land is on your farm? (owned and leased combined)
    - <50 ha
    - 51-100 ha
    - 100-150 ha
    - 151-200 ha
    - > 200 ha
2. Farm type
    - Conventional
    - Organic
    - Other
3. Do you employ any of the following practices on your farm? (tick more boxes if needed)
    - No-till
    - Conservation Agriculture
    - Integrated Pest Management
    - Mechanical weeding
4. Do you work with farming full time?
    - Full time
    - Part time
    - Other/I do not wish to disclose
5. How old are you?
    - <25 years
    - 26-40 years
    - 40-60 years
    - >60 years
6. Gender
    - Man
    - Woman
    - Other/I do not wish to disclose
7. Which soil type is dominant on your farm?
    - Sandy soil
    - Sandy loam
    - Loamy soil
    - Silty loam
    - Clay soil
    - Organic soil

8. Do you have livestock on your farm?
    - No
    - Yes – Cows (dairy or beef)
    - Yes – Pigs
    - Yes - Poultry
    - Yes – Other, please specify:_________

9. How much of your arable land is used for growing grain crops?

    - ________ % of your total arable land

10. How much of your arable land is used for growing grain legume crops?

- ________ % of your total arable land

11. How many different harvestable crops did you grow on your fields in the last growing season?

    - ________

	On farm	External partner	No
Farm advisory service			
Grain storage facilities			
Drying facilities			
Grain cleaning facilities			
Harvester			
Machinery for weed management			
Sowing machine			
Wide selection of seeds			
Access to credit			

12. On a scale from 1-5 do you experience any of the following challenges in your fields?

	1: Not at all	2: To a small extent	3: Neutral	4: To some extent	5: To a very high extent	I don´t know
Drought						
Erosion						
Low carbon content in the soil						
Low soil fertility						
Salinization						
Flooding of fields						
Weeds						
Other important challenges:__________						

2. Crop choice

The following section contains a set of questions regarding the background for your choice of crops.

13. On a scale from 1-5 to how important are the following information sources for your choice of crops?

	1: Not important at all	2: Slightly important	3: Neutral	4: Important	5: Very important	I don´t know
Social media						
Printed media						
Other farmers						
Farmer associations						
Advisory service						
Scientific literature						
Seed providers						
Processing companies						
Decision support tools/ Farm information systems						
Other						

14. Other platforms used and other reflections regarding media for communication?
    - ______________________________

15. Which of the following statements most accurately describe your decision making regarding the timing of your crop choice? (please select the most relevant option)
    - I plan which crops to grow on most my fields years in advance
    - I plan which crops to grow on some of my fields years in advance
    - I plan which crops to grow on most my fields months in advance
    - I plan which crops to grow on some of my fields months in advance
    - Other, please detail

16. On a scale from 1-5 to which extent do you agree with the following statements regarding your crop choice?

	1: Not at all	2: To a small extent	3: Neutral	4: To some extent	5: To a very high extent	I don´t know/ not applicable
I pay close attention to market signals before deciding which crops to grow?						
I select crops in collaboration with my advisor?						
It is very important that my crops are resistant to diseases?						
I prefer varieties that are strong in competition with weeds						
I select crops based on past experience						
I follow a fixed crop rotation plan						
I prefer varieties with a high yield						
I select crops that contribute to building humus in the soil						
I select crops I can use on my farm for feed						
The crops are selected for me						
My current cropping system is not sustainable						

3. Crop management

The following section contains a set of questions regarding how you manage your crops in the growing season.

17. What is the most important source of fertilization for your crops
    - I only use mineral fertilizers
    - Livestock manure
    - Legumes
    - Other source of nutrients (please specify): ______________
18. Do you irrigate your crops?
    - Yes – always
    - Yes – sometimes
    - No – but it would be great for the crops
    - No - Not relevant in my region

19. To which extent do you agree with the following statements regarding crop management on a scale from 1-5?

	1: Not at all	2: To a small extent	3: Neutral	4: To some extent	5: To a very high extent	I don´t know
Following a fixed spraying schedule is important to me						
My fields are managed by external contractors						
I find it is very important to continuously monitor crops for pests or disease						
Having clean fields is important to me						
Weed and pest management is something I plan before the beginning of the growing season						
I use decision support tools to adjust my disease and pest management in the growing season						
Consultants are important in my deciding how I should manage pests and disease in my fields						
Weed and pest management is planned during the growing season						

20. What do you typically do with your cereal and grain legume crops? (please select relevant options)

	Grain legumes	Cereal crops
Sell - On contract before harvest		
Sell - On the spot market		
Sell - Directly to another farmer		
Sell - Directly to processor/mill		
Use on farm		
I don’t grow the crop		
Other		

4. Intercropping

The following section contains a set of questions specifically addressing your perceptions of legume-cereal intercropping.

Legume-cereal intercropping is an agricultural technique where legume crops (such as beans or peas) are planted alongside cereal crops (such as wheat or barley) in the same field. The crop can either be sold as a mixed crop, separated or used as livestock feed.

21. Which statement most accurately describes your level of experience with respect to intercropping? (Please select the most relevant option)
    - I have never heard of intercropping before
    - I have heard a little about intercropping before
    - I have heard a lot about intercropping
    - I have tried intercropping
    - Intercropping is often a part of my crop rotation
    - I don't know

22. On a scale from 1-5 how likely is it that you would have intercropping on your fields in the future?

	1: Highly unlikely	2: Unlikely	3: Neutral	4: Likely	5: Very likely	I don´t know/not applicable

23. On a scale from 1-5, how familiar are you with the following intercropping systems?

	1: Unfa miliar	2: Some what unfamil iar	3: Neutral	4: Some what familiar	5: Very familiar	I don´t know
Cereal and pea mixtures						
Cereal and forage legumes						
Cereal and grain legume crops						
Oilseed and grain legume crop						
Other combinations, please elaborate						
Not familiar with intercropping at all						

24. A number of barriers typically prevent farmers from intercropping. Which of the following barriers are the three most important for you?

