The role of Psychological Factors in the Adoption of Improved Natural Grassland by Brazilian Cattle Farmers in Biome Pampa

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Abstract

Beef production on natural grasslands potentially allows for sustainable development in biome Pampa, Rio Grande do Sul (RS), Brazil. However, cattle farmers have managed the natural grasslands using practices that result in overgrazing, low productivity and low farm income. Farmers in the region converted natural grasslands from beef production to more profitable activities, such as cash crops. As this conversion and overgrazing have caused environmental problems in biome Pampa, farmers have been stimulated by the government, extension services and research centers to use livestock innovations that increase beef productivity without damaging the environment. However, the adoption rate is still low. One of the available innovations is improved natural grassland. This innovation increases the availability of natural grassland and means that farmers are more likely to keep feeding their cattle with natural grassland on their farms. The overall objective of this study was to explore factors determining cattle farmers' intention to adopt improved natural grassland in the biome Pampa, Rio Grande do Sul, Brazil. To accomplish this objective, first a literature review was made of studies on adoption of innovations in agriculture based on utility maximization (UM) and the theory of planned behavior (TPB). Results showed that the explanatory variables used in UM studies mostly had an insignificant effect on the adoption decision; and from the TPB studies, correlations between the psychological constructs used in this type of model were significant in most cases. Second, the TPB was used as a framework to understand the underlying psychological constructs that influence farmers' adoption decisions. Results showed that farmers' intention to use improved natural grassland was mainly determined by their perceptions about the social pressure to use this innovation (subjective norm), followed by their perceptions about their own capability to use this innovation (perceived behavioral control), and by farmers' evaluation of the use of improved natural grassland (attitude). Results also suggest that subjective norm is positively correlated with farmers' attitude and perceived behavioral control. A cluster analysis found two groups of farmers with different level of intention: farmers that were willing and farmers that were unwilling to use improved natural grassland. The farmers in the two groups differed in their socio-psychological characteristics, in their goals and relative risk attitudes, but they did not differ in most of their socioeconomic characteristics. The results of this thesis suggest two main strategies to increase farmers' intention to use improved natural grassland. First, increase social pressure on farmers to use this innovation. Second, inform farmers about the benefits of using improved natural grassland and increase their capability to use this innovation.
Keywords: Adoption; Biome Pampa; Brazil; Farmers' decisions; Improved natural grassland; Theory of planned behavior; Psychological constructs.

Contents

Chapter 1

General introduction

J. A. R. Borges

1.1 General background

Biome Pampa located in the state of Rio Grande do Sul is one of the six Brazilian biomes and it represents 63% and 2.07% of the Rio Grande do Sul and Brazilian territory, respectively (MAA, 2011) (Figure 1.1). This biome is characterized by a rich biodiversity (Carvalho and Batello, 2009; Overbeck et al., 2007). It is the habitat for 3000 vascular plants, 385 species of birds and 90 terrestrial mammals (Bilenca and Miñarro, 2004). In biome Pampa, beef production on natural grasslands potentially allows for sustainable development (Nabinger et al., 2009). However, cattle farmers have managed the natural grasslands using practices that result in overgrazing, low productivity, and low farm income (Nabinger et al., 2009). Farmers in the region are converted the natural grasslands into more profitable activities, such as cash crops (Carvalho and Batello, 2009). The total area of natural grasslands in the southern region of Brazil, where the biome *Pampa* is located, decreased by 25 percent from 1970 to 1996 (Overbeck et al., 2007). In addition, the original vegetation has been completely replaced in at least 50% of the biome Pampa (Overbeck et al., 2013).

Figure 1.1. Brazilian biomes (MAA, 2011).

The conversion and the unsustainable use (mainly overgrazing) of the natural grassland by cattle farmers have caused environmental problems in biome Pampa, such as landscape fragmentation, loss of biodiversity, biological invasion, soil erosion, water pollution, and land degradation (Carvalho and Batello, 2009). Moreover, different animal and natural forage species are threatened by extinction due to the land use change (Boldrini, 2009; Carvalho and Batello, 2009; Develey et al., 2008).

The environmental problems caused by land use change and overgrazing, have incentivized government, extension services and research centers to stimulate cattle farmers to use livestock innovations that increase productivity without damaging the environment. Examples of such innovations are adjustment of stocking rates, rotation grazing and improved natural grassland (Bencke, 2009). Using these innovations simultaneously could increase the current average productivity of beef from 70 Kg/hectare/year to more than 800 Kg/hectare/year (Nabinger et al., 2009). Such an increase in productivity could increase farm income and, farmers would more likely keep beef production under natural grasslands and reduce overgrazing (Nabinger et al, 2009).

This thesis focuses on adoption of improved natural grassland. It is defined as an innovation where one (or both) of the following practices is applied to natural grassland: use of fertilizers and introduction of new forage species. This innovative way of managing natural grassland increases the likelihood of farmers feeding their cattle with natural grassland. In the absence of the option to adopt improved natural grassland, farmers may convert the existing natural grassland to artificial pasture or crop land.

1.2 Problem statement

Although improved natural grassland is available to farmers in the region, the adoption rate is still low (Carvalho et al., 2006). In addition, attempts to inform farmers in the region about this innovation have failed (Jacques et al., 2009), which could be due to a lack of understanding of factors influencing farmers' decisions.

Given the current low adoption rate of improved natural grassland despite its potential to increase productivity, it is useful to explore factors determining farmers' adoption decisions. Such a research could provide insights to policy makers that can be used to adjust current policies and design new policies to stimulate the adoption and use of improved natural grassland by cattle farmers.

1.3 Methodological approach

The economic literature uses two main types of approaches to analyzing farmers' decisions to adopt an innovation. The first type of model is based on the concept of utility maximization (UM) and the second type is based on the socio-psychological theory of planned behavior (TPB). This thesis used TPB as a framework for exploring factors determining cattle farmers' intention to adopt improved natural grassland in the biome Pampa, Rio Grande do Sul, Brazil. In the TPB, behavior originates from the individual's intentions, which in turn are determined by three central psychological constructs: attitude, subjective norm, and perceived behavioral control. These constructs are derived from behavioral, normative and control beliefs, respectively. Attitude explains how farmers evaluate the use of improved natural grassland; the role of perceived social pressure on farmers to use improved natural grassland is explained by subjective norm; perceived behavioral control identifies farmers' perceptions about their capability to use this innovation. An analysis of the beliefs allows for identification of the drivers of farmers' attitude, subjective norm, and perceived behavioral control. The basic theoretical model used in this thesis is presented in Figure 1.2.

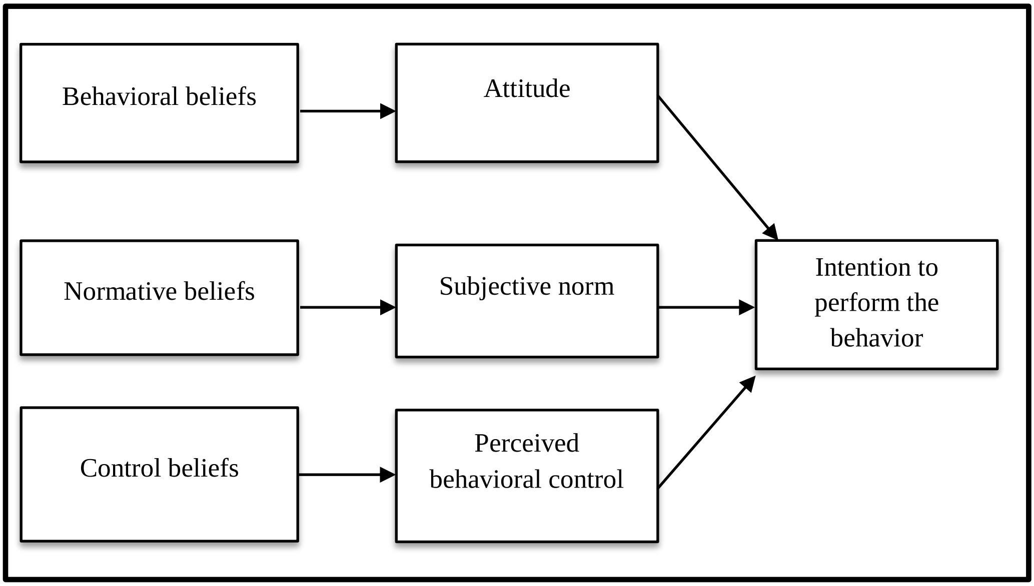

Figure 1.2. The TPB Model (adapted from Ajzen, 2005).

Although there is a long tradition of empirical research that seeks to explain farmers' adoption decision of a particular innovation, few studies have focused on the livestock sector (Abdulai and Huffman, 2005). In beef production, Abdulai and Huffman (2005) studied adoption of crossbred-cow technology by Tanzanian farmers. They found that adoption depends positively on the proximity of the adopter to other users, the level of education, the access to credit and contacts with extension agents. Kim et al. (2008) found that uncertainty plays an important role in American cattle farmers' willingness to pay for the adoption of rotational grazing. Studying cattle farmers' decision to adopt best management practices in the United States, Kim et al. (2005) found that the likelihood of adoption is higher when the farm includes more enterprises, the farmer has had contact with Natural Resources Conservation Service personnel at least once within the past year, the farmer holds a college bachelor's degree, the percentage of income from beef cattle production is higher, or the operation includes hilly land and more enterprises. Johnson et al. (2010) found that operation size and dependency upon income from the stocker operation influence the adoption of recommended practices by American cattle farmers. These previous studies have not emphasized the role of psychological factors on cattle farmers' decisions to adopt an innovation. An exception is the study by Martínez-García et al. (2013). They used an earlier version of the TPB, the theory of reasoned action, to study Mexican cattle farmers' decisions to use improved grassland. Their results showed a positive correlation between farmers' intention to use improved grassland and their attitude and subjective norm. However, the theory of reasoned action provides a less comprehensive explanation of farmers' intentions than TPB, as it does not consider the role of perceived behavioral control. To the best of the author's knowledge, this thesis is the first study to use the TPB to understand farmers' decisions on adoption of improved natural grassland. In addition, the TPB has not been previously applied in the context of Brazilian cattle farmers.

1.4 Objectives of the research

The overall objective of this thesis was to explore factors determining cattle farmers' intention to adopt improved natural grassland in the biome Pampa, Rio Grande do Sul, Brazil.

The specific objectives were to:

i) Review which variables have been used in the literature to understand farmers' decisions to adopt an innovation and the influence of these variables on the adoption decision;

ii) Identify the role of attitude, subjective norm, and perceived behavioral control in the intention of farmers to use improved natural grassland and understand the role of farmers' beliefs as drivers of their attitude, subjective norm, and perceived behavioral control;

iii) Examine whether differences in the level of farmers' intention to use improved natural grassland are explained by the TPB psychological constructs, socioeconomic characteristics, goals, and relative risk attitude;

iv) Determine the effect of attitude, subjective norm, and perceived behavioral control, on the intention of Brazilian cattle farmers to use improved natural grassland.

1.5 Description of the study area

This research was carried out in the state of Rio Grande do Sul (RS), in the south of Brazil. RS is geographically divided in 35 micro-regions (IBGE, 2014). This research focused on the micro-region of Campanha Central. The municipalities that belong to Campanha Central are: Rosário do Sul, Santa Margarida do Sul, São Gabriel, and Santana do Livramento. The four municipalities are located in biome Pampa (Figure 1.3). In Campanha Central, the average day temperature in the hottest month is around 30°C (in January) and in the coldest month around 8°C (in July); the rainfall is around 1600 mm (IBGE, 2014). Campanha Central has an estimated 1.3 million cattle herd which corresponds to 9.2% of the cattle in RS, and around 8.400 cattle farmers which corresponds to 2.54 % of the cattle farmers in RS (IBGE, 2012). The rural population of interest in this study are small cattle farmers in Campanha Central.

In RS, the cattle herd is mainly based on British breeds, extensive grazing is the prevalent feed system, and the productivity level is similar to other regions in Brazil, but lower than in other developed countries (Delgado et al., 1999; SEAPA, 2014). In Campanha Central, the technological level in most of the farms is low and farmers usually are reluctant to adopt innovations (Ribeiro, 2009). The quality of the land varies, but in general there is a consensus among researchers that the beef productivity could be higher given the quality of the land; however, the low adoption rate of innovations prevents a higher productivity (Nabinger et al., 2009). In Campanha Central, around 80% of the farms have 500 hectares or less, and these farms are classified as small to medium size (IBGE, 2012). Although the size of the farms seems big compared to European farms, they are small compared to cattle farms in other Brazilian regions, where there are many farms with more than 10000 hectares.

Although there are no exact numeric data available, some studies provide qualitative information about the population of small cattle farmers in Campanha Central. In this micro-region, beef production under natural grassland has a long tradition and this production system is part of the local culture (Ribeiro, 2009). The typical household has two to four people and there is an elderly person in the family (Ribeiro, 2009). The education level of the farmers and of the family members is low (most people had incomplete elementary school) and farmers received land from heritage (Cotrim, 2003; Ribeiro, 2009). Most of these small cattle farmers have only beef production as a source of income coming from agriculture and a complementary income from pension, since most household have at least one retired person (Ribeiro, 2009). Family labor is predominantly in the farms and farmer neighbors help each other in the daily tasks (Torres, 2001; Ribeiro, 2009). Farmers operate more in local communities and associations (Ribeiro, 2009). Governmental extension agencies provide support for these farmers, especially for the small ones (less than 300 hectares). When asked for the motivation to breed cattle in their farms, the farmers usually answer that tradition is the main motivation rather than making profit (Ribeiro, 2009). In addition, the timing of cattle sales by these farmers are generally driven by money needs rather than cattle prices or by slaughter ripeness (Ribeiro, 2009). Many of the local communities in which these farmers live do not have basic services, such as hospital or small health centers, public transportation, and even electricity (Torres 2001; Ribeiro, 2009).

Figure 1.3. Smaller map – map of Brazil with Rio Grande do Sul highlighted; Larger map – map of Rio Grande do Sul with Campanha Central highlighted (FEE, 2014).

1.6 Outline

The thesis consists of four research chapters, a general introduction and a general discussion. Each research chapter addresses one of the objectives of the thesis and provides an empirical application. Chapter 2 investigates the variables that have been used on studies of adoption of innovation in agriculture. The variables are identified by reviewing studies based on two types of models, i.e. utility maximization (UM) and the theory of planned behavior (TPB).

Chapter 3 estimates Spearman rank correlation coefficients to identify the influence of attitude, subjective norm, and perceived behavioral control on the intention of farmers to use improved natural grassland and to understand the role of farmers' beliefs as drivers of their attitude, subjective norm, and perceived behavioral control.

Chapter 4 uses cluster analysis to identify groups of farmers with different levels of intention to use improved natural grassland. Mann-Whitney tests and independent sample t-tests are used to analyze whether the differences in the level of farmers’ intention to use improved natural grassland are associated with socio-psychological factors, socioeconomic characteristics, goals, and relative risk attitude.

Chapter 5 uses structural equation modeling (SEM) with latent constructs to analyze the data. There are two steps in SEM. First, a confirmatory factor analysis (CFA) was used to test whether the measurable items of intention, attitude, subjective norm and perceived behavioral control were reliably represented as constructs. Second, structural modeling was used to determine the effect of attitude, subjective norm, and perceived behavioral control, on the intention of Brazilian cattle farmers to use improved natural grassland.

Chapter 6 presents the overall findings of this thesis, discusses research limitations and implications for policy makers and researchers.

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Chapter 2

Adoption of Innovation in Agriculture: A Critical Review of Economic and Psychological Models

J. A. R. Borges, G. Emvalomatis, A. G. J. M. Oude Lansink

Abstract

The economic literature uses two main models to analyze farmers' decisions to adopt an innovation; the first is based on the concept of utility maximization (UM) and the second is based on the theory of reasoned action (TRA), and its extension, the theory of planned behavior (TPB). This study uses a vote-count method to identify the effect of different variables on farmers' adoption decisions in 36 studies using either UM or the TRA/TPB. Results from the UM studies show that the explanatory variables mostly have an insignificant effect on the adoption decision. When the effects are significant, the sign of the effect is inconsistent across studies. Results from the TRA/TPB studies show that correlations between the psychological constructs used in this type of model are significant in most cases. However, most variables are only used in one or two studies and it is therefore not possible to detect a clear pattern across studies that used the TRA/TPB model.

Keywords: Adoption; Farmer; Innovation; Utility; Theory of reasoned action; Theory of planned behavior.

2.1 Introduction

Two main types of models are used in the economic literature to analyze farmers' decisions to adopt an innovation[1]. The first type of model is based on the concept of utility maximization (UM) and the second type is based on the socio-psychological theory of reasoned action (TRA), and its extension, the theory of planned behavior (TPB). Many studies have used these models to explore what causes farmers to adopt an innovation. However, the literature remains inconclusive on the determinants of adoption (Knowler and Bradshaw, 2007; Prokopy et al., 2008). Lindler (1987) pointed out the difficulty of finding unequivocal determinants of adoption due to the variety of methodology and models used by researchers. As UM and TRA/TPB models are widely applied to understand farmers' adoption decisions, it is critical to review studies that use these two models.