	1: Most importa nt	2: Second most important	3: Third most important	I don't know
I do not have access to machinery to implement intercropping at my farm				
Subsidy schemes do not provide support for intercropping				
I do not have sufficient skills to grow multiple species at a field				
Advisors are unable to support me with relevant knowledge				
For me it is difficult to sell a mix of cereal and grain legumes				
For me it is difficult to use a mix of cereal and grain legumes as feedstock				
It is very difficult to control weeds or pest in an intercropping field				
I do not have the resources (time/labour) to experiment with intercropping				
Yield of intercropping is uncertain				
Other concerns, prevent me from adopting intercropping: ____________				

25. Why do you consider these to be the biggest barriers?

- _________

26. On a scale from 1-5 to which extent would the following elements strengthen your ability to adopt intercropping?

	1: Not at all	2: To a small extent	3: Neutral	4: To some extent	5: To a very high extent	I don´t know
Field demonstrations						
Documentation of results of field trials						
Access to subsidies						
Better opportunities to sell mixed crops						
Access to machinery to separate mixed crops						
Access to advice						
Access to online decision support tool						
Other, please elaborate						

27. What is the most important element, and why?
   - ______________________________

28. Intercropping may also potentially provide a range of benefits. Which of the following benefits are the three most important for you?

	1: Most important	2: Second most important	3: Third most important	I don't know
Yield stability				
Reducing fertiliser applications				
Provision of nutrients for crops in subsequent growing seasons				
Pest and disease control				
Improving soil structure				
Weed control				
Crop diversity				
Reducing tillage				
Improving climate footprint of products				

29. Why do you consider this to be the biggest benefits?

- ○ _________

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Appendix B: Global structural equation model latent variables, regressions and variance

Table 5: Global model, description of latent variables.

	Estimate	Std.Err	z-value	P(>|z|)
Barriers				
Q_24.machinery	0.387	0.079	4.916	0.000
Q_24.subsidy	0.339	0.069	4.913	0.000
Q_24.skill	0.388	0.079	4.917	0.000
Q_24.dvsrknwld	0.434	0.088	4.920	0.000
Q_24.market	0.348	0.071	4.914	0.000
Q_24.weeds	0.421	0.086	4.919	0.000
Q_24.time	0.423	0.086	4.918	0.000
Q_24.yildncrtn	0.480	0.098	4.920	0.000
Opportunities				
Q_28.yldstblty	0.659	0.056	11.787	0.000
Q_28.rdcfrtlzr	0.533	0.045	11.738	0.000
Q_28.nutrients	0.660	0.056	11.802	0.000
Q_28.pstdsscnt	0.762	0.064	11.831	0.000
Q_28.clmtftprn	0.776	0.066	11.835	0.000
Q_28.reductllg	0.730	0.062	11.829	0.000
Q_28.crpdvrsty	0.769	0.065	11.835	0.000
Q_28.weedcntrl	0.794	0.067	11.837	0.000
Q_28.solstrctr	0.708	0.060	11.817	0.000
Farm				
Q_3.notill	-0.003	0.005	-0.538	0.591
Q_3.conservtng	-0.012	0.005	-2.176	0.030
Q_3.ipm	-0.074	0.012	-6.354	0.000
Q_3.mchnclwdcn	-0.098	0.015	-6.503	0.000
Q_soiltype	-0.309	0.048	-6.475	0.000
Q_8.othrlvstck	0.020	0.004	4.653	0.000
Q_8.poultry	-0.008	0.003	-2.969	0.003
Q_8.pigs	-0.004	0.004	-1.220	0.222
Q_8.cattledary	-0.055	0.009	-5.904	0.000
Crop_choice				
Q_16.dssrsstnc	0.751	0.040	18.742	0.000
Q_16.wedcmpttn	0.485	0.028	17.340	0.000
Q_16.buildhums	0.513	0.029	17.987	0.000
Crop_management				
Q_19.spryschdl	0.759	0.026	29.397	0.000
Q_19.cntnsmntr	0.907	0.027	33.532	0.000
Q_19.cleanflds	0.562	0.021	26.730	0.000
Q_19.preplan	0.733	0.026	28.698	0.000
Q_19.dcsnspprt	0.771	0.026	30.212	0.000
Q_19.consltnts	0.714	0.026	27.408	0.000
Q_19.planinssn	0.639	0.025	25.602	0.000

Table 6: Global model regressions.

	Estimate	Std.Err	z-value	P(>|z|)
Barriers				
Farm	1.129	0.586	1.928	0.054
Crop_choice	0.008	0.079	0.101	0.920
Crop_managemnt	0.260	0.072	3.631	0.000
Opportunities				
Farm	0.736	0.175	4.201	0.000
Crop_choice	0.280	0.032	8.859	0.000
Crop_managemnt	0.052	0.022	2.396	0.017
Crop_choice				
Crop_managemnt	0.570	0.040	14.417	0.000
Barriers				
Opportunities	0.625	0.187	3.348	0.001

Table 7: Global model variance (no co-variance identified).

	Estimate	Std.Err	z-value	P(>|z|)
.Q_24.machinery	0.905	0.028	32.316	0.000
.Q_24.subsidy	0.997	0.027	37.226	0.000
.Q_24.skill	0.720	0.028	25.381	0.000
.Q_24.dvsrknwld	0.468	0.033	13.981	0.000
.Q_24.market	1.029	0.027	38.014	0.000
.Q_24.weeds	0.667	0.029	23.389	0.000
.Q_24.time	0.652	0.030	22.029	0.000
.Q_24.yildncrtn	0.602	0.031	19.563	0.000
.Q_28.yldstblty	0.939	0.028	33.301	0.000
.Q_28.rdcfrtlzr	0.962	0.030	32.314	0.000
.Q_28.nutrients	0.750	0.029	25.910	0.000
.Q_28.pstdsscnt	0.512	0.029	17.395	0.000
.Q_28.clmtftprn	0.477	0.033	14.674	0.000
.Q_28.reductllg	0.519	0.031	16.971	0.000
.Q_28.crpdvrsty	0.490	0.030	16.131	0.000
.Q_28.weedcntrl	0.475	0.030	15.758	0.000
.Q_28.solstrctr	0.674	0.030	22.630	0.000
.Q_3.notill	0.219	0.004	58.103	0.000
.Q_3.conservtng	0.201	0.005	44.074	0.000
.Q_3.ipm	0.189	0.005	37.471	0.000
.Q_3.mchnclwdcn	0.221	0.004	51.862	0.000
.Q_soiltype	2.387	0.086	27.916	0.000
.Q_8.othrlvstck	0.082	0.005	15.231	0.000
.Q_8.poultry	0.049	0.005	10.731	0.000
.Q_8.pigs	0.095	0.006	17.157	0.000
.Q_8.cattledary	0.207	0.004	47.659	0.000
.Q_16.dssrsstnc	0.698	0.100	6.994	0.000
.Q_16.wedcmpttn	0.973	0.064	15.098	0.000
.Q_16.buildhums	1.176	0.061	19.288	0.000
.Q_19.spryschdl	1.822	0.061	29.792	0.000
.Q_19.cntnsmntr	0.805	0.090	8.935	0.000
.Q_19.cleanflds	0.773	0.063	12.248	0.000
.Q_19.preplan	1.407	0.062	22.737	0.000
.Q_19.dcsnspprt	1.746	0.061	28.546	0.000
.Q_19.consltnts	1.619	0.065	25.049	0.000
.Q_19.planinssn	1.226	0.075	16.245	0.000
.Barriers	1.000			
.Opportunities	1.000			
Farm	1.000			
.Crop_choice	1.000			
Crop_managemnt	1.000			

Appendix C: Regional European structural equation model latent variables, regressions and variance

Table 8: Regional European model, Latent variables (Central).

	Estimate	Std.Err	z-value	P(>|z|)
Barriers				
Q_24.machinery	0.436	0.035	12.504	0.000
Q_24.subsidy	0.336	0.029	11.654	0.000
Q_24.skill	0.451	0.036	12.708	0.000
Q_24.dvsrknwld	0.415	0.032	12.853	0.000
Q_24.market	0.309	0.027	11.314	0.000
Q_24.weeds	0.468	0.037	12.739	0.000
Q_24.time	0.429	0.034	12.622	0.000
Q_24.yildncrtn	0.549	0.042	13.083	0.000
Opportunities				
Q_28.yldstblty	0.531	0.026	20.555	0.000
Q_28.rdcfrtlzr	0.415	0.022	18.499	0.000
Q_28.nutrients	0.509	0.023	21.664	0.000
Q_28.pstdsscnt	0.752	0.028	26.438	0.000
Q_28.clmtftprn	0.787	0.029	27.322	0.000
Q_28.reductllg	0.771	0.029	26.890	0.000
Q_28.crpdvrsty	0.814	0.030	27.460	0.000
Q_28.weedcntrl	0.785	0.029	27.190	0.000
Q_28.solstrctr	0.584	0.025	23.700	0.000
Farm				
Q_3.notill	-0.117	0.018	-6.421	0.000
Q_3.conservtng	0.122	0.018	6.920	0.000
Q_3.ipm	0.155	0.019	8.117	0.000
Q_3.mchnclwdcn	0.046	0.016	2.936	0.003
Q_soiltype	0.357	0.047	7.671	0.000
Q_8.othrlvstck	0.053	0.008	6.993	0.000
Q_8.poultry	-0.011	0.009	-1.173	0.241
Q_8.pigs	-0.039	0.013	-2.986	0.003
Q_8.cattledary	0.105	0.018	5.835	0.000
Crop_choice				
Q_16.dssrsstnc	0.514	0.068	7.537	0.000
Q_16.wedcmpttn	0.553	0.073	7.580	0.000
Q_16.buildhums	0.614	0.079	7.781	0.000
Crop_management				
Q_19.spryschdl	0.806	0.047	17.136	0.000
Q_19.cntnsmntr	0.867	0.048	18.107	0.000
Q_19.cleanflds	0.483	0.035	13.679	0.000
Q_19.preplan	0.784	0.046	16.927	0.000
Q_19.dcsnspprt	1.007	0.049	20.443	0.000
Q_19.consltnts	0.735	0.047	15.717	0.000
Q_19.planinssn	0.460	0.045	10.280	0.000

Table 9: Regional European model, regressions (Central).

	Estimate	Std.Err	z-value	P(>|z|)
Barriers				
Farm	-0.673	0.151	-4.462	0.000
Crop_choice	-0.122	0.070	-1.748	0.080
Crop_managemnt	0.316	0.098	3.220	0.001
Opportunities				
Farm	-0.432	0.062	-6.980	0.000
Crop_choice	0.029	0.041	0.699	0.485
Crop_managemnt	0.344	0.049	7.036	0.000
Crop_choice				
Crop_managemnt	0.880	0.136	6.486	0.000
Barriers				
Opportunities	0.625	0.065	9.545	0.000

Table 10: Regional European model, intercepts (Central).