Earlier attempts to synthesize the literature on the adoption of innovation in agriculture include Knowler and Bradshaw (2007) and Pannell et al. (2006); both these studies reviewed the literature on the adoption of agricultural conservation practices. Pannell et al. (2006) brought together perspectives from different disciplines, including economics, rural sociology, and psychology. Using a vote-count methodology, Prokopy et al. (2008) summarized findings from studies on the adoption of best management practices in agriculture. Literature reviews that use a quantitative approach to summarize the effects of specific variables on the adoption decision, such as Knowler and Bradshaw (2007) and Prokopy et al. (2008), often find that the effects of the variables are insignificant. The literature review studies already published on the adoption decision in agriculture do not focus on the types of models used by researchers. A literature review focusing on UM and the TRA/TPB is necessary to identify if there are specific variables in these models, which consistently explain farmers' decisions to adopt an innovation. Therefore, this review study

[1] In this study, innovation encompasses all kinds of technologies. We use the definition given by Rogers (2003): "An innovation is an idea, practice, or object that is perceived as new by an individual or other unit of adoption". Using such a broad concept, there are many studies that can be classified as part of the literature on adoption in agriculture. For instance, the adoption of innovation literature includes studies focused on conservation practices, environmentally friendly innovations, agricultural best-management practices, water conservation practices, etc.

fills a gap in the literature: a synthesis of results that focuses on the models most frequently used by researchers to understand farmers' decisions to adopt an innovation.

The objectives of this study were twofold. First, to identify which variables have been included in studies that use either UM or the TRA/TPB and the effect of these variables on the adoption decision. Second, to use the results of this review to highlight and contrast the strengths and weaknesses of the UM and TRA/TPB models. The results of this study are expected to provide researchers with insight into how well the UM and TRA/TPB models can be applied to understand farmers' decisions to adopt an innovation. Furthermore, the results of this study also highlight potential areas for improvement that are useful for future studies on the adoption of innovation in agriculture.

The remainder of the paper is organized as follows. Section 2.2 describes the methodology used to review studies, which used UM and the TRA/TPB to understand the adoption of innovations in agriculture. Section 2.3 presents the results of the review and discusses the variables that influenced adoption decisions in these studies. Section 2.4 presents the strengths and weaknesses of the two models and Section 2.5 concludes and provides implications for future research.

2.2 Methodology

This study used a quantitative and a qualitative approach to review studies on the adoption of innovation in agriculture that use either UM or the TRA/TPB. First, a quantitative approach was used to review 36 studies (26 UM and 10 TRA/TPB) that were identified through a comprehensive search of the Scopus database. The search was conducted using a specific list of keywords[2]. We restricted the search to peer-reviewed studies, published from 2000 onwards. The quantitative analysis aimed to identify which variables have been

[2] Keywords used in the search were: adoption of innovation, adoption decision, technology adoption, conservation technology adoption, best management practices adoption, sustainable practices adoption, adoption of environmentally friendly practices, adoption of integrated pest management practices, behavior, theory of reasoned action, and theory of planned behavior. All these words were used with the word farmer or farmers.

included in studies that use either UM or the TRA/TPB, and the effect of these variables on the adoption decision. The second approach was qualitative, and reviewed theoretical studies based on UM and the TRA/TPB, in addition to the 36 studies included in the quantitative analysis. Strengths and weaknesses of the UM and TRA/TPB models were identified, as well as differences and similarities between the two types of models.

The studies based on UM that were selected for the quantitative analysis are summarized in Table 2A.1 in the Appendix 2. A study was included in the review if it explicitly used UM[3], and if at least one of the models used in the study investigated the adoption of one or more innovations as a dependent variable (or provided sufficient information to allow us to identify the variables that influenced the adoption decision).

TRA/TPB studies were chosen according to more general criteria, because UM is used much more frequently than TRA/TPB in adoption of innovation studies. Studies were included in the review if they used the TRA/TPB to explain farmers' decisions and behaviors, and presented at least one model correlating two or more psychological constructs based on TRA or TPB. Models that measured TRA or TPB constructs but did not correlate them with other constructs were not included in the review. The TRA and TPB studies selected for the quantitative analysis are presented in the Appendix 2 in Table 2A.2.

Following the selection of studies for review, we constructed two databases. One was for variables used in UM studies, and the other was for variables used in TRA/TPB studies. We used a vote-count methodology, which entailed the construction of tables of significance counts from the reviewed studies (Prokopy et al., 2008). A variable was assumed to have a significant effect if the parameter was significant at the critical 10% level. In our review, some variables appeared to be used very frequently, but were actually only used in a few studies. This is because some studies included a number of different models and tested for the same independent variables across all the models.

[3] There were many others studies that empirically analyzed the impact of the UM concept, mainly profitability and risk attitudes, on the adoption decision. However, we focused on studies that explicitly used this concept to explain adoption.

Three procedures provided some structure for the large number of independent variables in the UM database. First, given similarities between the variables used in different studies, an aggregation was undertaken.[4] Second, a variable was only included in the final UM table (Table 2.1) if it was used in at least three different studies.[5] Finally, we classified variables into groups.

In the final TRA/TPB table (Table 2.2), we only show the variables that represented the psychological constructs from these theories.

2.3 Results and discussion of the quantitative analysis

2.3.1 UM studies

The main assumption in the UM type of model is that farmers make adoption decisions based on utility considerations, and that their actions are consistent with the objective of maximizing their utility (Adesina and Zinnah, 1993; Batz et al., 1999). The central argument is that a farmer adopts an innovation if the utility from adopting exceeds the utility from not adopting, or if the utility from adopting a technology exceeds the utility from adopting another available technology.

Table 2.1 shows the synthesis of the most frequently used variables in the studies based on UM, which we reviewed. Variables were grouped into five categories: farmer characteristics, farm characteristics, household characteristics, farming context, and acquisition of information/learning process (column 1 in Table 2.1). The specific variables and the number of times each appeared in the models that we analyzed are presented in

[4] We grouped variables that were similar but not necessarily identical. For example, some authors measured education as a dummy variable and others as years of schooling. For our purposes, we combined variables such as this together into the single measure, *educational level*. Prokopy et al. (2008) also used this approach for grouping variables related to the adoption decision.

[5] Knowler and Bradshaw (2007) also used this cut-off point, because variables that are used infrequently are unlikely to provide much information or to show a pattern across empirical studies.

columns 2 and 3 of Table 2.1. For each variable, we calculated the frequency of significant positive effects, significant negative effects, and insignificant effects (columns 4, 5, and 6 in Table 2.1) on the decision to adopt an innovation. The last column in Table 2.1 shows the number of studies in which a specific variable was used. This shows that although some variables were only used in a few studies, they were often used in multiple models in the same study. For instance, *risk aversion* was only used in 4 of the 26 studies, but appeared in 35 models.

Using the three procedures explained in Section 2.2, we decreased the number of independent variables from 120 to 31. The initial number of variables was high, and consistent with Prokopy et al.'s (2008) observation that many independent variables in studies on the adoption of innovation are included without any theoretical basis. In addition, independent variables that are more easily measured appeared in most of the reviewed studies. For instance, *age, education level, farm size, assets,* and *assistance or contact with extension* were used in at least half of the 26 studies. Prokopy et al. (2008) also highlighted this result. They argued that variables that are more easily measured are included in many studies, and often authors do not even discuss a theoretical reason for the inclusion of these variables – they appear to be included simply because it is expected.

The frequency analysis in Table 2.1 shows that an insignificant effect on the adoption decision was more frequent than a significant effect for the majority of the variables. This finding is consistent with results from the reviews of Knowler and Bradshaw (2007) and Prokopy et al. (2008). In the results presented in Table 2.1, 23 of the 31 variables had an insignificant effect more frequently than a significant effect. Two of the variables had a significant effect in half of the models (*soil type or fertility or characteristics* and *income from agriculture*). Only six variables had a significant effect more frequently than an insignificant effect, i.e. *irrigation, slope category, farm size, distance to the farm from home, attendance at training sessions or on-farm demonstrations,* and *membership in farmers' associations or other groups*.

When the variable had a significant effect on the adoption decision, the sign was often not consistent across studies, with the variable positively affecting the adoption decision in some models and negatively in others. This was the case for 19 of the 31 variables. This result is also in line with the findings of Knowler and Bradshaw (2007) and Prokopy et al. (2008). In our review, the 11 variables that showed a consistent sign were used in only a few of the reviewed studies. Only *access to credit* and *membership in farmers' associations or other groups* were used in more than five studies. The other nine variables were used in five or fewer studies. Knowler and Bradshaw (2007) argued that one could expect that, as the number of studies that used a specific variable increased, the results would show convergence toward a particular finding (significant and same sign, or insignificant). Similar to our results, this expectation was not confirmed in their study. They found that the greater the number of studies, which used a specific variable, the less consistent was the causal effect of the variable.

When we consider the results by groups of variables, the variables classified as farmer and household characteristics had an insignificant effect more frequently than a significant effect, except for *income from agriculture* (significant in half of the models). The farmer characteristics *gender, education level,* and *age,* and the household characteristic *assets* were used in a large number of studies. When the effect was significant, two farmer characteristics had a consistent sign: *risk-aversion* and *experience in farming*. No household characteristics showed a consistent sign. In the farm characteristics group, three variables (*irrigation*, *slope category*, and *farm size*) had a significant effect more frequently than an insignificant effect, and *labor* and *irrigation* also had a consistent sign. In this group, *farm size* was the only variable that was used in more than half of the studies. In the farming context group, only *distance to the farm from home* had a significant effect more frequently than an insignificant effect. Three farming context variables showed a consistent sign across studies, i.e. *credit, security of land tenure,* and *distance to the farm from home*. *Region* was the variable used most often in the farming context group, although it was used in less than half of the studies. In the information/learning group, two variables frequently had a significant effect, *Attendance at training sessions or on-farm demonstrations* and *membership in farmers' associations or other groups*. These two variables and *farmer perceptions of the problem that the innovation can help to solve* also had a consistent sign. In this group, *assistance or contact with extension* was the most frequently used variable.

Table 2.1 – Frequency of significant and insignificant effects on the adoption decision for the independent variables in the UM studies; results from the vote-count methodology

Group	Variable	No. of models	Sig (+)	Sig (-)	Insig	No. of studies
Farmer characteristics	Off-farm work	7	14.29%	14.29%	71.43%	4
	Risk-aversion	35	0.00%	22.86%	77.14%	4
	Gender (male)	33	30.30%	6.06%	63.64%	11
	Educational level	71	40.85%	7.04%	52.11%	21
	Experience in farming	9	22.22%	0.00%	77.78%	5
	Age	68	10.29%	10.29%	79.41%	20
Farm characteristics	Diversification	39	46.15%	2.56%	51.28%	5
	Have a lake or stream	39	23.08%	10.26%	66.67%	4
	Labor	8	25.00%	0.00%	75.00%	5
	Irrigation	7	85.71%	0.00%	14.29%	5
	Soil type or fertility or characteristics	12	33.33%	16.67%	50.00%	7
	Slope category (flatter higher probability to adopt)	10	60.00%	10.00%	30.00%	5
	Farm size	39	64.10%	5.13%	30.77%	20
	Land tenure (owner)	42	16.67%	4.76%	78.57%	7
Household characteristics	Income from agriculture	36	47.22%	2.78%	50.00%	4
	Family labor	18	0.00%	0.00%	100.00 %	3
	Income	37	29.73%	2.70%	67.57%	7
	Assets (agricultural or non-agricultural)	62	16.13%	3.23%	80.65%	15
	Family size	15	20.00%	26.67%	53.33%	8
	Off farm income	19	5.26%	21.05%	73.68%	6

Table 2.1 – Frequency of significant and insignificant effects on the adoption decision for the independent variables in the UM studies; results from the vote-count methodology (continued)

Group	Variable	No. of models	Sig (+)	Sig (-)	Insig	No. of studies
Farming context	Participate in government environmental programs or receive subsidies	17	41.18%	0.00%	58.82%	3
	Region	30	36.67%	10.00%	53.33%	11
	Distance from village or farm to town or market or input shop	13	23.08%	15.38%	61.54%	7
	Credit	15	46.67%	0.00%	53.33%	8
	Security of land tenure	6	16.67%	0.00%	83.33%	3
	Distance to the farm from home	9	0.00%	66.67%	33.33%	5
	Extent of erosion in the village or in the farm	89	23.60%	6.74%	69.66%	5
Information /learning	Attendance at training sessions or on-farm demonstrations	8	87.50%	0.00%	12.50%	3
	Farmer perception about problem that the innovation can help to solve	6	16.67%	0.00%	83.33%	3
	Membership in farmers' associations or other groups	12	66.67%	0.00%	33.33%	7
	Assistance or contact with extension	90	38.89%	6.67%	54.44%	18

Our findings can be summarized as follows. The effects of independent variables are frequently insignificant. When the effects are significant, the sign is often contradictory. Hereafter, we will discuss possible explanations for these results.

Four reasons could explain the frequently insignificant effect for most of the variables presented in Table 2.1. First, there are no independent variables that provide a generic explanation of farmers' decisions to adopt an innovation (see also Knowler and Bradshaw, 2007). Second, there are different ways to measure a specific independent variable, and the way these variables are measured influences the effect on the dependent variable. Although this is not a valid explanation for variables that are easily measured, it could explain the results for more complex variables, such as *risk-aversion*. Third, multi-collinearity between independent variables influences the effect of a specific variable. For example, a model that includes *age* and *experience* tends to result in an insignificant effect for both variables, although these variables could individually and jointly affect the adoption decision. Finally, the independent variables usually influence the adoption decision in more than one way. For instance, *age* may increase *experience* and hence have a positive impact on the adoption decision. However, *age* also decreases the time horizon and older farmers may also be more *risk-averse*, in which case, *age* would have a negative impact on the decision. If the positive and negative effects cancel each other out, then a model that includes *age* as an independent variable would reveal an insignificant effect. This last argument may also explain the contradictory signs in cases where variables have a significant effect. For instance, farmers with a higher *educational level* may have greater ability and knowledge to adopt a complex innovation. This variable would then have a positive impact on the adoption decision. On the other hand, farmers with a higher *education level* may more easily find a job outside the farm, which would mean that they would not adopt an innovation. In that case, *education level* would have a negative sign.

The inconsistent effects of the independent variables on the adoption decision, which we found in our review, may have been caused by aggregating variables from studies that dealt with different types of innovations with different objectives. To check this, we further disaggregated the analysis for two groups of innovations, environmental and system innovations. The results of the disaggregated analysis are presented in Table 2A.3 in the Appendix 2.

Thirty-one and twenty-nine independent variables were used to study the adoption of environmental and system innovations, respectively. An insignificant effect was more frequent than a significant effect for 21 variables in the studies on the adoption of environmental innovations, and for 17 variables in the studies on the adoption of system innovations. These results are consistent with the results from the aggregated analysis, suggesting that our general finding that most independent variables had an insignificant effect on the adoption decision was not due to aggregation. However, a more consistent pattern was evident for the signs of the significant parameters. Whereas in the aggregated analysis (Table 2.1) only 11 significant parameters had a consistent sign, when environmental and system innovations were considered separately this number increased to 17 and 13, respectively. In this supplementary investigation, we were particularly interested in variables that showed a consistent sign according to the type of innovation. Our results show that the variable *lake or stream* frequently had an insignificant effect on the adoption of both types of innovations. However, when the effect was significant, the sign of the coefficient was consistent for the type of innovation, i.e. a positive effect for environmental and negative impact for system innovations. This pattern also occurred for the variable *land tenure*.

2.3.2 TRA/TPB studies

The TRA and TPB attempt to frame human behavior in a limited number of psychological constructs (Beedell and Rehman, 2000). Both theories assume that human behavior originates from the individuals' intentions to perform a specific behavior (Hansson et al., 2012). By introducing behavioral intention, these models are restricted to those behaviors that are under the volitional control of the individual, that is, that are performed because the person consciously wishes to perform them (Burton, 2004).

In the TRA, intention (*I*) is determined by two central constructs, attitude (*ATT*) and subjective norm (*SN*). The TPB is an extension of the TRA, and assumes that perceived behavioral control (*PBC*) also influences intention. Attitude, subjective norm, and perceived behavioral control originate from, respectively, behavioral beliefs, normative beliefs, and control beliefs (Hansson et al., 2012). The general TPB model is presented in Figure 2.1.