	Estimate	Std.Err	z-value	P(>|z|)
.Q_24.machinery	1.475	0.061	24.347	0.000
.Q_24.subsidy	1.359	0.059	22.979	0.000
.Q_24.skill	0.938	0.053	17.697	0.000
.Q_24.dvsrknwld	0.580	0.045	13.036	0.000
.Q_24.market	1.462	0.059	24.781	0.000
.Q_24.weeds	1.234	0.058	21.339	0.000
.Q_24.time	1.263	0.056	22.694	0.000
.Q_24.yildncrtn	1.025	0.055	18.710	0.000
.Q_28.yldstblty	1.217	0.061	19.936	0.000
.Q_28.rdcfrtlzr	1.636	0.057	28.776	0.000
.Q_28.nutrients	1.444	0.055	26.203	0.000
.Q_28.pstdsscnt	0.931	0.055	17.054	0.000
.Q_28.clmtftprn	0.681	0.050	13.582	0.000
.Q_28.reductllg	0.812	0.052	15.589	0.000
.Q_28.crpdvrsty	0.942	0.054	17.469	0.000
.Q_28.weedcntrl	0.817	0.052	15.693	0.000
.Q_28.solstrctr	1.547	0.055	27.919	0.000
.Q_3.notill	0.433	0.023	18.481	0.000
.Q_3.conservtng	0.326	0.022	14.704	0.000
.Q_3.ipm	0.317	0.022	14.406	0.000
.Q_3.mchnclwdcn	0.315	0.022	14.331	0.000
.Q_soiltype	1.259	0.056	22.345	0.000
.Q_8.othrlvstck	0.049	0.010	4.806	0.000
.Q_8.poultry	0.078	0.013	6.156	0.000
.Q_8.pigs	0.172	0.018	9.634	0.000
.Q_8.cattledary	0.460	0.024	19.511	0.000
.Q_16.dssrsstnc	4.088	0.052	78.835	0.000
.Q_16.wedcmpttn	3.723	0.059	62.646	0.000
.Q_16.buildhums	3.485	0.058	60.423	0.000
.Q_19.spryschdl	3.676	0.066	56.110	0.000
.Q_19.cntnsmntr	4.199	0.061	69.305	0.000
.Q_19.cleanflds	4.438	0.044	100.033	0.000
.Q_19.preplan	3.681	0.061	60.735	0.000
.Q_19.dcsnspprt	2.638	0.071	37.015	0.000
.Q_19.consltnts	2.901	0.071	40.576	0.000
.Q_19.planinssn	3.768	0.060	62.706	0.000
.Barriers	0.000			
.Opportunities	0.000			
Farm	0.000			
.Crop_choice	0.000			
Crop_managemnt	0.000			

Table 11: Regional European model, Variances (Central).

	Estimate	Std.Err	z-value	P(>|z|)
.Q_24.machinery	1.175	0.058	20.357	0.000
.Q_24.subsidy	1.288	0.053	24.080	0.000
.Q_24.skill	0.752	0.070	10.693	0.000
.Q_24.dvsrknwld	0.460	0.074	6.192	0.000
.Q_24.market	1.323	0.052	25.530	0.000
.Q_24.weeds	0.956	0.063	15.170	0.000
.Q_24.time	0.932	0.061	15.375	0.000
.Q_24.yildncrtn	0.595	0.073	8.170	0.000
.Q_28.yldstblty	1.295	0.059	22.075	0.000
.Q_28.rdcfrtlzr	1.221	0.054	22.559	0.000
.Q_28.nutrients	1.019	0.054	18.885	0.000
.Q_28.pstdsscnt	0.588	0.073	8.026	0.000
.Q_28.clmtftprn	0.307	0.087	3.533	0.000
.Q_28.reductllg	0.430	0.080	5.351	0.000
.Q_28.crpdvrsty	0.426	0.078	5.481	0.000
.Q_28.weedcntrl	0.399	0.080	4.959	0.000
.Q_28.solstrctr	0.924	0.057	16.300	0.000
.Q_3.notill	0.232	0.005	43.669	0.000
.Q_3.conservtng	0.205	0.009	23.281	0.000
.Q_3.ipm	0.193	0.010	19.274	0.000
.Q_3.mchnclwdcn	0.214	0.008	25.912	0.000
.Q_soiltype	1.295	0.120	10.778	0.000
.Q_8.othrlvstck	0.044	0.009	4.752	0.000
.Q_8.poultry	0.072	0.011	6.729	0.000
.Q_8.pigs	0.141	0.012	12.012	0.000
.Q_8.cattledary	0.238	0.004	56.330	0.000
.Q_16.dssrsstnc	0.736	0.159	4.626	0.000
.Q_16.wedcmpttn	1.040	0.167	6.210	0.000
.Q_16.buildhums	0.821	0.158	5.184	0.000
.Q_19.spryschdl	1.274	0.152	8.401	0.000
.Q_19.cntnsmntr	0.893	0.196	4.554	0.000
.Q_19.cleanflds	0.649	0.131	4.970	0.000
.Q_19.preplan	1.031	0.152	6.807	0.000
.Q_19.dcsnspprt	1.262	0.142	8.887	0.000
.Q_19.consltnts	1.751	0.123	14.285	0.000
.Q_19.planinssn	1.407	0.153	9.168	0.000
.Barriers	1.000			
.Opportunities	1.000			
Farm	1.000			
.Crop_choice	1.000			
Crop_managemnt	1.000			

Table 12: Regional European model, Latent variables (North).

	Estimate	Std.Err	z-value	P(>|z|)
Barriers =				
Q_24.machinery	0.554	0.016	34.342	0.000
Q_24.subsidy	0.562	0.016	34.508	0.000
Q_24.skill	0.553	0.016	34.490	0.000
Q_24.dvsrknwld	0.499	0.015	34.349	0.000
Q_24.market	0.539	0.016	33.384	0.000
Q_24.weeds	0.565	0.016	34.611	0.000
Q_24.time	0.568	0.016	34.664	0.000
Q_24.yildncrtn	0.573	0.017	34.692	0.000
Opportunities =				
Q_28.yldstblty	0.923	0.015	61.535	0.000
Q_28.rdcfrtlzr	0.858	0.015	58.432	0.000
Q_28.nutrients	0.933	0.015	64.237	0.000
Q_28.pstdsscnt	1.002	0.015	68.578	0.000
Q_28.clmtftprn	0.927	0.014	66.131	0.000
Q_28.reductllg	0.903	0.014	65.548	0.000
Q_28.crpdvrsty	0.906	0.014	64.979	0.000
Q_28.weedcntrl	0.998	0.015	68.536	0.000
Q_28.solstrctr	0.949	0.015	64.225	0.000
Farm =				
Q_3.notill	0.099	0.015	6.713	0.000
Q_3.conservtng	0.163	0.014	11.358	0.000
Q_3.ipm	0.135	0.015	9.299	0.000
Q_3.mchnclwdcn	0.125	0.015	8.588	0.000
Q_soiltype	0.307	0.033	9.199	0.000
Q_8.othrlvstck	-0.003	0.007	-0.494	0.621
Q_8.poultry	0.011	0.005	2.300	0.021
Q_8.pigs	0.000	0.009	0.053	0.958
Q_8.cattledary	0.082	0.013	6.130	0.000
Crop_choice =				
Q_16.dssrsstnc	0.653	0.052	12.454	0.000
Q_16.wedcmpttn	0.488	0.046	10.709	0.000
Q_16.buildhums	0.550	0.048	11.450	0.000
Crop_management =				
Q_19.spryschdl	0.640	0.036	18.026	0.000
Q_19.cntnsmntr	0.938	0.045	21.001	0.000
Q_19.cleanflds	0.562	0.033	17.227	0.000
Q_19.preplan	0.514	0.037	13.763	0.000
Q_19.dcsnspprt	0.494	0.035	14.201	0.000
Q_19.consltnts	0.815	0.044	18.403	0.000
Q_19.planinssn	0.622	0.039	15.872	0.000

Table 13: Regional European model, regressions (North).

	Estimate	Std.Err	z-value	P(>|z|)
Barriers				
Farm	-0.367	0.054	-6.848	0.000
Crop_choice	-0.064	0.032	-1.988	0.047
Crop_managemnt	0.182	0.025	7.207	0.000
Opportunities				
Farm	-0.217	0.025	-8.739	0.000
Crop_choice	0.185	0.019	9.702	0.000
Crop_managemnt	0.058	0.015	3.988	0.000
Crop_choice				
Crop_managemnt	0.290	0.038	7.618	0.000
Barriers				
Opportunities	1.055	0.034	31.346	0.000

Table 14: Regional European model, intercepts (North).

	Estimate	Std.Err	z-value	P(>|z|)

.Q_24.machinery	1.326	0.040	33.376	0.000
.Q_24.subsidy	1.332	0.040	33.236	0.000
.Q_24.skill	1.358	0.039	34.952	0.000
.Q_24.dvsrknwld	1.152	0.035	32.772	0.000
.Q_24.market	1.824	0.043	42.832	0.000
.Q_24.weeds	1.602	0.040	40.034	0.000
.Q_24.time	1.371	0.040	34.391	0.000
.Q_24.yildncrtn	1.506	0.040	37.371	0.000
.Q_28.yldstblty	1.776	0.043	41.558	0.000
.Q_28.rdcfrtlzr	1.822	0.041	43.955	0.000
.Q_28.nutrients	1.785	0.041	43.199	0.000
.Q_28.pstdsscnt	1.567	0.042	37.351	0.000
.Q_28.clmtftprn	1.469	0.041	36.260	0.000
.Q_28.reductllg	1.438	0.040	36.257	0.000
.Q_28.crpdvrsty	1.514	0.040	37.549	0.000
.Q_28.weedcntrl	1.569	0.042	37.561	0.000
.Q_28.solstrctr	1.821	0.042	43.528	0.000
.Q_3.notill	0.436	0.017	25.548	0.000
.Q_3.conservtng	0.151	0.012	12.269	0.000
.Q_3.ipm	0.254	0.015	16.960	0.000
.Q_3.mchnclwdcn	0.340	0.016	20.871	0.000
.Q_soiltype	0.769	0.031	24.468	0.000
.Q_8.othrlvstck	0.055	0.008	7.048	0.000
.Q_8.poultry	0.032	0.006	5.276	0.000
.Q_8.pigs	0.119	0.011	10.699	0.000
.Q_8.cattledary	0.295	0.016	18.816	0.000
.Q_16.dssrsstnc	4.451	0.030	148.459	0.000
.Q_16.wedcmpttn	3.937	0.035	111.459	0.000
.Q_16.buildhums	3.416	0.040	84.440	0.000
.Q_19.spryschdl	2.076	0.045	45.918	0.000
.Q_19.cntnsmntr	4.293	0.041	105.247	0.000
.Q_19.cleanflds	4.112	0.034	120.474	0.000
.Q_19.preplan	2.992	0.046	65.611	0.000
.Q_19.dcsnspprt	2.148	0.050	42.617	0.000
.Q_19.consltnts	3.438	0.050	68.301	0.000
.Q_19.planinssn	4.035	0.040	99.797	0.000
.Barriers	0.000			
.Opportunities	0.000			
Farm	0.000			
.Crop_choice	0.000			
Crop_managemnt	0.000			

Table 15: Regional European model, Variances (North).