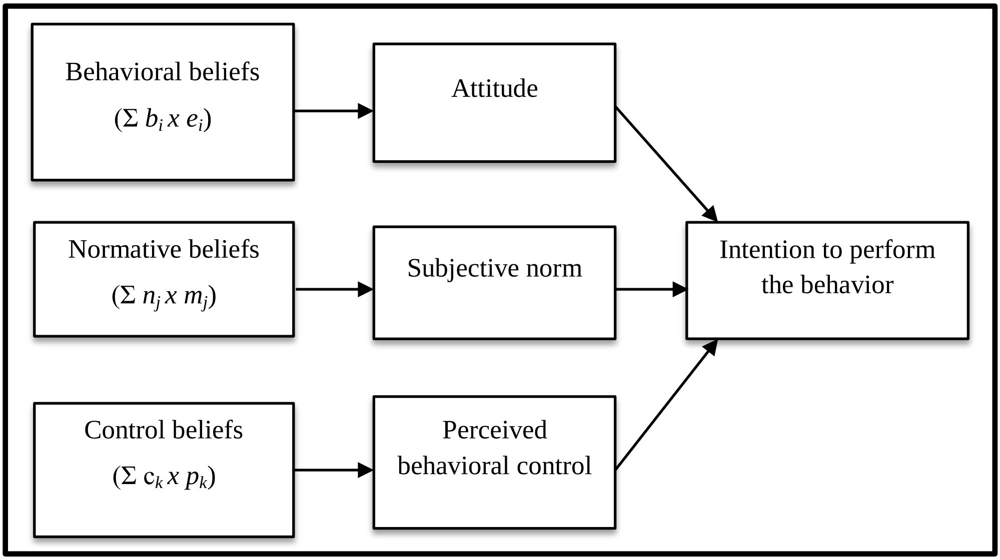

Figure 2.1. The TPB model (adapted from Ajzen, 2005).

According to Beedell and Rehman (2000) and Wauters et al. (2010), *I* is the intention to perform the behavior, *ATT* is the degree to which execution of the behavior is positively or negatively evaluated, *SN* refers to people's perceptions of the social pressures on them to perform or not perform a behavior, and *PBC* is the perceived own capability to successfully perform a behavior.

In the TPB, attitude is derived from behavioral beliefs ($b_i \times e_i$), where b_i is the belief about the likelihood of outcome *i* of the behavior, and e_i is the evaluation of the i^{th} outcome (Wauters et al., 2010). The subjective norm is derived from normative beliefs ($n_j \times m_j$), where n_j is the belief about the normative expectations of the j^{th} important referent, and m_j is the motivation to comply with the opinion of the j^{th} important referent (Wauters et al., 2010). Perceived behavioral control originates from control beliefs ($c_k \times p_k$), where c_k is the belief about the presence of the k^{th} factor that may facilitate or inhibit the performance of the behavior, and p_k is the perceived power of the k^{th} factor to facilitate or inhibit the behavior (Wauters et al., 2010). The sums of behavioral beliefs, normative beliefs, and control beliefs result in indirect measures of attitude, subjective norm, and perceived behavioral control, respectively.

All of the studies based on TRA/TPB, which we reviewed, used beliefs and/or the psychological constructs of intention, attitude, subjective norm and perceived behavioral control. Although the variables used in the models differed little across studies, the emphasis given to each of the psychological constructs and how they are measured did differ across studies, as noted by Burton (2004).

We faced two challenges in reviewing the TRA/TPB studies. First, psychological constructs are used interchangeably as dependent and independent variables in different models. This is understandable, as the TRA/TPB predicts that there are correlations between more than two psychological constructs. If a model allowed us to classify whether a psychological construct was used as a dependent or independent variable, we followed the classification of the authors. Otherwise, we based this classification on the TRA/TPB structure presented in Figure 2.1.

The second challenge was more problematic. Different studies measured psychological constructs in different ways. In order to define the psychological construct to which a specific measurement belonged, we based the analysis on the intentions as stated by the authors. The results in Table 2.2 should be interpreted in the following manner. Variables that were used in the studies as dependent variables are shown in column 1; for each dependent variable, column 2 shows the independent variables that were used in the models. For instance, when behavior was a dependent variable, the independent variables used in at least one model were intention, attitude, subjective norm, perceived behavioral control, behavioral beliefs, normative beliefs, and control beliefs. Column 3 shows the number of models that found a significant correlation between each dependent and independent variable; column 4 shows the number of models for which the correlation was insignificant. For example, when behavior was the dependent variable, this psychological construct had a significant correlation with attitude in three of the models analyzed. The last column in Table 2.2 shows the number of studies that used each combination of dependent and independent variables.

Table 2.2 – Frequency of significant and insignificant correlations between dependent and independent variables in the TRA/TPB studies; results from the vote-count methodology

Dependent variable	Independent variable	Sig	Ins	No. of studies
Behavior	Intention	3	0	1
	Attitude	3	0	2
	Subjective norm	2	0	1
	Perceived behavioral control	3	5	2
	Behavioral beliefs	5	3	1
	Normative beliefs	0	8	1
	Control beliefs	3	5	1
Intention	Attitude	12	1	5
	Subjective norm	11	1	6
	Perceived behavioral control	5	4	2
	Behavioral beliefs	40	26	3
	Normative beliefs	17	25	3
	Control beliefs	3	6	1
Attitude	Behavioral beliefs	12	8	1
Subjective norm	Normative beliefs	9	1	1
Perceived behavioral control	Control beliefs	2	10	1

In general, correlations between the psychological constructs were more frequently significant than insignificant. Ten of the sixteen possible correlations were mostly significant and only one correlation was insignificant in all cases, which was behavior with normative beliefs. The correlation between control beliefs and the other psychological constructs was also generally insignificant. The TPB predicts that perceived behavioral control originates from control beliefs, however our results show that this correlation was significant in only two of the twelve models.

Following the structure of the TRA/TPB presented in Figure 2.1., we found that farmers' intentions to perform a specific behavior are mostly correlated with their attitudes and subjective norm, and less often with perceived behavioral control. Our review also suggests that farmers' attitudes and subjective norm are correlated with their behavioral beliefs and normative beliefs, respectively.

The other finding from the vote-count is that studies based on the TRA/TPB did not follow a common approach. Most of the correlations were used in just one or two studies. Burton (2004) argued that many studies that use a behavioral approach make little mention of subjective norm as a contributor to intention. In our review, the correlation between intention and subjective norm was the only one that was used in more than five studies.

2.4 Results and discussion of the qualitative analysis

UM and TRA/TPB models have similar theoretical background. Both models are part of the larger expectancy-value framework (Feather, 1982; Lynne, 1995). Both the subjective expected utility model, mainly used by traditional economists, and the TRA/TPB, mainly used by social-psychologists, are extensions of the expectancy value (Lynne, 1995). Indeed, the attitude concept in the TRA/TPB is closely related to the utility notion, in that attitude reflects and measures latent utility (Lynne, 1995). In effect, UM and TRA/TPB are the same model in a theoretical sense, differing in an operational sense. Despite the similarities in the two types of approaches, UM and TRA/TPB use very different sets of variables to explain the adoption decision. Whereas TRA/TPB models use psychological constructs, the explanatory variables, which are most frequently used in UM models are farming context, information/learning, farmer characteristics, farm characteristics, and household characteristics.

Our review showed that studies based on the TRA/TPB analyze decisions and behaviors in a deeper way than studies based on UM. Researchers who used TRA/TPB models usually started with a pre-survey of key stakeholders in order to identify the possible outcomes for a specific behavior, possible important referents, and possible factors that facilitate or prevent the behavior. This first step gives researchers that use the TRA/TPB an advantage, because it allows them to develop survey questions that capture what farmers think is important, rather than what researchers think is important.

Another strength of the TRA/TPB is that it explicitly considers the role of social pressure on farmers to adopt an innovation, by using the subjective norm construct. Similarly, researchers use perceived behavioral control to identify barriers that could restrict farmers' adoption behavior. This psychological construct can play an important role in agriculture, given that farmers are subject to fluctuations in the physical, economic, and political environments (Burton, 2004).

A weakness of TRA/TPB models is that researchers do not usually measure the revealed behavior, but rather the intention to perform a specific behavior. Another weakness of TRA/TPB studies is that a strict application of the questionnaire is time-consuming, leaving little time for exploring other influences (Burton, 2004). The questionnaire usually focuses on a very specific innovation and the results are therefore not generalizable to a wider context. A further weakness of this approach is the lack of consistency in the methodology among studies on adoption in agriculture. This complicates the comparison of results from studies that use this framework. In addition, studies that use the TRA/TPB do not explicitly consider the role of other potential explanatory factors, such as farmer, farm, and household characteristics, farming context, and acquisition of information/learning process.

A strength of the UM model is that, in practice, it captures the 'real' behavior of farmers, using the concept of revealed preference. That is, a farmer's decision to adopt an innovation is based on utility maximization and it is assumed that his/her preference is revealed by observing his/her behavior. Another strength of the UM approach is that the variables that are most frequently used in this type of model are more easily measured than psychological constructs. Researchers who use UM can compare their results with a wider range of studies. This is not only because UM is widely used, but also because these types of studies follow a similar approach and methodology.

2.5 Concluding comments and implications for future research

The objectives of this study were to identify the effects of the variables used in UM or TRA/TPB models on the adoption behavior of farmers, and to highlight and contrast the strengths and weaknesses of both types of models.

Results showed that the UM studies used a large number of variables, some of which lacked a theoretical basis. Only a few variables included in the UM studies are clearly linked to utility maximization, such as risk attitude and profitability of the innovation. Most of the variables included in the UM studies had an insignificant effect more frequently than a significant effect. If there was a significant effect, the sign of the coefficient was not consistent across studies. These results are in line with the findings from other reviews. We presented three reasons that could explain this lack of convergence, in addition to the argument of Knowler and Bradshaw (2007) that there are no independent variables that can consistently explain adoption.

Results from the TRA/TPB studies showed that correlations between the psychological constructs were more often significant than insignificant. Farmers' intentions to perform a behavior are influenced by important other people (subjective norm) and by their own attitudes (attitude) and perceptions about the prerequisites for performing the behavior (perceived behavioral control). The review of the TRA/TPB also showed that most variables were only used in one or two studies, so it was not possible to detect a clear pattern across studies that used the TRA/TPB model.

The studies we reviewed, based on either UM or the TRA/TPB, used many correlations, but failed to find underlying causes for adoption behavior. There are many correlated factors but few, if any, causal factors.

There are some suggested improvements for future studies that aim to understand farmers' decisions to adopt an innovation. First, a key insight that is missing from the UM model is that there is an interaction aspect that influences the effect of some variables. For example, adoption depends on the risk associated with an innovation, and the degree of risk-aversion of the decision maker. Or, on how profitable the innovation is and how strongly the potential adopter is motivated by profit. Abadi Ghadim and Pannell (1999) provide a framework for utility maximization that considers this interaction aspect. Second, both UM and TRA/TBP models ignore the latest findings in behavioral economics and neuroeconomics (see e.g. Kahneman (2011) and Wilkinson and Klaes (2012) for an overview). These disciplines can explain how the brain actually works and can point to causes rather than correlations. Third, although the topic exceeds the scope of this study, some authors have suggested a way to integrate ideas from UM and TRA/TPB models in a different and creative way (Bishop et al., 2010; Chouinard et al., 2008; Lynne, 1995; Lynne and Casey, 1998; Lynne et al., 1995; Sautter et al., 2011). These studies also recognize the latest findings in behavioral economics and neuroeconomics, indicating a potentially productive direction for future research on farmers' decisions and behaviors.

Appendix 2

Table 2A.1 - Studies based on UM, which were included in the review

Authors	Model ( )*	Country	Innovation
Adesina and Chianu (2002)	Logit (1)	Nigeria	Alley farming technology
Anley et al. (2007)	Tobit (4)	Ethiopia	Soil conservation practices
Asfaw and Admassie (2004)	Logit (2)	Ethiopia	Chemical fertilizer
Bekele and Drake (2003)	Multinomial logit (1)	Ethiopia	Soil and water conservation practices
Cavatassi et al. (2011)	Probit (1)	Ethiopia	Modern sorghum varieties
D'Emden et al. (2008)	Logit (1)	Australia	No-till
Feleke and Zegeye (2006)	Logit (1)	Ethiopia	Maize varieties
Gedikoglu and McCann (2012)	Probit (4)	United States	Environment-oriented, profit-oriented and win-win practices
Gillespie et al. (2007)	Multinomial logit (16)	United States	Best management practices
Jara-Rojas et al. (2012)	Poisson regression model (1), Logit (2) and Mutinomial logit (1)	Chile	Water conservation practices
Kim et al. (2005)	Probit (16)	United States	Best management practices (16)
Lambert et al. (2007)	Probit (1) and Multinomial logit (1)	United States	Conservation practices
Lapar and Ehui (2004)	Probit (1)	Philippines	Dual-purpose forage
Larson et al. (2008)	Logit (1)	United States	Remote sensing for variable-rate application of inputs
Mariano et al. (2012)	Logit (1) and Poisson regression model (1)	Philippines	Certified rice seed and Integrated package of rice production technologies
Mazvimavi and Twomlow (2009)	Tobit (1)	Zimbabwe	Conservation practices
Moser and Barret (2006)	Probit (1) and Tobit (1)	Madagascar	System of rice intensification
Noltze et al. (2012)	Double-hurdle (2)	Timor Leste	System of rice intensification
Sidibé (2005)	Probit (2)	Burkina Faso	Soil conservation ('zai' technique) and water conservation ('stone trip') practices
Somda et al. (2002)	Logit (3)	Burkina Faso	Composting technology (soil fertility)
Teklewold and Kohlin (2011)	Multinomial logit (1)	Ethiopia	Soil conservation practices (stone terraces and soil bunds)
Wubeneh and Sanders (2006)	Tobit (2)	Ethiopia	Sorghum varieties (Striga resistant) and inorganic fertilizer
Xu and Wang (2012)	Heckman probit (2)	China	Artisan fruit production
Zhang et al. (2012)	Logit (1)	China	Raising sheep in folds
Zheng et al. (2012)	Probit (1)	China	Plant varieties
Zhou et al. (2008)	Logit (1)	China	Water-saving technology (called ground cover rice production system)

* Number of analyzed models

Table 2A.2 - Studies based on the TRA/TPB, which were included in the review

Authors	Theory	Model	Country	Behavior/Innovation
Beedell and Rehman (2000)	TPB	Correlation	United Kingdom	Conservation behavior
Bruijnis et al. (2013)	TPB	Correlation	Netherlands	Improve dairy cow foot health
Hansson et al. (2012)	TPB	Multinomial logit	Sweden	Decision to diversify or specialize
Läpple and Kelley (2013)	TPB	Probit	Ireland	Organic agriculture
Martínez-Garcia et al. (2013)	TRA	Correlation	Mexico	Improved grassland management
Mettepenningen et al. (2013)	TPB	Logit	Belgium and United States	Agri-environmental schemes
Pennings and Leuthold (2000)	Not mentioned	Covariance structure model	Netherlands	Futures contract usage
Poppenborg and Koellner (2012)	TPB	Multinomial logit	South Korea	Agricultural land use practices
Rehman et al. (2007)	TRA	Correlation	England	Recommended observation times for heat detection
Wauters et al. (2010)	TPB	Logit	Belgium	Soil conservation practices

Table 2A.3 – Frequency of significant and insignificant effects on the adoption decision, for variables included in UM studies on the adoption of environmental and system innovations; results from the vote-count methodology

Group	Variable	Environmental Innovation				System Innovation			
		No. of Models	sig (+)	sig (-)	insig	No. of models	sig (+)	sig (-)	insig
Farmer characteristics	Off-farm work	6	16.67%	16.67%	66.67%	1	0.00%	0.00%	100%
	Risk-aversion	21	0.00%	14.29%	85.71%	14	0.00%	35.71%	64.29%
	Gender (male)	20	45.00%	10.00%	45.00%	13	7.69%	0.00%	92.31%
	Educational level	43	41.86%	2.33%	55.81%	28	39.29%	14.29%	46.43%
	Experience in farming	6	16.67%	0.00%	83.33%	3	33.33%	0.00%	66.67%
	Age	40	10.00%	10.00%	80.00%	28	10.71%	10.71%	78.57%
Farm characteristics	Diversification	24	54.17%	4.17%	41.67%	15	33.33%	0.00%	66.67%
	Have a lake or stream	26	34.62%	0.00%	65.38%	13	0.00%	30.77%	69.23%
	Labor	7	14.29%	0.00%	85.71%	1	100.00%	0.00%	0.00%
	Irrigation	1	100.00%	0.00%	0.00%	6	83.33%	0.00%	16.67%
	Soil type or fertility or characteristics	4	50.00%	0.00%	50.00%	8	25.00%	25.00%	50.00%
	Slope category (flatter higher probability to adopt)	7	71.43%	14.29%	14.29%	3	33.33%	0.00%	66.67%
	Farm size	20	75.00%	5.00%	20.00%	19	52.63%	5.26%	42.11%
	Land tenure (owner)	26	26.92%	0.00%	73.08%	16	0.00%	12.50%	87.50%
Household characteristics	Income from agriculture	23	65.22%	0.00%	34.78%	13	15.38%	7.69%	76.92%
	Family labor	11	0.00%	0.00%	100.00%	7	0.00%	0.00%	100%
	Income	22	31.82%	0.00%	68.18%	15	26.67%	6.67%	66.67%
	Assets (agricultural or non-agricultural)	39	20.51%	2.56%	76.92%	23	8.70%	4.35%	86.96%
	Family size	10	20.00%	10.00%	70.00%	5	20.00%	60.00%	20.00%

Table 2A.3 – Frequency of significant and insignificant effects on the adoption decision, for variables included in UM studies on the adoption of environmental and system innovations; results from the vote-count methodology (continued)

Group	Variable	Environmental Innovation				System Innovation			
		No of model	sig (+)	sig (-)	insig	No. of models	sig (+)	sig (-)	insig
Household characteristics	Off farm income	11	0.00%	9.09%	90.91%	8	12.50%	37.50%	50.00%
Farming context	Participate in government environmental programs or receive subsidies	16	43.75%	0.00%	56.25%	1	0.00%	0.00%	100%
	Region	16	25.00%	6.25%	68.75%	14	50.00%	14.29%	35.71%
	Distance from village or farm to town or market or input shop	4	25.00%	0.00%	75.00%	9	22.22%	22.22%	55.56%
	Credit	6	16.67%	0.00%	83.33%	9	66.67%	0.00%	33.33%
	Security of land tenure	6	16.67%	0.00%	83.33%	0	0.00%	0.00%	0.00%
	Distance to the farm from home	6	0.00%	83.33%	16.67%	3	0.00%	33.33%	66.67%
	Extent of erosion in the village or in the farm	58	32.76%	1.72%	65.52%	31	6.45%	16.13%	77.42%
Information/ Learning	Attendance at training sessions or on-farm demonstrations	2	100.00%	0.00%	0.00%	6	83.33%	0.00%	16.67%
	Farmer perception about problem that the innovation can help to solve	6	16.67%	0.00%	83.33%	0	0.00%	0.00%	0.00%
	Membership in farmers associations or other groups	8	75.00%	0.00%	25.00%	4	50.00%	0.00%	50.00%
	Assistance or contact with extension	54	24.07%	3.70%	72.22%	36	61.11%	11.11%	27.78%

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Chapter 3

Understanding Farmers' Intention to Adopt Improved Natural Grassland using the Theory of Planned Behavior

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Abstract

Studies on the adoption of innovations usually ignore underlying psychological constructs that affect farmers' decisions and behavior, such as intention, perceptions, and beliefs. This paper uses psychological constructs from the theory of planned behavior (TPB) to analyze factors that affect the adoption of improved natural grassland. The TPB hypothesizes that adoption is driven by intention, which in turn is determined by three psychological constructs: attitude, subjective norm, and perceived behavioral control. These three psychological constructs are derived from behavioral, normative and control beliefs, respectively. The first objective was to identify the influence of attitude, subjective norm, and perceived behavioral control on the intention of farmers to use improved natural grassland. The second objective was to understand the role of farmers' beliefs as drivers of their attitude, subjective norm, and perceived behavioral control. The theoretical framework and model were applied to a sample of 214 Brazilian cattle farmers. Results showed that attitude, subjective norm, and perceived behavioral control were all positively and significantly correlated with intention. The intention of farmers to use improved natural grassland was therefore influenced by farmers' evaluation of the use of improved natural grassland (attitude), their perceptions about the social pressure to use this innovation (subjective norm), and their perceptions about their own capability (perceived behavioral control). Six behavioral beliefs were the drivers of attitude: increase cattle weight gains, increase number of animals per hectare, have pasture throughout the year, increase pasture resistance, prevent soil erosion, and decrease feeding costs. Seven normative beliefs were the drivers of subjective norm: family, friends, neighbor farmers, cattle traders, workers in the place where they buy their inputs, extension agents, and government. Three control beliefs were the drivers of perceived behavioral control: sufficient knowledge, sufficient skills, and availability of qualified technical assistance. The drivers of attitude, subjective norm, and perceived behavioral control can be used by policy makers to increase the adoption rate of improved natural grassland. Emphasis should be given to the six perceived benefits of adopting improved natural grassland, the drivers of attitude. The individuals and groups who were found to influence farmers' decisions to use it, the drivers of subjective norm, can be used as channels to disseminate information about the innovation. The drivers of perceived behavioral control are factors which facilitate the use of improved natural grassland. Ensuring that these three factors are available to farmers can improve the adoption rate for this innovation.

Keywords: Adoption; Farmers' decisions; Improved natural grassland; Theory of planned behavior.

3.1 Introduction

The food production system faces the challenge of increasing food production to feed the growing world population, without compromising the environment. As agricultural practices determine the level of food production and impact on the environment, it is important that farmers adopt innovations that increase productivity and reduce environmental damage (Guerin, 2001). Improved natural grassland[6] is an innovation that is expected to increase production and profits, and reduce damage to the environment. This innovation is available to cattle farmers in Rio Grande do Sul (RS), Brazil. Although the innovation is promoted by governmental extension agencies, the adoption rate has been low. Given the current low adoption rate, it is useful to explore whether these farmers actually have any intention to adopt improved natural grassland. An understanding of the factors, which determine the intention to use improved natural grassland, could help policy makers design policy initiatives to improve adoption rates for this innovation. Therefore this paper had two research questions. Firstly, how strong is the intention of farmers in Rio Grande do Sul to use improved natural grassland? Secondly, which factors determine their intention to use this innovation?

Existing studies on the adoption of innovations in agriculture are usually based on a random utility framework. These studies focus on explaining how characteristics of the innovation and observable socioeconomic characteristics influence farmers' decisions (Borges et al., 2014). Such socioeconomic characteristics include: age, gender, educational level, and farm size. These studies generally analyze actual adoption behavior, rather than the intention to adopt. There is little understanding of the psychological constructs underlying farmers' decisions (Hansson et al., 2012). Indeed, Wauters and Mathijs (2013) observed that scientists show a rising interest in socio-psychological methods to study

[6] Improved natural grassland is defined as an innovation where one (or both) of the following practices is applied to natural grassland: use of fertilizers and introduction of new forage species. This innovation increases natural grassland availability to feed the cattle. Thereby, farmers are more likely to keep feeding their cattle with natural grassland on their farms. Otherwise, farmers may destroy the natural grassland to grow artificial pasture or change the land use by introducing crops, such as soybeans.

adoption decisions. This interest has been induced by a growing discontent with random utility models of adoption behavior. For instance, a recent meta-analysis (Borges et al., 2014) showed that the variables used in random utility models of adoption behavior are often insignificant. This finding is corroborated by the meta-analyses of Knowler and Bradshaw (2007) and Propopy et al. (2008), although these latter studies were not restricted to random utility models. These two meta-analyses also found that the variables used to explain farmers' adoption decisions, such as socioeconomic characteristics, tend to be insignificant.

A socio-psychological theory that is pertinent to the analysis of farmers' decisions and behavior is the theory of planned behavior (TPB), developed by Ajzen (1991). In the TPB, behavior originates from individuals' intentions, which in turn are determined by three central psychological constructs: attitude, subjective norm, and perceived behavioral control. These constructs are derived from beliefs. The strength of farmers' intentions to use improved natural grassland can be determined using the TPB as a framework. Using the three central constructs, it is also possible to identify how farmers evaluate the use of improved natural grassland (attitude construct), to explore the role of perceived social pressure on farmers to use improved natural grassland (subjective norm), and to identify the farmers' perceptions about their capacity to use this innovation (perceived behavioral control). This theory is, therefore, suitable to study the research questions.

Models based on the TPB have been used to provide a better understanding of farmers' decisions and adoption behavior in diverse areas of agriculture: conservation (Beedell and Rehman, 2000), entrepreneurship (Bergevoet et al., 2004), soil conservation (Wauters et al., 2010), diversification or specialization (Hansson et al., 2012), land use practices (Poppenborg and Koellner, 2012), animal welfare practices (de Lauwere et al., 2012; Bruijnis et al., 2013), organic farming (Läpple and Kelley, 2013), pro-environmental agricultural practices (Price and Leviston, 2014), and water conservation practices (Yazdanpanah et al., 2014). Martinez-Garcia et al. (2013) used an earlier version of the TPB, the Theory of Reasoned Action, to study farmers' decisions to use improved grassland. However, the Theory of Reasoned Action provides a less comprehensive explanation of farmers' intentions, as it does not consider the role of perceived behavioral control. The TPB, as it is applied in this study, has not previously been used to analyze the use of improved natural grassland.

The objectives of this study were twofold. Firstly, to identify the influence of attitude, subjective norm, and perceived behavioral control on the intention of farmers to use improved natural grassland. Secondly, to understand the role of farmers' beliefs as drivers of their attitude, subjective norm, and perceived behavioral control.

This paper contributes to the existing literature on the adoption of innovations in agriculture by using psychological constructs from the TPB to explore the factors that influence farmers' decisions to use improved natural grassland. In addition, as far as we know, it is the first paper that uses the TPB in the context of Brazilian cattle farmers. Hansson et al. (2012) argue that studies based on the TPB provide more insight into farmers' behavior. Therefore, the results of this paper are expected to provide policy makers with insight into the underlying psychological factors that influence the use of improved natural grassland. These insights can be used to adjust current policies and to develop new policy initiatives to stimulate the adoption and use of this practice by farmers.

The remainder of this paper is organized as follows. Section 3.2 presents the framework of the TPB, and the theoretical and empirical models used in this paper. This is followed by the results in Section 3.3, and the discussion of results in Section 3.4. Section 3.5 presents the concluding comments.

3.2 Material and Methods

3.2.1 Theoretical framework: the theory of planned behavior (TPB) and hypotheses

The TPB assumes that human behavior originates from individuals' intentions to perform a specific behavior (Ajzen, 1991). Intention to act is the immediate determinant of behavior (Ajzen, 2005). In this study, the intention of a farmer is defined as follows: a farmer anticipates using improved natural grassland, in at least part of the farm, within the next year.

In the TPB, intention is determined by three central psychological constructs: attitude, subjective norm, and perceived behavioral control. According to Beedell and Rehman (2000) and Wauters et al. (2010), attitude is the degree to which execution of the behavior is positively or negatively evaluated, subjective norm refers to a person's perception of the social pressure on them to perform or not perform the behavior, and perceived behavioral control is the perceived own capability to successfully perform the behavior. As a general rule, the intention to act is stronger when attitude and subjective norm are more favorable, and when perceived behavioral control is greater (Davis et al., 2002). Attitude, subjective norm, and perceived behavioral control can either be elicited directly, or derived from beliefs (Läpple and Kelley, 2013). In this study, we used both measures, as this allowed us to correlate the TPB constructs. Therefore, in the context of this paper, farmers will have a higher intention to use improved natural grassland in the following circumstances: when they evaluate the use of this practice as more favorable (direct attitude), when they perceive social pressure to use this practice to be higher (direct subjective norm), and the more positive their perceptions about their own ability to implement this practice on their farms (direct perceived behavioral control), as shown in Figure 3.1. This led to the following hypothesis:

H_1: The intention of farmers to use improved natural grassland is positively correlated with direct measures of their attitude, subjective norm, and perceived behavioral control.

In the TPB, attitude is derived from behavioral beliefs ($b_i \times e_i$), where b_i is the belief about the likelihood of outcome i^{th} of the behavior, and e_i is the evaluation of the i^{th} outcome (Wauters et al., 2010). The subjective norm is derived from normative beliefs ($n_j \times m_j$), where n_j is the belief about the normative expectations of the j^{th} important referent, and m_j is the motivation to comply with the opinion of the j^{th} important referent (Wauters et al., 2010). Perceived behavioral control originates from control beliefs ($c_k \times p_k$), where c_k is the belief about the presence of the k^{th} factor that may facilitate or inhibit the performance of the behavior, and p_k is the perceived power of the k^{th} factor to facilitate or inhibit the behavior (Wauters et al., 2010). Therefore, behavioral, normative beliefs and control beliefs present a double function in TPB. Firstly, the sums of behavioral beliefs, normative beliefs, and control beliefs result in indirect measures of attitude, subjective norm, and perceived behavioral control, respectively. These relations are represented by discontinuous arrows in Figure 3.1. The indirect attitude, subjective norm and perceived behavioral control are also expected to influence farmers' intention to use improved natural grassland. Therefore, we derived the following hypothesis:

H_2: The intention of farmers to use improved natural grassland is positively correlated with indirect measures of their attitude, subjective norm, and perceived behavioral control.

Secondly, behavioral, normative, and control beliefs are expected to drive direct attitude, subjective norm and perceived behavioral control, respectively, as shown in Figure 3.1. This led to the following hypotheses:

H_3: The direct measure of attitude is positively correlated with behavioral beliefs.

H_4: The direct measure of subjective norm is positively correlated with normative beliefs.

H_5: The direct measure of perceived behavioral control is positively correlated with control beliefs.

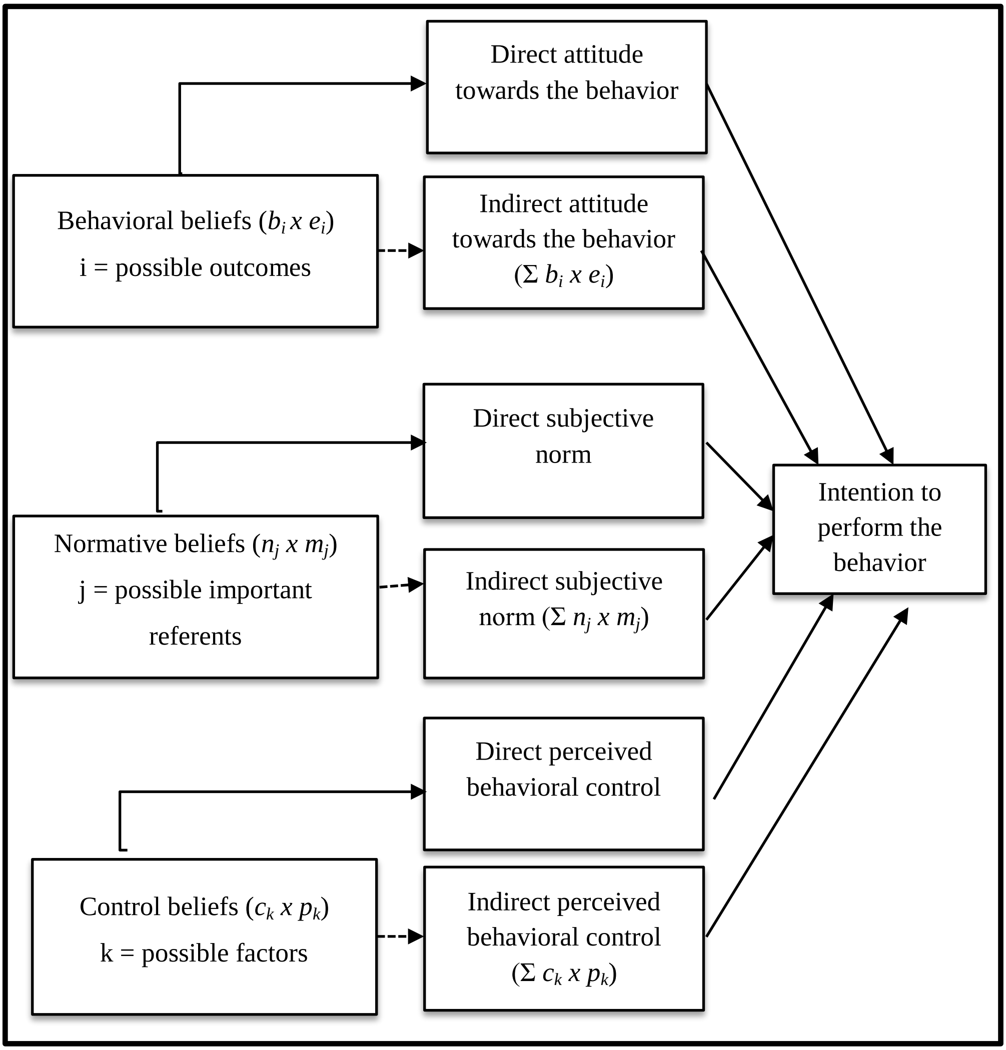

Figure 3.1. The TPB Model; Continuous arrows represent relationships where positive correlation is expected, and discontinuous arrows represent relationships where beliefs generate indirect measures. Adapted from Ajzen (2005).

3.2.2 TPB Measurements

For indirect measures, the first step was to identify the possible outcomes for a specific behavior, possible important referents, and possible factors that facilitate or prevent the behavior, that is, *i*, *j*, and *k* as shown in Figure 3.1. To do that, semi-structured interviews with 13 farmers were carried out in the study region, in the period from September 2013 until October 2013 (the questions used in this step of the analysis are presented in the Appendix 3). These 13 farmers were chosen by specialists, to somehow be a good representation of the small cattle farmers in the region. The results of these semi-structured interviews were then used to elicit the indirect measures; the results are presented in Table 3.1.

Table 3.1 – Outcomes (i), important referents (j), and factors (k) identified in the semi-structured interviews

Outcomes (*i*)	Important referents (*j*)	Factors (*k*)
Increase number of animals per hectare [a]	Family[c]	Lack of information about the practice
Have pasture available throughout the year	Extension agents	Lack of money to invest
Increase pasture resistance [b]	Government	Availability of governmental credit
Decrease feeding costs	Friends	Sufficient skills
Prevent soil erosion	Neighbor farmers	Sufficient knowledge
Increase cattle weight gains	Workers in the place where you buy your inputs	Difficulty to deal with weeds
Have to buy machines	Cattle traders	Availability of qualified technical assistance
Have to hire employees		

[a] Increase number of animals per hectare is similar to increase number of animal units (AU) per hectare. In Brazil, farmers usually do not talk about animal units (AU) but instead, they talk about animals per hectare. [b] Increase pasture resistance is equivalent to say that pasture is more resistant to critical weather conditions, like droughts or frost. [c] Specific family members were included as group of important others.