	Estimate	Std.Err	z-value	P(>|z|)
.Q_24.machinery	0.548	0.044	12.355	0.000
.Q_24.subsidy	0.549	0.044	12.442	0.000
.Q_24.skill	0.493	0.043	11.441	0.000
.Q_24.dvsrknwld	0.409	0.042	9.631	0.000
.Q_24.market	0.791	0.046	17.139	0.000
.Q_24.weeds	0.537	0.043	12.422	0.000
.Q_24.time	0.516	0.044	11.814	0.000
.Q_24.yildncrtn	0.534	0.043	12.390	0.000
.Q_28.yldstblty	0.613	0.047	13.071	0.000
.Q_28.rdcfrtlzr	0.649	0.047	13.759	0.000
.Q_28.nutrients	0.493	0.047	10.413	0.000
.Q_28.pstdsscnt	0.391	0.045	8.774	0.000
.Q_28.clmtftprn	0.449	0.043	10.518	0.000
.Q_28.reductllg	0.439	0.042	10.415	0.000
.Q_28.crpdvrsty	0.477	0.042	11.241	0.000
.Q_28.weedcntrl	0.389	0.044	8.744	0.000
.Q_28.solstrctr	0.495	0.049	10.189	0.000
.Q_3.notill	0.236	0.004	64.866	0.000
.Q_3.conservtng	0.102	0.010	10.399	0.000
.Q_3.ipm	0.171	0.008	20.507	0.000
.Q_3.mchnclwdcn	0.209	0.006	32.920	0.000
.Q_soiltype	0.741	0.090	8.200	0.000
.Q_8.othrlvstck	0.052	0.007	7.495	0.000
.Q_8.poultry	0.031	0.006	5.440	0.000
.Q_8.pigs	0.105	0.008	12.389	0.000
.Q_8.cattledary	0.202	0.007	29.654	0.000
.Q_16.dssrsstnc	0.298	0.106	2.824	0.005
.Q_16.wedcmpttn	0.798	0.088	9.087	0.000
.Q_16.buildhums	1.057	0.094	11.188	0.000
.Q_19.spryschdl	1.319	0.079	16.755	0.000
.Q_19.cntnsmntr	0.528	0.140	3.765	0.000
.Q_19.cleanflds	0.671	0.081	8.289	0.000
.Q_19.preplan	1.496	0.073	20.593	0.000
.Q_19.dcsnspprt	1.906	0.081	23.476	0.000
.Q_19.consltnts	1.481	0.105	14.087	0.000
.Q_19.planinssn	0.997	0.110	9.079	0.000
.Barriers	1.000			
.Opportunities	1.000			
Farm	1.000			
.Crop_choice	1.000			
Crop_managemnt	1.000			

Table 16: Regional European model, Latent variables (South).

	Estimate	Std.Err	z-value	P(>|z|)
Barriers =				
Q_24.machinery	0.347	0.025	13.897	0.000
Q_24.subsidy	0.459	0.027	16.944	0.000
Q_24.skill	0.387	0.025	15.769	0.000
Q_24.dvsrknwld	0.511	0.026	19.713	0.000
Q_24.market	0.510	0.028	17.964	0.000
Q_24.weeds	0.564	0.029	19.235	0.000
Q_24.time	0.538	0.029	18.787	0.000
Q_24.yildncrtn	0.564	0.030	19.003	0.000
Opportunities =				
Q_28.yldstblty	0.615	0.027	22.935	0.000
Q_28.rdcfrtlzr	0.640	0.025	25.237	0.000
Q_28.nutrients	0.707	0.025	28.024	0.000
Q_28.pstdsscnt	0.886	0.027	33.048	0.000
Q_28.clmtftprn	0.867	0.027	32.328	0.000
Q_28.reductllg	0.898	0.027	33.408	0.000
Q_28.crpdvrsty	0.921	0.027	34.296	0.000
Q_28.weedcntrl	0.861	0.027	32.199	0.000

Q_28.solstrctr	0.871	0.026	32.924	0.000
Farm =				
Q_3.notill	0.138	0.015	9.135	0.000
Q_3.conservtng	0.231	0.023	9.857	0.000
Q_3.ipm	-0.043	0.017	-2.552	0.011
Q_3.mchnclwdcn	-0.248	0.025	-10.017	0.000
Q_soiltype	-0.856	0.084	-10.143	0.000
Q_8.othrlvstck	0.007	0.012	0.591	0.554
Q_8.poultry	-0.005	0.009	-0.594	0.553
Q_8.pigs	0.021	0.012	1.789	0.074
Q_8.cattledary	-0.042	0.015	-2.873	0.004
Crop_choice =				
Q_16.dssrsstnc	0.776	0.078	9.932	0.000
Q_16.wedcmpttn	0.727	0.074	9.849	0.000
Q_16.buildhums	0.438	0.048	9.065	0.000
Crop_management =				
Q_19.spryschdl	0.741	0.049	15.195	0.000
Q_19.cntnsmntr	0.594	0.050	11.825	0.000
Q_19.cleanflds	0.468	0.047	9.911	0.000
Q_19.preplan	1.053	0.058	18.138	0.000
Q_19.dcsnspprt	1.111	0.059	18.822	0.000
Q_19.consltnts	0.648	0.050	12.934	0.000
Q_19.planinssn	0.588	0.048	12.311	0.000

Table 17: Regional European model, regressions (South).

	Estimate	Std.Err	z-value	P(>|z|)
Barriers				
Farm	0.238	0.055	4.347	0.000
Crop_choice	-0.168	0.059	-2.841	0.004
Crop_managemnt	-0.015	0.067	-0.226	0.821
Opportunities				
Farm	0.218	0.029	7.494	0.000
Crop_choice	-0.002	0.033	-0.046	0.963
Crop_managemnt	0.302	0.038	8.064	0.000
Crop_choice				
Crop_managemnt	0.684	0.082	8.300	0.000
Barriers				
Opportunities	0.811	0.047	17.160	0.000

Table 18: Regional European model, intercepts (South).