TPB constructs were measured using a seven-point scale anchored in the extreme points, with one being the most negative answer and seven being the most positive one. A seven-point scale was also used in other TPB studies (de Lauwere et al., 2012; Wauters et al., 2010).

For each outcome *i* presented in the first column of Table 3.1, farmers were asked two questions, which they answered using the seven-point scale anchored in the extreme points. Firstly, 'How likely is it that, if you use improved natural grassland in at least part of your farm within the next year, you would [*outcome i*], (unlikely – likely)'. Secondly, 'How important is it that, if you use improved natural grassland in at least part of your farm within the next year, you would [*outcome i*], (unimportant – important)'. For each outcome *i*, these two questions elicited b_i and e_i as shown in Figure 3.1. For each outcome *i*, the product of b_i and e_i was calculated, resulting in eight behavioral beliefs ($b_i \times e_i$). The indirect attitude was calculated as the sum of these behavioral beliefs ($\Sigma\, b_i\, x\, e_i$).

For each important referent *j* presented in the second column of Table 3.1, farmers were asked two questions, which they answered using the seven-point scale anchored in the extreme points. Firstly, 'How likely is it that the individual/group [*important referent j*] would think that you should use improved natural grassland in at least part of your farm for the next year, (unlikely – likely)'. Secondly, 'How much do you care what the individual/group [*important referent j*] think you should do on your farm, for example to use improved natural grassland in at least part of your farm within the next year, (not at all – very much)'. For each important referent *j*, these two questions elicited n_j and m_j as shown in Figure 3.1. For each important referent *j*, the product of n_j and m_j was calculated, resulting in seven normative beliefs ($n_j \times m_j$). The indirect subjective norm was calculated as the sum of these normative beliefs ($\Sigma\, n_j\, x\, m_j$).

For each factor *k* presented in the third column of Table 3.1, farmers were asked two questions, which they answered using the seven-point scale anchored in the extreme points. Firstly, 'How likely is it that [*factor k*] would be present to facilitate, or to prevent you to use improved natural grassland in at least part of your farm within the next year, (unlikely – likely)'. Secondly, 'How strongly would [*factor k*] facilitate or prevent you to use improved natural grassland in at least part of your farm within the next year? (very weak – very strong)'. For each factor k, these two questions elicited c_k and p_k as shown in Figure 3.1. For each factor k, the product of c_k and p_k was calculated, resulting in seven control beliefs ($c_k \times p_k$). The indirect perceived behavioral control was calculated as the sum of these control beliefs ($\Sigma\, c_k\, x\, p_k$).

Intention was measured by calculating the mean scores of four statements (see Table 3.3). Direct attitude was measured as the mean of the scores of the four attitude statements (see Table 3.4). Direct subjective norm was measured as the mean of the scores for the three subjective norm statements (see Table 3.5). Direct perceived behavioral control was measured as the mean of the scores for the five perceived behavioral control statements (see Table 3.6).

3.2.3 Sampling and survey

The population of interest consisted of small cattle farmers in the micro-region of *Campanha Central*, in Rio Grande do Sul state, Brazil. Four municipalities belong to this micro-region: Rosário do Sul, Santa Margarida do Sul, São Gabriel, and Santana do Livramento.

A list of small cattle farmers for each municipalities was obtained from the governmental extension agency, which has a record of the majority of small cattle farmers in the micro-region. Using the farmers in the list as the target population, a random sample of 214 farmers was selected, representing 20% of the small cattle farmers in each municipality. The 13 farmers' who participated in the semi-structured interviews do not belong to the final sample.

Before applying the survey, a pretest was carried out with 10 farmers and two specialists, to ensure that the questions could be clearly understood. The final version of the survey consisted of four groups of questions: socioeconomic characteristics, questions based on the TPB, farmers goals, and personality traits (the latter two groups are not further addressed in this paper).

The 214 farmers were contacted and invited to participate in the survey, either by telephone or during a visit to their farm. If the farmers were not found, or if they were unwilling to participate, then other farmers were random selected from the list. Upon acceptance, farmers were invited to fill out the survey face-to-face with one interviewer. The first author was one of the interviewers and four local interviewers were hired to help in the data collection. The interviewers were necessary to increase the response rate by providing instructions and guidance to farmers. The data collection took place from December 2013 until February 2014.

3.2.4 Data analysis

Prior to the analysis, the reliability of the scales used to measure the TBP constructs was investigated using Cronbach's α coefficient. A Cronbach's α coefficient higher than 0.6 indicates that the different beliefs can be summed to calculate indirect attitude, indirect subjective norm and indirect perceived behavioral control (Bruijnis et al., 2013). Likewise, a Cronbach's α coefficient higher than 0.6 indicates that the results of the different statements used for intention, direct attitude, direct subjective norm, and direct perceived behavioral control can be summed, and that the mean can be used to represent these constructs. The Spearman rank correlation coefficient (r_s) was used to test our hypotheses; a non-parametric test was preferred as the data were measured using an ordinal scale (Bruijnis et al., 2013; Martínez-García et al., 2013).

3.3 Results

3.3.1 Socioeconomic characteristics of the sample

The socioeconomic characteristics[7] of the sample of farmers are shown in Table 3.2. In addition to the variables shown in Table 3.2, education level was measured. The results showed that 1.9% of the farmers were illiterate, 66.4% had incomplete elementary school, 7.9% complete elementary school, 3.7% incomplete high school, 14.5% complete high school, 0.9% an incomplete bachelor degree, 4.2% a complete bachelor degree, and only 0.5% had postgraduate studies.

Table 3.2 – Means and standard deviations of farmers' socioeconomic characteristics

Variable	Mean	SD
Age (years)	56.0	13.6
Experience (years)	31.0	15.1
Farm size (number of hectares)[a]	78.8	104.2
Percentage of farm income from agriculture	81.2	25.9
Number of family members who depend on farm income	2.9	1.2
Gender (0=female; 1=male)	0.9	0.3

[a] This variable presents a large variation. We identified 'outliers' and rerun the correlations without them. Results do not change significantly.

3.3.2 The direct measures of the TPB and correlations among them

The intention to use improved natural grassland within the next year, in at least part of the farm, was generally high (see Table 3.3). More than 50% of respondents gave a five or

[7] In the questionnaire, there was also questions to measure if farmers were already using improved natural grassland and as well as their experience with this innovation. Given data inconsistency, however, these variables are not presented.

higher for all four intention statements. The statement for which the most farmers (66%) gave a five or higher was 'how strong is your intention to use improved natural grassland in at least part of your farm within the next year?'. The intention statement for which the least farmers (55%) gave a five or higher was 'I plan to use improved natural grassland in at least part of my farm within the next year (I know where and how I will do this)'.

Cronbach's α coefficient for the four intention statements was higher than 0.6 (see Table 3.3). Therefore, the results for the four statements were added, and the mean was used to represent the intention construct.

Table 3.3 – Scale, median, interquartile range (IQR) and the Cronbach's α for the four statements used to measure the intention of farmers to use improved natural grassland

Intention	Scale (1-7)	Median (IQR)
I intend to use improved natural grassland in at least part of my farm within the next year	definitely not-definitely yes	5 (4-6)
How strong is your intention to use improved natural grassland in at least part of your farm within the next year	very weak-very strong	5 (4-6)
How likely is it that you will use improved natural grassland in at least part of your farm within the next year	unlikely-likely	5 (3-6)
I plan to use improved natural grassland in at least part of my farm within the next year (I know where and how I will do this).	strongly disagree-strongly agree	5 (3-6)
Cronbach's α 0.92		
Calculated intention (Mean=4.78)		5 (4-6)

The results in Table 3.4 show that farmers had a positive attitude towards using improved natural grassland. At least 45% of the respondents gave the highest score (seven) for all four statements used to measure attitude. Moreover, at least 89% of the farmers gave a five or higher for all four attitude statements.

Cronbach's α coefficient for the four attitude statements was higher than 0.6 (see Table 3.4). Therefore, we added the results for the four statements, and used the mean as a representation of the direct attitude construct.

Table 3.4 – Scale, median, interquartile range (IQR) and the Cronbach's α for the for four statements used to measure the direct attitude of farmers

Direct attitude	Scale (1-7)	Median (IQR)
Using improved natural grassland in at least part of my farm within the next year is:	bad-good	6.5 (6-7)
Using improved natural grassland in at least part of my farm within the next year is:	disadvantageous-advantageous	7 (6-7)
Using improved natural grassland in at least part of my farm within the next year is:	unnecessary-necessary	6 (5-7)
Using improved natural grassland in at least part of my farm within the next year is:	unimportant-important	7 (6-7)
Cronbach's α 0.88		
Calculated direct attitude (Mean=6.20)		6.5(5.75-7)

Farmers perceived the social pressure to use improved natural grassland as high (see Table 3.5). More than 50% of the farmers answered with a five or higher for all three subjective norm statements. Indeed, more than 70% of the farmers gave a score of five or higher for the subjective norm statements 'Most people who are important to me think that I should use improved natural grassland in at least part of my farm within the next year', and

'Most people whose opinion I value would approve that I use improved natural grassland in at least part of my farm within the next year'. In contrast, 51% of respondents gave a score of four or higher for the subjective norm statement 'Most farmers like me will use improved natural grassland in at least part of their farms within the next year'.

Cronbach's α coefficient for the three subjective norm statements was higher than 0.6 (see Table 3.5). Therefore, the results for the three statements were added, and the mean was used to represent the direct subjective norm construct.

Table 3.5 – Scale, median, interquartile range (IQR) and the Cronbach's α for the three statements used to measure the direct subjective norm of farmers

Direct subjective norm	Scale (1-7)	Median (IQR)
Most people who are important to me think that I should use improved natural grassland in at least part of my farm within the next year.	strongly disagree-strongly agree	5 (4-6)
Most people whose opinion I value would approve that I use improved natural grassland in at least part of my farm within the next year.	improbable-probable	6 (4-7)
Most farmers like me will use improved natural grassland in at least part of his farm within the next year.	unlikely-likely	5 (3-5)
Cronbach's α 0.81		
Calculated direct subjective norm (Mean=4.96)		5.33 (4-6)

Farmers perceived that they had the ability to successfully use improved natural grassland in at least part of their farms within the next year (see Table 3.6). More than 60% of respondents gave a score of five or higher for four of the perceived behavioral control statements. The only perceived behavioral control statement in which the majority of the farmers (58%) answered with a score of four or lower was 'If I want to use improved natural grassland in at least part of my farm within the next year, I have sufficient resources'.

Cronbach's α coefficient for the five perceived behavioral control statements was higher than 0.6 (see Table 3.6). Therefore, we added the results for the five statements, and used the mean as a representation of the perceived behavioral control construct.

Table 3.6 – Scale, median, interquartile range (IQR) and the Cronbach's α for the five statements used to measure the direct perceived behavioral control of farmers

Direct perceived behavioral control	Scale (1-7)	Median (IQR)
If I want to use improved natural grassland in at least part of my farm within the next year, I have sufficient knowledge.	definitely not-definitely yes	5 (4-6)
If I want to use improved natural grassland in at least part of my farm within the next year, I have sufficient resources.	definitely not-definitely yes	4 (3-5)
How confident are you that you could overcome barriers that prevent you to use improved natural grassland in at least part of your farm within the next year?	completely unconfident-completely confident	5 (4-6)
Using improved natural grassland in at least part of my farm within the next year is completely up to me.	disagree-agree	6 (3-7)
For me to use improved natural grassland in at least part of my farm within the next year is under my control.	not at all-completely	5 (4-6)
Cronbach's α 0.82		
Calculated direct perceived behavioral control (Mean=4.76)		5(3.8-5.8)

Results for the Spearman rank correlation coefficients (r_s) presented in Table 3.7 show that the direct measures of the TPB were positively and significantly correlated with intention. Therefore, we failed to reject hypothesis H_1: the intention of farmers to use improved natural grassland is positively correlated with direct measures of their attitude, subjective norm, and perceived behavioral control.

Table 3.7 – Means of direct measures and spearman rank coefficient (r_s) for the correlation between direct attitude, direct subjective norm, direct perceived behavioral control and intention

Direct measures	Mean	Correlation with intention (r_s) [a]
Attitude	6.20	0.47
Subjective norm	4.96	0.61
Perceived behavioral control	4.76	0.52

[a] Only variables with P<0.05 are reported.

3.3.3 Indirect measures of the TBP, and correlations with direct measures and intention

Results for the Spearman rank coefficients presented in Table 3.8 show that six of the eight behavioral beliefs ($b_i \times e_i$) were positively and significantly correlated with direct attitude. Only ‘have to buy machines’ and ‘have to hire employees’ were not significantly correlated with direct attitude. Therefore, we partially rejected hypothesis H_3: the direct measure of attitude is positively correlated with behavioral beliefs. This hypothesis was not rejected for six of the eight the behavioral beliefs.

Cronbach’s α coefficient for the eight behavioral beliefs was higher than 0.6 (see Table 3.8). Therefore, the sum of these eight behavioral beliefs was used to represent indirect attitude.

Table 3.8 – Spearman rank coefficient (r_s) for the correlation between behavioral beliefs and direct attitude and the the Cronbach's α for the eight behavioral beliefs

Behavioral beliefs ($b_i \times e_i$)	Correlation with direct attitude (r_s) [a]
Increase number of animals per hectare	0.57
Have pasture available throughout the year	0.57
Increase pasture resistance	0.56
Decrease feeding costs	0.44
Prevent soil erosion	0.47
Increase cattle weight gains	0.60
Have to buy machines [b]	
Have to hire employees [b]	
Cronbach's α 0.80	

[a] Only variables with P<0.05 are reported. [b] Belief was recoded, as it was negatively formulated in the questionnaire.

Results for the Spearman rank correlation coefficient presented in Table 3.9 show that the seven normative beliefs ($n_j \times m_j$) were positively and significantly correlated with the direct subjective norm. Therefore, we failed to reject hypothesis H_4: the direct measure of subjective norm is positively correlated with normative beliefs.

Cronbach's α coefficient for the seven normative beliefs was higher than 0.6 (see Table 3.9). We therefore used the sum of these seven normative beliefs to represent the indirect subjective norm.

Table 3.9 – Spearman rank coefficient (r_s) for the correlation between normative beliefs and direct subjective norm and the Cronbach's α for the seven normative beliefs

Normative beliefs ($n_j \times m_j$)	Correlation with direct subjective norm (r_s) [a]
Family[b]	0.67
Extension agents	0.26
Government	0.23
Friends	0.57
Neighbor farmers	0.55
Workers in the place that you buy your inputs	0.49
Cattle traders	0.52
Cronbach's α 0.86	

[a] Only variables with $P<0.05$ are reported. [b] Data about specific family members was not collected, given time restrictions in applying the questionnaire.

Results for the Spearman rank coefficients presented in Table 3.10 show that five out of seven control beliefs ($c_k \times p_k$) were significantly correlated with direct perceived behavioral control. Two of them, however, had negative signs: 'lack of information about the practice', and 'difficulty to deal with weeds'. Only three of the control beliefs were significantly and positively correlated with direct perceived behavioral control. Therefore, we partially rejected hypothesis H_5: the direct measure of perceived behavioral control is positively correlated with control beliefs. This hypothesis was not rejected for only three of the seven control beliefs.

Cronbach's α coefficient for the seven control beliefs was higher than 0.6 (see Table 3.10). Therefore, the indirect perceived behavioral control was calculated as the sum of these seven control beliefs.

Table 3.10 – Spearman rank coefficient (r_s) for the correlation between control beliefs and direct perceived behavioral control and the Cronbach's α for the seven control beliefs

Control beliefs ($c_k \times p_k$)	Correlation with direct perceived behavioral control (r_s) [a]
Lack of information about the practice [b]	-0.25
Lack of money to invest [b]	
Availability of governmental credit	
Sufficient skills	0.35
Sufficient knowledge	0.45
Difficulty to deal with weeds [b]	-0.24
Availability of qualified technical assistance	0.35
Cronbach's α 0.80	

[a] Only variables with P<0.05 are reported. [b] Belief was recoded, as it was negatively formulated in the questionnaire.

Results of the Spearman rank correlation coefficients presented in Table 3.11 show that the indirect measures of the TPB were positively and significantly correlated with intention. Therefore, we did not reject hypothesis H_2: the intention of farmers to use improved natural grassland is positively correlated with indirect measures of their attitude, subjective norm, and perceived behavioral control.

Table 3.11 – Spearman rank coefficient (r_s) for the correlation between indirect attitude, indirect subjective norm, indirect perceived behavioral control and intention

Indirect measures	Correlation with intention (r_s) [a]
Attitude	0.56
Subjective norm	0.44
Perceived behavioral control	0.27

[a] Only variables with P<0.05 are reported.