	Estimate	Std.Err	z-value	P(>|z|)
.Q_24.machinery	1.281	0.065	19.723	0.000
.Q_24.subsidy	1.348	0.065	20.802	0.000
.Q_24.skill	1.081	0.059	18.183	0.000
.Q_24.dvsrknwld	0.564	0.047	12.032	0.000
.Q_24.market	1.296	0.065	20.018	0.000
.Q_24.weeds	0.901	0.058	15.408	0.000
.Q_24.time	0.883	0.058	15.165	0.000
.Q_24.yildncrtn	1.031	0.062	16.737	0.000
.Q_28.yldstblty	1.262	0.067	18.922	0.000
.Q_28.rdcfrtlzr	1.571	0.063	24.837	0.000
.Q_28.nutrients	1.522	0.063	24.226	0.000
.Q_28.pstdsscnt	1.236	0.062	19.790	0.000
.Q_28.clmtftprn	0.821	0.059	13.837	0.000
.Q_28.reductllg	1.135	0.063	18.145	0.000
.Q_28.crpdvrsty	1.029	0.061	16.891	0.000
.Q_28.weedcntrl	1.265	0.063	20.015	0.000
.Q_28.solstrctr	1.384	0.064	21.542	0.000
.Q_3.notill	0.117	0.016	7.132	0.000
.Q_3.conservtng	0.330	0.024	13.754	0.000
.Q_3.ipm	0.226	0.021	10.592	0.000

.Q_3.mchnclwdcn	0.514	0.025	20.172	0.000
.Q_soiltype	2.896	0.088	32.967	0.000
.Q_8.othrlvstck	0.081	0.014	5.801	0.000
.Q_8.poultry	0.049	0.011	4.467	0.000
.Q_8.pigs	0.068	0.013	5.276	0.000
.Q_8.cattledary	0.138	0.018	7.833	0.000
.Q_16.dssrsstnc	3.881	0.060	65.176	0.000
.Q_16.wedcmpttn	3.901	0.059	65.919	0.000
.Q_16.buildhums	3.143	0.065	48.429	0.000
.Q_19.spryschdl	2.384	0.074	32.086	0.000
.Q_19.cntnsmntr	3.579	0.070	50.823	0.000
.Q_19.cleanflds	4.047	0.064	63.699	0.000
.Q_19.preplan	3.088	0.077	40.160	0.000
.Q_19.dcsnspprt	2.462	0.079	31.266	0.000
.Q_19.consltnts	3.390	0.070	48.140	0.000
.Q_19.planinssn	3.639	0.067	54.287	0.000
.Barriers	0.000			
.Opportunities	0.000			
Farm	0.000			
.Crop_choice	0.000			
Crop_managemnt	0.000			

Table 19: Regional European model, Variances (South).

	Estimate	Std.Err	z-value	P(>|z|)
.Q_24.machinery	1.398	0.059	23.635	0.000
.Q_24.subsidy	1.224	0.062	19.671	0.000
.Q_24.skill	1.081	0.069	15.625	0.000
.Q_24.dvsrknwld	0.357	0.082	4.334	0.000
.Q_24.market	1.129	0.067	16.752	0.000
.Q_24.weeds	0.723	0.084	8.594	0.000
.Q_24.time	0.764	0.085	8.970	0.000
.Q_24.yildncrtn	0.868	0.080	10.840	0.000
.Q_28.yldstblty	1.285	0.062	20.649	0.000
.Q_28.rdcfrtlzr	1.076	0.061	17.564	0.000
.Q_28.nutrients	0.952	0.063	15.110	0.000
.Q_28.pstdsscnt	0.610	0.074	8.250	0.000
.Q_28.clmtftprn	0.501	0.094	5.316	0.000
.Q_28.reductllg	0.591	0.079	7.478	0.000
.Q_28.crpdvrsty	0.464	0.084	5.543	0.000
.Q_28.weedcntrl	0.694	0.072	9.672	0.000
.Q_28.solstrctr	0.728	0.070	10.396	0.000
.Q_3.notill	0.085	0.013	6.396	0.000
.Q_3.conservtng	0.168	0.014	12.450	0.000
.Q_3.ipm	0.174	0.012	14.735	0.000
.Q_3.mchnclwdcn	0.189	0.012	15.361	0.000
.Q_soiltype	2.241	0.189	11.889	0.000
.Q_8.othrlvstck	0.074	0.012	6.370	0.000
.Q_8.poultry	0.047	0.010	4.721	0.000
.Q_8.pigs	0.063	0.011	5.658	0.000
.Q_8.cattledary	0.117	0.013	9.161	0.000
.Q_16.dssrsstnc	0.482	0.180	2.670	0.008
.Q_16.wedcmpttn	0.574	0.176	3.259	0.001
.Q_16.buildhums	1.341	0.120	11.180	0.000
.Q_19.spryschdl	1.579	0.126	12.542	0.000
.Q_19.cntnsmntr	1.559	0.141	11.075	0.000
.Q_19.cleanflds	1.336	0.171	7.828	0.000
.Q_19.preplan	1.171	0.160	7.338	0.000
.Q_19.dcsnspprt	1.156	0.167	6.929	0.000
.Q_19.consltnts	1.490	0.143	10.435	0.000
.Q_19.planinssn	1.386	0.147	9.445	0.000
.Barriers	1.000			
.Opportunities	1.000			
Farm	1.000			
.Crop_choice	1.000			
Crop_managemnt	1.000			

Appendix D: Outside Europe comparison structural equation model latent variables, regressions and variance

Table 20: Comparison between Europe and outside Europe (Pakistan and Egypt), latent variables.