3.4 Discussion

3.4.1 Intention

More than 50% of the respondents showed a positive intention to use improved natural grassland on their farms next year. This result seems to contradict the low adoption rate of this innovation in the region. Several reasons may explain this apparent contradiction. Firstly, we measured farmers' intention to use improved natural grassland next year. Therefore, the ideal approach would be to apply another questionnaire one year later with the same farmers to analyze whether farmers who showed intention to use the innovation do really use it on their farms. However, such a research would be beyond the scope of this paper. Secondly, the theory of planned behavior assumes that intentions are the most important predictor of behavior; however this theory also recognizes that people may not always have sufficient control over performing the behavior to actually enact their intentions (Ajzen, 1991). Therefore, farmers may have the intention to use improved natural grassland, but still do not adopt it in practice. A third reason is that certain behaviors are more likely to be controlled by "habits" than by conscious intentions (Triandis, 1980). Hence, farmers may have intention to adopt an innovation, but they do not adopt it because they keep doing the way that they usually do.

3.4.2 Intention and direct and indirect measures of attitude, subjective norm and perceived behavioral control

The first objective was to identify the influence of attitude, subjective norm, and perceived behavioral control on the intention of farmers to use improved natural grassland. To achieve this objective, we measured correlations between direct measures of the TPB and intention, and between indirect measures of the TPB and intention.

The positive and significant correlation between direct attitude and intention indicates that farmers' evaluation of the use of improved natural grassland influenced their intention to use this practice. The more favorable farmers evaluated the use of improved natural grassland to be, the higher their intention to use it. The positive and significant correlation between indirect attitude and intention indicates that the behavioral beliefs concerning the outcomes of using improved natural grassland influenced the intention of farmers to use it. Therefore, policy makers and extension agents must emphasize that this practice is favorable to the farmers to increase their intention to use improved natural grassland. Our results are consistent with the literature. Garforth et al. (2004) found that attitude towards a technology had a strong influence on farmers' intention to adopt it. Similarly, Martínez-García et al. (2013) found a significant and positive correlation between the intention of small farmers in Mexico to use improved grassland, and their direct and indirect attitude. Rehman et al. (2007) found a positive correlation between the intention of English farmers to follow an externally recommended practice for estrus detection in cows, and farmers' direct and indirect attitude. Finally, Bruijnis et al. (2013) also found a positive correlation between the intention of Dutch farmers to adopt an innovation to improve dairy cow foot health, and their indirect attitude.

The positive and significant correlation between direct subjective norm and intention indicates that perceived social pressure influenced the intention of farmers to use improved natural grassland. The greater the perceived social pressure, the higher the intention of farmers to use improved natural grassland. The positive and significant correlation between the indirect subjective norm and intention demonstrates that the normative beliefs of farmers concerning important others influenced their intention to use improved natural grassland. Subjective norm influence individuals' intentions because individuals do not act independently of cultural and social influences, instead they continuously refer their behavior back to important referents (Burton, 2004). Therefore, generally speaking, society can actively increases farmers' intention to use improved natural grassland by pressuring them to use this innovation. Our results are consistent with those found by Rehman et al. (2007) and Martínez-García et al. (2013). In contrast, Bruijnis et al. (2013) did not find a significant correlation between intention and the indirect subjective norm.

The positive and significant correlation between intention and direct perceived behavioral control indicates that farmers' perceptions about their own capability to successfully use improved natural grassland is another important factor that influences their intention to use this practice. The higher the perceived capability to use improved natural grassland, the greater the intention of farmers to use this practice. The positive and significant correlation between indirect perceived behavioral control and intention demonstrates that the intention of farmers was influenced by their control beliefs concerning factors that could facilitate or inhibit the use of improved natural grassland. Perceived behavioral control influences individuals' intentions because it reflects any constraining or encouraging factors that may affect a behavior (Beedell and Rehman, 2000). In contrast to this research, Rehman et al. (2007) and Martínez-García et al. (2013) did not consider the role of perceived behavioral control, as these studies used an earlier version of the TPB called the Theory of Reasoned Action. Although Bruijnis et al. (2013) considered it, they did not correlate the indirect measure of perceived behavioral control with intention. Hence this result cannot be compared with the existing literature.

3.4.3 Direct measures of attitude, subjective norm, and perceived behavioral control and their respective beliefs

The second objective was to understand the role of farmers' beliefs as drivers of their attitude, subjective norm, and perceived behavioral control. To achieve this objective, we measured correlations between direct attitude and behavioral beliefs, the direct subjective norm and normative beliefs, and direct perceived behavioral control and control beliefs.

Direct attitude was positively and significantly correlated with six of the eight behavioral beliefs. These six beliefs were therefore the main drivers of farmers' direct attitude. The following drivers, listed in order of the size of the correlation, were identified as the main drivers of farmers' direct attitude: (i) increase cattle weight gains, (ii) increase number of animals per hectare, (iii) have pasture throughout the year, (iv) increase pasture resistance, (v) prevent soil erosion, and (vi) decrease feeding costs. Following the theory of the TPB, emphasizing these drivers will increase the intention of farmers to use improve natural grassland. Extension programs could be used to reinforce and emphasize these six perceived benefits of improved natural grassland (Garforth et al., 2006; Martínez-García et al., 2013). The two behavioral beliefs 'have to buy a machine' and 'have to hire employees' were not significantly correlated with direct attitude. There are two possible explanations for the non-significant correlation. Firstly, farmers may already have enough machines and labor on their farms, which means that is unnecessary to purchase more machines or hire more employees to use improved natural grassland. Secondly, as this practice does not demand intensive use of machines and labor, farmers may think that these resources are not relevant to the use of improved natural grassland.

The direct subjective norm was positively and significantly correlated with the seven normative beliefs. These beliefs were the drivers of farmers' direct subjective norm. These beliefs represent the people or groups whose opinion was important to farmers in the decision to use improved natural grassland. The highest correlation was found for family, followed by friends, neighbor farmers, cattle traders, workers in the place where they buy their inputs, extension agents, and lastly government. There are different reasons why farmers are influenced by important others: they seek approval, they wish to show commitment to values shared within families and institutions, or they seek to benefit from the expertise and knowledge of others (Martínez-García et al., 2013). Thus, important others might play an important role in farmers' decisions. Even though a farmer holds a positive attitude towards, for example the use of improved natural grassland, then social pressure may prevent this attitude to be expressed in actual adoption (Burton, 2004). On the other hand, important others may motivate farmers to adopt an innovation, also if farmers have a negative attitude towards the behavior. These important referents can be used as channels and sources to influence and motivate farmers to adopt an innovation (Garforth et al., 2004; Bruijnis et al., 2013; Martínez-García et al., 2013). Our results suggest that the farmers were more influenced by people who were closer to them, that is, family, friends, and neighbors. This result has implications for extension agents. Extension agents must disseminate information about the practice to the farmers and to people close to them, such as their families. It is expected, with this strategy, that farmers' intention to use this innovation increases. This is because if people close to the farmers have more information about improved natural grassland, they more likely will support farmers in their decisions to use it. Instead of correlating normative beliefs with the direct subjective norm, Rehman et al. (2007), Bruijnis et al. (2013), and Martínez-García et al. (2013) all correlated normative beliefs with intention. The literature provides very mixed results for the role of normative beliefs in the intention to adopt and in the adoption of innovations in agriculture. Martínez-García et al. (2013) found that only fathers influenced the intention to use improved natural grassland, whereas other family members, the government, the veterinarian, and other farmers did not. Bruijnis et al. (2013) found that advisors influenced the intention to improve the foot health of dairy cows, whereas family members, friends, and colleagues did not. Rehman et al. (2007) found that other farmers and advisors (veterinarians) influenced the intention to follow a recommended practice for estrus detection in cows. There are two possible explanations for the lack of similar results in normative beliefs. Firstly, de Lauwere et al. (2012) argue that, in the TPB, people are assumed to include subjective norm and normative beliefs in their conscious deliberation as to whether or not to perform a certain behavior. People, however, tend to deny the influence of other people's behavior on their actions, which suggests that people are unware of the influence on them of subjective norm and normative beliefs (Nolan et al., 2008). If this is the case, farmers will deny the influence by important others when asked about it. Another possible explanation is that the relevance of important others might vary in different cultures. Our results show that in Brazil, people close to the farmers influence their intentions to adopt innovation, while in other cultures, advisors play a more important role.

Direct perceived behavioral control was positively and significantly correlated with only three of the seven control beliefs. These three were the drivers of farmers' direct perceived behavioral control, and represent factors which were perceived to facilitate the use of improved natural grassland. The highest correlation was found for sufficient knowledge, followed by sufficient skills, and lastly, availability of qualified technical assistance. Bruijnis et al. (2013) also found that knowledge was an important driver for perceived behavioral control. Two control beliefs, lack of money to invest (recoded) and availability of governmental credit, were not correlated with direct perceived behavioral control. Martínez-García et al. (2013) found that farmers believed that using improved natural grassland did not demand high investment; this result could explain why farmers did not perceive financial resources as important factors to facilitate the use of improved natural grassland. Results of control beliefs suggest that to increase the intention of the farmers to use improved natural grassland, government should provide qualified technical assistance. It is expected, with this strategy, that farmers' intention to use this innovation increases, because if the government provides qualified technical assistance, farmers more likely will perceive that they have knowledge and skills to use improved natural grassland. Two control beliefs, lack of information about the practice (recoded) and difficulty to deal with weeds (recoded), were negatively and significantly correlated with direct perceived behavioral control. These negative correlations mean that the more the farmers perceive that they have information about the practice and the more they perceive that they can deal with weeds, the lower their direct perceived behavioral control. This was an unexpected result and cannot be explained using the TPB theory. Possibly, farmers have misinterpreted the question, but this is not clear from our data.

3.5 Conclusions

Results showed that farmers' intention was influenced by both direct and indirect measures of attitude, subjective norm, and perceived behavioral control. Direct attitude referred to farmers' evaluation of the use of improved natural grassland. Direct subjective norm referred to their perceptions about social pressures to use improved natural grassland. Direct perceived behavioral control referred to their perceptions about their own capability to use this practice. Our findings showed that these three factors influenced farmers' intention to use it. The intention to use was also influenced by behavioral beliefs concerning the outcomes of using improved natural grassland (Indirect attitude), normative beliefs concerning important others (Indirect subjective norm), and control beliefs concerning factors that could facilitate or inhibit the use of improved natural grassland (Indirect perceived behavioral control).

Six behavioral beliefs were identified as the drivers of attitude: increase cattle weight gains, increase number of animals per hectare, have pasture throughout the year, increase pasture resistance, prevent soil erosion, and decrease feeding costs. Farmers' intention to use improved natural grassland could be increased by emphasizing and reinforcing these six perceived benefits of adopting improved natural grassland. Furthermore, seven drivers for the subjective norm were identified: family, friends, neighbor farmers, cattle traders, workers in the place where they buy their inputs, extension agents, and government. These important others could be used as channels to disseminate information about the practice, especially the groups of people close to famers, such as their families. The three main drivers of perceived behavioral control were sufficient knowledge, sufficient skills, and availability of qualified technical assistance. The presence of these factors would facilitate the adoption and use of improved natural grassland. This study showed that factors related to financial resources were less important for the use of improved natural grassland.

Appendix 3

Semi-structure interviews were conducted to identify outcomes for using improved natural grassland, import referents, and factors that would facilitate or prevent the use of improved natural grassland. The following open questions were asked during the interviews: ‘What do you see as the advantages and disadvantages of using improved natural grassland in at least part of your farm within the next year’?; ‘Please list the individuals or groups who would approve/disapprove or think you should/should not use improved natural grassland in at least part of your farm within the next year’; ‘Please list any factors or circumstances that would make it easier/difficult or enable/prevent you to use improved natural grassland in at least part of your farm within the next year’.

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Chapter 4

Comparing Groups of Brazilian cattle Farmers with different levels of Intention to use Improved Natural Grassland

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Abstract

This study used the theory of planned behavior (TPB) as a framework to analyze the intention of Brazilian farmers to use improved natural grassland. The TPB hypothesizes that the adoption of an innovation is driven by the intention to use it, which in turn is determined by three socio-psychological constructs: attitude, subjective norm, and perceived behavioral control. These constructs are derived from beliefs. The theoretical framework and model were applied to a sample of 214 Brazilian cattle farmers. Based on the socio-psychological constructs that influence intention, two groups of farmers were identified; farmers that were willing and farmers that were unwilling to use improved natural grassland. Results showed that compared to unwilling farmers, willing farmers evaluated the use of improved natural grassland on their farms more favorably (attitude), they felt a greater social pressure on them to adopt this innovation (social norm), and they reported a higher capability (perceived behavioral control) to use improved natural grassland. Willing and unwilling farmers also differed in their behavioral beliefs concerning the outcomes of using improved natural grassland, their normative beliefs concerning important others, and their control beliefs concerning factors that could facilitate or inhibit the use of improved natural grassland. The two groups did not differ in most of their socioeconomic characteristics, but did differ in their goals and relative risk attitudes.

Keywords: Farmers' intention; Goals; Improved natural grassland; Relative risk attitude; Theory of planned behavior.

4.1 Introduction

Concerns exist about the low adoption rate of sustainable innovations in regions with natural grasslands. Biome *Pampa*, the Brazilian part of the largest biome *Campos*, represents 90% of the natural grasslands in Rio Grande do Sul state. In this region, continuous and extensive grazing of natural grasslands is the main type of cattle production (Beretta et al., 2002; Da Trindade et al., 2012). Biome *Pampa* has been threatened by overgrazing and the expansion of agriculture (mainly cash crops, forestation, etc.), with negative consequences for the environment. These consequences include: landscape fragmentation, loss of biodiversity, biological invasion, soil erosion, water pollution, and land degradation (Carvalho and Batello, 2009). It is important that farmers in the Biome *Pampa*, who graze their cattle on natural grasslands, adopt innovations that increase productivity and reduce damage to the environment. Improved natural grassland[8] is an example of such an innovation that is currently available to these farmers. Although previous research has demonstrated that farmers in this region have the intention to adopt improved natural grassland (Borges, et al., 2014b), the actual adoption rate has remained low.

Studies on the adoption of innovations increasingly focus on socio-psychological factors that influence farmers' decisions and behavior. Most of these studies use the theory of planned behavior (TPB) or its previous version, the Theory of Reasoned Action (TRA). The TPB assumes that intention is the best predictor of behavior. Intention is determined by three socio-psychological constructs: attitude, subjective norm, and perceived behavioral control. These constructs, in turn, are determined by beliefs. In general, farmers have a higher intention to adopt an innovation when they evaluate the outcomes of adopting the innovation as favorable (attitude), when they perceive a lot of social pressure to adopt (social norm), and when they feel that they are capable of implementing the practice on their farms (perceived behavioral control) (Borges et al., 2014b). The TRA and TPB were

[8] Improved natural grassland is defined as either the introduction of new forage species or the use of fertilizers, or both.

previously used to explain the intention of farmers to use improved natural grassland (Borges et al., 2014b; Martínez-García et al., 2013). Using the TRA, which does not consider the role of perceived behavioral control, Martinez-Garcia et al. (2013) found a significant and positive correlation between the intention of farmers in Mexico to use improved natural grassland, and their attitude and subjective norm. Borges et al. (2014b) found a positive correlation between the intention of Brazilian cattle farmers to use improved natural grassland, and farmers' attitude, subjective norm, and perceived behavioral control. These studies, however, did not investigate differences in the level of intention between farmers and the possible factors that could explain these differences. These factors include socio-psychological factors, socioeconomic characteristics, goals, and perceptions of relative risk attitude. A better understanding of the factors that influence farmers' intentions to adopt this innovation is useful for policy makers and extension agents, and can be used to develop policy initiatives to stimulate the adoption of improved natural grassland.

The objective of this study was to examine whether differences in the level of farmers' intention to use improved natural grassland can be explained by socio-psychological factors, socioeconomic characteristics, goals, and relative risk attitude.

The remainder of this paper is organized as follows. Section 4.2 presents the framework of the TPB, and the theoretical and empirical models used in this paper. This is followed by the results and discussion in Section 4.3. Section 4.4 presents the concluding comments.

4.2 Methodology

4.2.1 Theoretical framework: the theory of planned behavior (TPB)

The TPB assumes that human behavior originates from individuals' intentions to perform a specific behavior (Ajzen, 1991) Intention to act is the immediate determinant of behavior (Ajzen, 2005). In the TPB, intention is determined by three central socio-psychological constructs: attitude, subjective norm, and perceived behavioral control. According to Beedell and Rehman (2000) and Wauters et al. (2010), attitude is the degree to which execution of the behavior is positively or negatively evaluated, subjective norm refers to a person's perception of the social pressure on them to perform or not perform the behavior, and perceived behavioral control is the perceived own capability to successfully perform the behavior. As a general rule, the intention to act is stronger when attitude and subjective norm are more favorable, and when perceived behavioral control is greater (Davis et al., 2002). We assume that farmers may differ in their level of intention to use improved natural grassland. Therefore we derived the following hypothesis:

H_1: Farmers with higher levels of intention to use improved natural grassland have higher values for attitude, subjective norm, and perceived behavioral control.

In the TPB, attitude is derived from behavioral beliefs ($b_i \times e_i$), where b_i is the belief about the likelihood of outcome i^{th} of the behavior, and e_i is the evaluation of the i^{th} outcome (Wauters et al., 2010). The subjective norm is derived from normative beliefs ($n_j \times m_j$), where n_j is the belief about the normative expectations of the j^{th} important other, and m_j is the motivation to comply with the opinion of the j^{th} important other (Wauters et al., 2010). Perceived behavioral control originates from control beliefs ($c_k \times p_k$), where c_k is the belief about the presence of the k^{th} factor that may facilitate or inhibit the performance of the behavior, and p_k is the perceived power of the k^{th} factor to facilitate or inhibit the behavior (Wauters et al., 2010). The sums of behavioral beliefs, normative beliefs, and control beliefs result in indirect measures of attitude, subjective norm, and perceived behavioral control, respectively. The TPB model used in this study is summarized in Figure 4.1.

Based on the theoretical relations between intention and the other socio-psychological constructs, as presented in Figure 4.1, we derived the following hypotheses:

H_2: Farmers with higher levels of intention to use improved natural grassland have higher values for behavioral beliefs.

H_3: Farmers with higher levels of intention to use improved natural grassland have higher values for normative beliefs.

H_4: Farmers with higher levels of intention to use improved natural grassland have higher values for control beliefs.

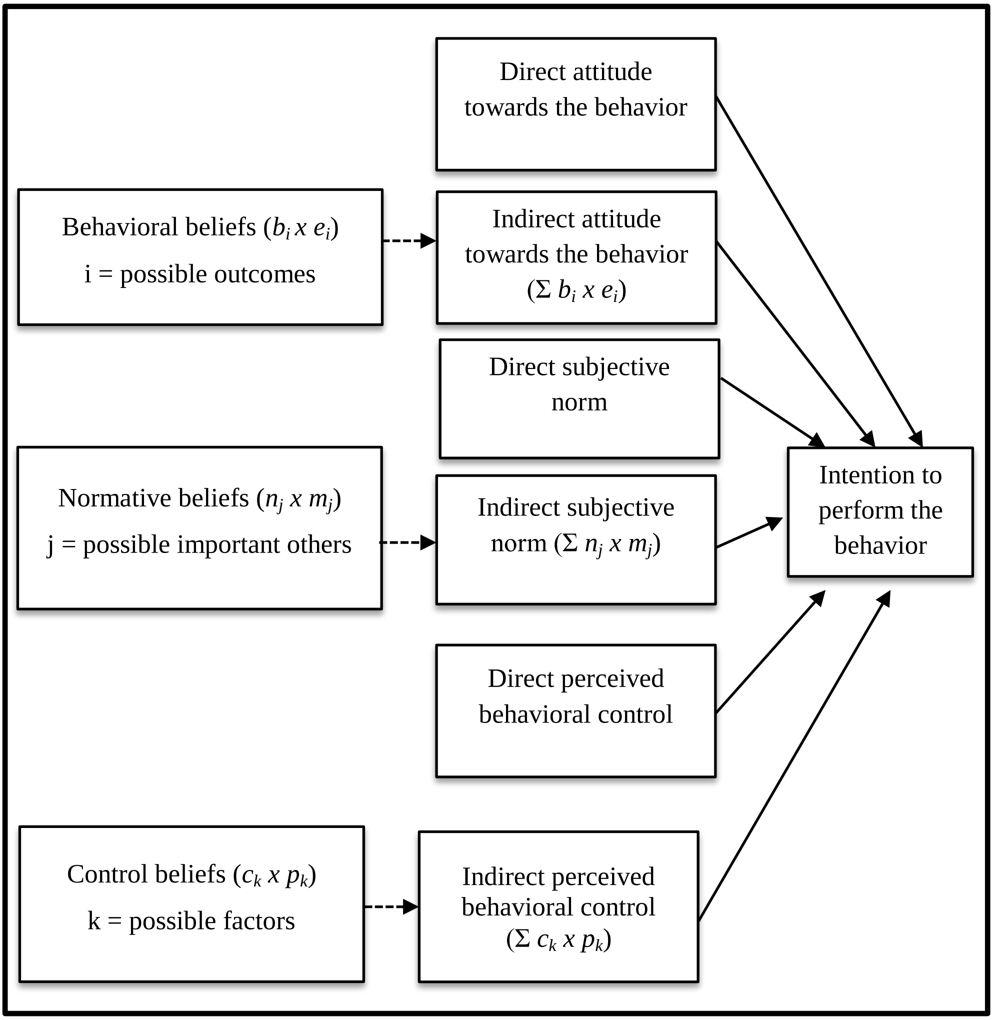

Figure 4.1. The TPB Model. Continuous arrows represent relationships with direct influence, and discontinuous arrows represent relationships where beliefs generate indirect measures (adapted from Ajzen, 1991; Borges et al., 2014b).

4.2.2 Farmers' goals, perceptions of relative risk attitude, and socioeconomic characteristics

In addition to socio-psychological factors, other characteristics and factors may also explain differences in the levels of intention to adopt improved natural grassland. Pannell et al. (2006) claimed that farmers adopt an innovation if it helps them to achieve their goals, which may include social, status, lifestyle, economic, and environmental goals. As improved natural grassland is an innovation, which can increase production and profits, and reduce damage to the environment, we expect that farmers who have economic and environmental goals will have a higher intention to use this innovation. We also expect that farmers with a status goal will have a higher intention to use improved natural grassland, as farmers who adopt sustainable innovations such as improved natural grassland are likely to be appreciated by other people. In contrast, we expect that farmers with a lifestyle goal have a lower intention to use improved natural grassland, because farmers with this goal usually farm following traditional practices and rarely adopt innovations.

Risk attitude describes an individual's tendency to take or avoid risks in their decision making (Pannell et al., 2006). The more risk-averse a farmer is, the greater the tendency to adopt an innovation that is perceived to reduce risk or to not adopt an innovation that is perceived to increase risk (Pannell et al., 2006). We expect that the more risk-averse a farmer is, the greater the intention to adopt improved natural grassland, as this innovation is expected to decrease risk at farm level. Instead of a direct measure of risk attitude, we used the self-reported risk attitude of the farmer (Meuwissen et al., 2001).

Socioeconomic characteristics, such as age, education, experience, farm size, income, and number of family members who depend on the farm income, are frequently used as variables that influence farmers' decisions on the adoption of innovations (Borges et al., 2014a). Based on the literature on the adoption of innovations, we expect that the following types of farmers will all have a higher intention to use improved natural grassland: younger farmers, higher educated farmers, farmers with more experience, farmers with larger farms, farmers with higher income coming from agriculture (Prokopy et al., 2008), and farmers with more family members who depend on farm income (Jara-Rojas et al., 2012).

4.2.3 Sampling and survey

The population of farmers investigated in this study were small cattle farmers in the micro-region of *Campanha Central*, in Rio Grande do Sul state, Brazil (Figure 4.2). Four municipalities belong to this micro-region: Rosário do Sul, Santa Margarida do Sul, São Gabriel, and Santana do Livramento.

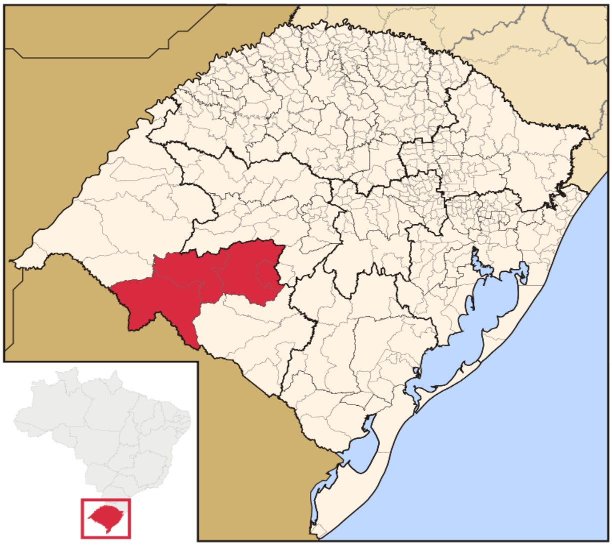

Figure 4.2. Smaller map – map of Brazil with Rio Grande do Sul highlighted; Larger map – map of Rio Grande do Sul with Campanha Central highlighted (FEE, 2014).

The first step was to identify the possible outcomes from the use of improve natural grassland, possible important others, and the possible factors that facilitate or prevent the adoption of this innovation, that is, *i*, *j*, and *k* as shown in Figure 4.1. For this purpose, semi-structured interviews with 13 farmers were carried out in the study region, during the period from September 2013 until October 2013 (the questions used in this step are presented in Table 4A.2 in the Appendix 4).

As a second step, a list of small cattle farmers for each municipality was obtained from the governmental extension agency, which has a record of the majority of small cattle farmers in the micro-region. Using the farmers in the list as the target population, a random sample of 214 farmers was selected, representing 20% of the small cattle farmers in each municipality.

Before applying the survey, a pretest was carried out with ten farmers and two specialists, to ensure that the questions could be clearly understood. The final version of the survey consisted of five groups of questions: socioeconomic characteristics, questions based on the TPB, farmers' goals, relative risk attitude, and personality traits (the latter group is not further addressed in this paper).

The 214 farmers were contacted and invited to participate in the survey, either by telephone or during a visit to their farm. If the farmers were not found, or if they were unwilling to participate, then other farmers were contacted. Upon acceptance, farmers were invited to fill out the survey face-to-face with one interviewer. The interviewer was necessary to increase the response rate by providing instructions and guidance to farmers. The data collection took place from December 2013 until February 2014.

4.2.4 Measurements

4.2.4.1 TPB constructs

The TPB constructs were measured using a seven-point scale, with one being the most negative answer and seven being the most positive answer (for example, very weak to very strong or strongly disagree to strongly agree). Intention was measured by calculating the mean scores of four statements. Attitude, subjective norm, and perceived behavioral control can either be elicited directly, or derived from beliefs (Läpple and Kelley, 2013). In this study we used both measures, as this allowed us to understand the intention of farmers in a more detailed way. The direct attitude of the farmers towards the use of improved natural grassland was measured as the mean of the scores for four statements. Similarly, the direct subjective norm and direct perceived behavioral control were measured as the means of the scores for three and five statements, respectively. The statements used to measure intention and the direct constructs are presented in Table 4A.1 in the Appendix 4.

The results of the semi-structured interviews presented in Table 4A.3 in the Appendix 4 were used to elicit the indirect measures.

For each outcome i identified in the semi-structured interviews, farmers were asked two questions (see Table 4A.4 in the Appendix 4), which they answered using the seven-point scale. The two questions elicited b_i and e_i for each outcome i, as shown in Figure 4.1. For each outcome i, the product of b_i and e_i was calculated, resulting in eight behavioral beliefs ($b_i \times e_i$). The indirect attitude was calculated as the sum of these behavioral beliefs.

For each important other j identified in the semi-structured interviews, farmers were asked two questions (see Table 4A.4 in the Appendix 4), which they answered using the seven-point scale. The two questions elicited n_j and m_j for each important other j, as shown in Figure 4.1. For each important other j, the product of n_j and m_j was calculated, resulting in seven normative beliefs ($n_j \times m_j$). The indirect subjective norm was calculated as the sum of these normative beliefs.

For each factor k identified in the semi-structured interviews, farmers were asked two questions (see Table 4A.4 in the Appendix 4), which they answered using the seven-point scale. The two questions elicited c_k and p_k for each factor k, as shown in Figure 4.1. For each factor k, the product of c_k and p_k was calculated, resulting in seven control beliefs ($c_k \times p_k$). The indirect perceived behavioral control was calculated as the sum of these control beliefs.

The reliability of the scales measuring the TBP constructs was investigated using Cronbach's α coefficient. A Cronbach's α higher than 0.6 indicates that the products of different beliefs can be summed to calculate indirect attitude, indirect subjective norm, and indirect perceived behavioral (Bruijnis et al., 2013). Likewise, a Cronbach's α higher than 0.6 indicates that the results of the different statements used for intention, direct attitude, direct subjective norm, and direct perceived behavioral control can be summed and that the mean can be used to represent these constructs. The Cronbach's α coefficients for all the TBP constructs were higher than 0.6 (see Table 4A.5 in the Appendix 4).

4.2.4.2 Farmers' goals

Farmers were asked to rate the importance of eighteen items/goals using a seven-point scale, with one being 'not at all important' and seven being 'extremely important'. The eighteen goals used in the questionnaire are shown in Table 4A.6 in the Appendix 4.

Factor analysis was used to reduce the number of items used to represent farmers' goals. Principal component was used as the extraction method. The criterion to define the number of factors was an eigenvalue greater than one (Hair et al., 2010). Two items with communalities less than or equal to 0.4 were excluded from the analysis. Items were included in a factor when they presented factor loadings greater than 0.5. We excluded one item that loaded higher than 0.5 in multiple factors. Factors scores were generated for subsequent analysis.

4.2.4.3 Farmers' perceptions of relative risk attitude

Farmers were asked to rate their level of agreement with two statements about their perceptions of relative risk attitude: "In general, I am willing to take more risks than other farmers" and "Regarding the adoption of innovations on my farm, I am willing to take more risks than other farmers". Both statements were measured using a seven-point scale, with one being the most negative answer and seven being the most positive one (strongly disagree to strongly agree). Similar statements were used by Meuwissen et al. (2001) and Greiner et al. (2009). The reliability of the scale was investigated using Cronbach's α coefficient. A Cronbach's α higher than 0.6 indicates that the results of the two questions can be summed and the mean used to represent farmers' perceptions of relative risk attitudes. The Cronbach's α coefficient was higher than 0.6 (see Table 4A.5 in the Appendix 4).

4.2.5 Data analysis

Cluster analysis is an appropriate method for identifying homogenous groups, where objects (farmers) in a specific cluster share the grouping characteristics, but are very dissimilar to objects not belonging to that cluster (Hair et al., 2010; Mooi and Sarstedt, 2011). Given the assumption that farmers would differ in their intention to use improved natural grassland, we used direct attitude, direct subjective norm, and direct perceived behavioral control as grouping variables (see Table 4.1). If this assumption was correct, farmers with different values for these direct measures would also have different levels of intention, which would allow us to test our hypotheses. Therefore, a two-stage cluster approach was used to group farmers according to the socio-psychological constructs that influence their intention to use improved natural grassland. First, an agglomerative procedure (Ward method) using Euclidean distance squared as the similarity measure was applied. Second, a non-hierarchical cluster procedure (K-means) was used. To define the number of clusters, we used the Calinski /Harabasz and Duda/Hart indices as stopping rules (Hair et al., 2010; Mooi and Sarstedt, 2011).

Differences between groups (clusters) were tested using a Mann-Whitney test for ordinal variables and an independent sample t-test for continuous variables.

Table 4.1 – Descriptive statistics for the TPB constructs used as clustering variables

TPB constructs	Mean	Median
Direct attitude	6.20	6.50
Direct subjective norm	4.96	5.33
Direct perceived behavioral control	4.76	5.00

4.3 Results and Discussion

4.3.1 Groups of farmers and the differences between them based on TPB variables

Two clusters of farmers were identified; we termed these clusters as farmers who were willing (n=141) or unwilling (n=73) to use improved natural grassland. Having identified these groups, we examined whether differences in the level of farmers' intention to use improved natural grassland could be explained by socio-psychological factors.

When performing a cluster analysis it is important to test whether the identified groups differ in some criterion variables (Hair et al., 2010; Mooi and Sarstedt, 2011). That is, it was important to test if the groups would differ in some theoretical sense. Based on the TPB, we assumed that different values for the direct constructs would result in different levels of intention to perform a behavior. The results presented in Table 4.2 confirm that the two groups differed in their direct measures, with willing farmers having a higher score for direct attitude, direct subjective norm, and direct perceived behavioral control than unwilling farmers. In addition, willing farmers had significantly higher values for intention and indirect attitude, indirect subjective norm, and indirect perceived behavioral control. Therefore we did not reject H_1: farmers with higher levels of intention to use improved natural grassland have higher values for attitude, subjective norm, and perceived behavioral control. These results suggest that, based on socio-psychological factors, there are two homogeneous groups of farmers with different levels of intentions; willing farmers with a high level of intention and unwilling farmers with a low level of intention.

Compared to unwilling ones, willing farmers evaluated the use of improved natural grassland on their farms more favorably (direct attitude), they perceived a greater social pressure on them to adopt this innovation (direct subjective norm), and they reported a higher capability (direct perceived behavioral control) to use improved natural grassland. Although the unwilling group of farmers had lower scores for all the constructs, results in Table 4.2 show that unwilling farmers had a positive attitude towards improved natural grassland, as this group also had a high score for direct attitude. In contrast, the scores for both the direct subjective norm and direct perceived behavioral control were low, indicating that unwilling farmers did not perceive lot of social pressure to adopt and that they perceived a low capability to use improved natural grassland.