	Estimate	Std.Err	z-value	P(>|z|)
Barriers =				
Q_24.machinery	1.000			
Q_24.subsidy	-0.123	0.021	-5.793	0.000
Q_24.skill	0.356	0.020	17.675	0.000
Q_24.dvsrknwld	1.260	0.049	25.719	0.000
Q_24.market	0.750	0.033	22.621	0.000
Q_24.weeds	0.971	0.038	25.575	0.000
Q_24.time	1.219	0.045	26.931	0.000
Q_24.yildncrtn	1.382	0.052	26.420	0.000
Opportunities =				
Q_28.yldstblty	1.000			
Q_28.rdcfrtlzr	-0.190	0.043	-4.420	0.000
Q_28.nutrients	2.226	0.115	19.313	0.000
Q_28.pstdsscnt	1.397	0.075	18.534	0.000
Q_28.clmtftprn	2.301	0.115	19.926	0.000
Q_28.reductllg	2.132	0.107	20.001	0.000
Q_28.crpdvrsty	2.517	0.124	20.231	0.000
Q_28.weedcntrl	2.304	0.117	19.644	0.000
Q_28.solstrctr	2.268	0.117	19.409	0.000
Farm =				
Q_3.conservtng	1.000			
Q_3.ipm	-1.343	0.124	-10.853	0.000
Q_3.mchnclwdcn	-1.475	0.133	-11.071	0.000
Q_soiltype	-2.028	0.322	-6.288	0.000
Q_8.othrlvstck	0.044	0.069	0.641	0.522
Q_8.poultry	-0.390	0.055	-7.094	0.000
Q_8.cattledary	-0.194	0.069	-2.832	0.005
Crop_choice =				
Q_16.dssrsstnc	1.000			
Q_16.wedcmpttn	-0.014	0.018	-0.782	0.434
Q_16.buildhums	0.105	0.023	4.532	0.000
Crop_management =				
Q_19.spryschdl	1.000			
Q_19.cntnsmntr	0.776	0.106	7.313	0.000
Q_19.cleanflds	0.848	0.111	7.629	0.000
Q_19.preplan	0.685	0.102	6.716	0.000
Q_19.dcsnspprt	0.832	0.119	6.980	0.000
Q_19.consltnts	0.310	0.080	3.861	0.000
Q_19.planinssn	1.312	0.167	7.860	0.000

Table 21: Comparison between Europe and outside Europe (Pakistan and Egypt), regressions.

	Estimate	Std.Err	z-value	P(>|z|)
Barriers				
Farm	-1.628	1.697	-0.959	0.338
Crop_choice	-0.139	0.103	-1.347	0.178
Crop_managemnt	0.063	0.060	1.049	0.294
Opportunities				
Farm	2.316	0.418	5.540	0.000
Crop_choice	0.462	0.852	0.543	0.587
Crop_managemnt	-0.275	0.645	-0.426	0.670
Crop_choice				
Crop_managemnt	0.752	0.132	5.706	0.000

	Estimate	Std.Err	z-value	P(>|z|)
Barriers				
Opportunities	2.597	0.756	3.434	0.001

Table 22: Comparison between Europe and outside Europe (Pakistan and Egypt) variances

	Estimate	Std.Err	z-value	P(>|z|)
.Q_24.machinery	0.263	0.082	3.199	0.001
.Q_24.subsidy	0.534	0.071	7.481	0.000
.Q_24.skill	0.394	0.061	6.469	0.000
.Q_24.dvsrknwld	0.509	0.105	4.842	0.000
.Q_24.market	0.496	0.061	8.127	0.000
.Q_24.weeds	0.241	0.073	3.295	0.001
.Q_24.time	0.211	0.093	2.265	0.024
.Q_24.yildncrtn	0.334	0.133	2.520	0.012
.Q_28.yldstblty	0.608	0.099	6.140	0.000
.Q_28.rdcfrtlzr	0.657	0.086	7.673	0.000
.Q_28.nutrients	0.635	0.090	7.086	0.000
.Q_28.pstdsscnt	0.493	0.060	8.240	0.000
.Q_28.clmtftprn	0.733	0.081	9.070	0.000
.Q_28.reductllg	0.541	0.085	6.339	0.000
.Q_28.crpdvrsty	0.510	0.083	6.180	0.000
.Q_28.weedcntrl	0.435	0.088	4.914	0.000
.Q_28.solstrctr	0.496	0.097	5.110	0.000
.Q_3.conservtng	0.222	0.007	34.034	0.000
.Q_3.ipm	0.150	0.016	9.464	0.000
.Q_3.mchnclwdcn	0.137	0.017	8.011	0.000
.Q_soiltype	3.219	0.172	18.767	0.000
.Q_8.othrlvstck	0.215	0.011	18.765	0.000
.Q_8.poultry	0.063	0.015	4.369	0.000
.Q_8.cattledary	0.196	0.013	14.579	0.000
.Q_16.dssrsstnc	2.300	1.948	1.181	0.238
.Q_16.wedcmpttn	1.341	0.147	9.114	0.000
.Q_16.buildhums	1.819	0.135	13.483	0.000
.Q_19.sprysch dl	0.947	0.205	4.620	0.000
.Q_19.cntnsmntr	0.828	0.244	3.397	0.001
.Q_19.cleanflds	0.402	0.170	2.358	0.018
.Q_19.preplan	1.438	0.181	7.960	0.000
.Q_19.dcsnspprt	1.788	0.176	10.147	0.000
.Q_19.consltnts	1.521	0.155	9.823	0.000
.Q_19.planinssn	1.003	0.289	3.472	0.001
.Barriers	0.187	0.066	2.838	0.005
.Opportunities	-0.179	0.413	-0.433	0.665
Farm	0.026	0.005	4.840	0.000
.Crop_choice	1.046	1.929	0.542	0.587
Crop_managemnt	0.699	0.123	5.671	0.000