Table 4.2 – Medians for the direct measures and indirect measures of TPB constructs for the two groups of farmers

TPB constructs[a]	Willing	Unwilling
Direct attitude	6.75	5.75
Direct subjective norm	5.66	3.33
Direct perceived behavioral control	5.60	3.60
Intention	5.50	3.75
Indirect attitude	252	192
Indirect subjective norm	203	110
Indirect perceived behavioral control	131	112

[a)] A significant difference ($P<0.05$) between the groups was found for all TBP constructs using the Mann-Whitney test.

Results in Table 4.3 show that willing and unwilling farmers differed in their behavioral beliefs. The two groups differed in their perceptions about the likelihood of the outcomes (*b*) and the evaluation of these outcomes (*e*). The only outcome where the perceived likelihood did not differ between the two groups of farmers was 'have to buy machines'. Compared to the unwilling group, willing farmers perceived it as more likely and more important that using improved natural grassland would result in the six positive outcomes. Although the scores were higher for willing farmers, unwilling farmers also had high scores for the six positive outcomes, as all the medians were above or equal to five. It is often suggested that extension programs can increase the intention to adopt an innovation by emphasizing and reinforcing the positive outcomes to farmers (Borges et al., 2014b; Garforth et al., 2006; Martínez-García et al., 2013). This strategy may be less appropriate for farmers in this region, as the results in Table 4.3 show that they already have positive opinions about the outcomes of using improved natural grassland. For the two negative outcomes, 'have to buy machines' and 'have to hire employees', the interpretation is different, as these outcomes were recoded. Willing farmers perceived it as less likely that using improved natural grassland would result in 'have to hire employees' than unwilling farmers. Additionally, willing farmers perceived it as less important that using improved natural grassland would result in 'have to buy machines' and 'have to hire employees'. Given these results, we did not reject H_2: farmers with higher levels of intention to use improved natural grassland have higher values for behavioral beliefs. Our results are partially consistent with the literature on the adoption of sustainable innovations. Fielding et al. (2005) found that groups of farmers with a strong or weak intention to manage riparian zones in Australia significantly differed in their behavioral beliefs about the positive outcomes, but not in their beliefs about the negative outcomes.

Table 4.3 – Medians of the behavioral beliefs for the two groups of farmers

	Likelihood of outcome (*b*)		Evaluation of outcome (*e*)	
Outcomes	Willing	Unwilling	Willing	Unwilling
Increase number of animals per hectare[a]	6	5	7	5
Have pasture available throughout the year[a]	6	5	6	5
Increase pasture resistance[a]	6	5	6	5
Decrease feeding costs[a]	5	5	6	5
Prevent soil erosion[a]	6	5	7	5
Increase cattle weight gains[a]	7	5	7	6
Have to buy machines[bc]	4	3	5	3
Have to hire employees[ac]	4	3	5	3

a) Significant difference between groups for both *b* and *e* at $P<0.05$ using the Mann-Whitney test.

b) Significant difference between groups for *e* but not for *b* at $P<0.05$ using the Mann-Whitney test.

c) Variables were recoded as these were presented as a negative outcome in the questionnaire.

Results in Table 4.4 show that willing and unwilling farmers differed in their normative beliefs. The two groups differed in their normative expectations of important others (*n*) and in their motivation to comply with the opinion of these important others (*m*). Compared to unwilling farmers, the willing group perceived it as more likely that the important others would support them in their decision to use improved natural grassland and they also indicated a higher motivation to comply with the opinion of these important others. Therefore we did not reject H_3: farmers with higher levels of intention to use improved natural grassland have higher values for normative beliefs. The results in Table 4.4 show that, in general, willing farmers perceived it as likely that the seven important others would support them in their decision to use improved natural grassland, as the median scores for this group were all greater or equal to five. Both groups of farmers thought that extension agents and workers in the place where inputs are purchased would be most likely to support the decision to use improved natural grassland, while willing farmers also thought that family would be most likely to support the decision. Both groups indicated a higher motivation to comply (*m* in Table 4.4) with the opinion of family compared to other important others. Willing farmers were motivated to comply with the opinion of different groups of people, as the median scores were greater or equal to five for all the important others. Compared to willing farmers, unwilling farmers were less motivated to comply with the opinion of others, especially with the opinions of government, friends, neighbor farmers, and workers in the place where they buy inputs. Differences in the degree to which farmers are motivated to comply with important others can suggest channels which are likely to have a greater impact on the intention of farmers (Garforth et al., 2004). In this study, family is the best channel to disseminate information about improved natural grassland, as both groups presented the highest median score for this important other. Extension agents are also an appropriate channel to disseminate information about improved natural grassland, as this important other had the second highest median score for both groups, together with cattle traders. Our results are consistent with those of Fielding et al. (2005), who found that farmers with different levels of intention differed in their normative beliefs.

Table 4.4 – Medians of the normative beliefs for the two groups of farmers

Important others	Normative expectations of important other (*n*)		Motivation to comply with important other (*m*)	
	Willing	Unwilling	Willing	Unwilling
Family[a]	6	4	6	5
Extension agents[a]	6	5	5	4
Government[a]	5	4	5	3
Friends[a]	5	4	5	3
Neighbor farmers[a]	5	4	5	3
Workers in the place where you buy your inputs[a]	6	5	5	3
Cattle traders[a]	6	5	5	4

a) Significant difference between groups for both *n* and *m* at $P<0.05$ using the Mann-Whitney test.

Results in Table 4.5 show that willing and unwilling farmers differed in their control beliefs. The two groups differed in their perception of the likelihood that each factor would be present to facilitate or inhibit their adoption of improved natural grassland (*c*), and in the perceived power of each factor to facilitate or inhibit their adoption (*p*). Compared to the unwilling group, willing farmers perceived a higher likelihood of the four facilitating factors being present and they also perceived that the power of these factors to facilitate adoption was greater. The two groups differed in their perceptions about which was the stronger facilitating factor; for willing farmers this was ‘availability of qualified technical assistance’ and for unwilling farmers, ‘availability of governmental credit’. For the three factors that would inhibit the use of improved natural grassland, ‘lack of information about the practice’, ‘lack of money to invest’, and ‘difficulty to deal with weeds’, the interpretation is different, as these factors were recoded. Compared to unwilling farmers, willing farmers perceived it as less likely that these three factors would be present to inhibit their use of improved natural grassland and the perceived power of these three factors to inhibit adoption was lower. Given these results, we did not reject H_4: farmers with higher levels of intention to use improved natural grassland have higher values for control beliefs. In contrast to this research, Fielding et al. (2005) did not consider the role of perceived power. However, they found that farmers with different levels of intention differed in their perception of the likelihood of factors being present that would inhibit the performance of the behavior (equivalent to *c* in Table 4.5).

Table 4.5 – Medians of the control beliefs for the two groups of farmers

Control factors	Perceived likelihood that factor is present (*c*)		Perceived power of factor (*p*)	
	Willing	Unwilling	Willing	Unwilling
Lack of information about the practice[ab]	6	4	5	4
Lack of money to invest[ab]	5	4	6	5
Availability of governmental credit[a]	5	4	5	5
Sufficient skills[a]	5	4	5	4
Sufficient knowledge[a]	5	4	5	4
Difficulty to deal with weeds[ab]	5	4	5	5
Availability of qualified technical assistance[a]	6	4	6	4

a) Significant difference between groups in *c* and *p* at $P<0.05$ using the Mann-Whitney test.

b) Variables recoded as were negative presented in the questionnaire.

4.3.2 Groups of farmers and the differences between them based on their socioeconomic characteristics, goals, and perceptions of relative risk attitude

The socioeconomic characteristics of willing and unwilling farmers were similar. Results in Table 4.6 show that a significant difference between the two groups was found for only two variables, 'experience' and 'number of family members who depend on farm income'. Contrary to our prior expectation, unwilling farmers had more farming experience than willing farmers. Confirming our prior expectation, willing farmers had more family members who depended on farm income than unwilling farmers. Our results are partially consistent with the literature. Martinez Garcia et al. (2013) found no significant correlation between the intention of farmers in Mexico to use improved natural grassland and the following socioeconomic characteristics: age, education, experience, and family members. However, they found a positive correlation between intention and farm variables, such as herd size and farm size (Martínez-García et al., 2013). Fielding et al. (2005) found no differences in socioeconomic characteristics between groups of farmers with strong or weak intentions to manage riparian zones in Australia. Finally, Bruijnis et al. (2013) also found no differences in socioeconomic characteristics between farmers with different levels of intention to improve the foot health of dairy cows in the Netherlands.

The list of goals was reduced to a three-factor model using factor analysis (see Table 4A.6 in the Appendix 4), with each factor representing a combination of individual goals. We used the following terms for these three factors: economic/social goal, status goal, and lifestyle goal. Farmers who tended to have high ratings for the economic/social goal were driven by financial and family concerns, combined with a sense of obligation to others regarding the quality of their products and environmental issues. Farmers who tended to have a high score for the status goal were driven by a desire to be appreciated and recognized by society. Farmers who tended to have high ratings for the lifestyle goal were driven by a desire for freedom, combined with a respect for family traditions. The list of goals that loaded in each factor is provided in Table 4A.6 in the Appendix 4. Results in Table 4.6 show that willing and unwilling farmers differed for two of the three goals. Confirming our prior expectation, willing farmers tended to score higher than unwilling farmers for the economic/social and status goals. No differences were found between the two groups for the lifestyle goal. A possible explanation for this result is given by Pannell et al. (2006). They claimed that personal goals are one of the most important drivers for farmers' decisions about the adoption of innovations, and if farmers do not perceive that adoption will help them achieve their goals, then adoption will certainly not occur. Therefore willing farmers with a higher intention, who had higher 'economic/social' and 'status' goals in this study, could be intrinsically motivated to use improved natural grassland because they perceive that this innovation will help them to achieve these goals.

Willing and unwilling farmers differed in their relative risk attitude. Results in Table 4.6 show that the median relative risk attitude was lower for unwilling farmers; unwilling farmers perceived themselves as more risk-averse than willing farmers. This result contradicts our prior expectation. We expected improved natural grassland to be an innovation that would decrease risks at farm level, and therefore that the risk-averse farmers would be more willing to adopt this innovation. There are two possible explanations for this result. Firstly, risk-averse farmers may have perceived that the use of improved natural grassland would not decrease the risks at farm level. Secondly, the self-reported measure of relative risk attitude used in this study may not have been a sufficient risk descriptor in the absence of more quantifiable variables (Greiner et al., 2009).

Table 4.6 – Means and medians of the socioeconomic characteristics, goals, and perceptions of relative risk attitude for the two groups of farmers

Variables	Willing (Mean[a] or Median[b])	Unwilling (Mean[a] or Median[b])
Socioeconomic characteristics		
Age (years)[a]	55.81	56.42
Education[b] (levels[c])	2	2
Experience (years)[ad]	29.47	34.02
Farm size (number of hectares)[a]	72.98	83.05
Percentage of farm income from agriculture[a]	81.13	81.30
Number of family members who depend on farm income[bd]	3	2
Goals		
Economic/social[ad] (factor scores)	0.20	-0.39
Status[ad] (factor scores)	0.19	-0.36
Lifestyle[a] (factor scores)	0.02	-0.05
Risk attitude		
Relative risk attitude[bd]	5	4

[a)] Continuous variables (independent sample t-Test).

[b)] Ordinal variables (Mann-Whitney test).

[c)] Measured as: 1=illiterate, 2=incomplete elementary school, 3=complete elementary school, 4=incomplete high school, 5=complete high school, 6=incomplete bachelor degree, 7=complete bachelor degree, 8=post-graduate studies.

[d)] Significant difference between groups at $P<0.05$.

4.4 Conclusions

In this paper, socio-psychological factors from the TPB were used to explain differences in the level of farmers' intention to use improved natural grassland. In addition, this study explored differences in socioeconomic characteristics, goals, and relative risk attitude between groups of farmers with different levels of intention.

Two groups of farmers with different intention levels were found; farmers that were willing and farmers that were unwilling to use improved natural grassland. Willing and unwilling farmers differed in terms of their direct and indirect measures of attitude, subjective norm, and perceived behavioral control. Compared to unwilling farmers, willing farmers evaluated the use of improved natural grassland on their farms more favorably (attitude), they felt a greater social pressure (subjective norm) to adopt this innovation, and they perceived that they had a higher capability (perceived behavioral control) to use improved natural grassland.

Willing and unwilling farmers also differed in their behavioral beliefs concerning the outcomes of using improved natural grassland, their normative beliefs concerning important others, and their control beliefs concerning factors that could facilitate or inhibit the use of improved natural grassland. These results have implications for policy makers and extension agents. Regarding behavioral beliefs, emphasizing and reinforcing positive outcomes is a valid strategy to increase intention and one which is especially relevant for unwilling farmers. However, our results imply that this strategy is less useful for farmers located in Biome *Pampa*, as most farmers already perceived the benefits of using improved natural grassland. Furthermore, our results for the normative beliefs suggest that farmers' intention to use improved natural grassland could be increased by using extension agents to disseminate information about the practice to farmers and their families. We expect that this strategy would lead to a direct and indirect increase in farmers' intention to use improved natural grassland. The direct impact occurs because farmers in both groups are motivated to comply with the opinion of extension agents. The indirect impact occurs because if family members have more information about improved natural grassland, we expect that they are then more likely to support farmers in their decision to adopt. Finally, our results for the control beliefs suggest the that intention of both groups could be increased by the governmental provision of qualified technical assistance and credit, as these factors were perceived by farmers to be the factors which most facilitated the use of improved natural grassland.

Farmers with different levels of intention to use improved natural grassland did not differ in most of their socioeconomic characteristics. However, they did differ in their goals and relative risk attitude. Willing farmers had higher economic/social and status goals, and seem to be intrinsically motivated to use improved natural grassland. Finally, unwilling farmers had a higher self-reported risk aversion than willing farmers.

Because our research focused on Biome *Pampa* in Rio Grande do Sul, Brazil, the implications for policy makers and extension agents do not necessarily apply to other regions. However, the approach used in our study can be applied to different regions to develop specific strategies to increase the adoption and use of sustainable innovations in agriculture.

Appendix 4

Table 4A.1 – Statements used to measure intention, direct attitude, direct subjective norm, and direct behavioral control

Statements	Scale (1 – 7)
Intention	
1) I intend to use improved natural grassland in at least part of my farm within the next year	definitely not-definitely yes
2) How strong is your intention to use improved natural grassland in at least part of your farm within the next year	very weak-very strong
3) How likely is it that you will use improved natural grassland in at least part of your farm within the next year	unlikely-likely
4) I plan to use improved natural grassland in at least part of my farm within the next year (I know where and how I will do this).	strongly disagree- strongly agree
Direct attitude	
1) Using improved natural grassland in at least part of my farm within the next year is:	bad-good
2) Using improved natural grassland in at least part of my farm within the next year is:	disadvantageous-advantageous
3) Using improved natural grassland in at least part of my farm within the next year is:	unnecessary-necessary
4) Using improved natural grassland in at least part of my farm within the next year is:	unimportant-important
Direct subjective norm	
1) Most people who are important to me think that I should use improved natural grassland in at least part of my farm within the next year.	strongly disagree-strongly agree
2) Most people whose opinion I value would approve that I use improved natural grassland in at least part of my farm within the next year.	improbable-probable
3) Most farmers like me will use improved natural grassland in at least part of his farm within the next year.	unlikely-likely
Direct perceived behavioral control	
1) If I want to use improved natural grassland in at least part of my farm within the next year, I have sufficient knowledge.	definitely not- definitely yes
2) If I want to use improved natural grassland in at least part of my farm within the next year, I have sufficient resources.	definitely not- definitely yes
3) How confident are you that you could overcome barriers that prevent you to use improved natural grassland in at least part of your farm within the next year?	completely unconfident-completely confident
4) Using improved natural grassland in at least part of my farm within the next year is completely up to me.	disagree-agree
5) For me to use improved natural grassland in at least part of my farm within the next year is under my control.	not at all-completely

Table 4A.2 – Open questions posed to respondents during the semi-structured interviews to identify outcomes (*i*), important others (*j*), and factors (*k*)

TPB aspect	Open question
Outcomes (*i*)	What do you see as the advantages and disadvantages of using improved natural grassland in at least part of your farm for the next year?
Important others (*j*)	Please list the individuals or groups who would approve/disapprove or think you should/should not use improved natural grassland in at least part of your farm for the next year
Factors (*k*)	Please list any factors or circumstances that would make it easier/difficult or enable/prevent you to use improved natural grassland in at least part of your farm for the next year

Table 4A.3 – Outcomes (i), important others (j), and factors (k) identified in the semi-structured interviews

Outcomes (*i*)	Important others (*j*)	Factors (*k*)
Increase number of animals per hectare	Family	Lack of information about the practice
Have pasture available throughout the year	Extension agents	Lack of money to invest
Increase pasture resistance	Government	Availability of governmental credit
Decrease feeding costs	Friends	Sufficient skills
Prevent soil erosion	Neighbor farmers	Sufficient knowledge
Increase cattle weight gains	Workers in the place where you buy your inputs	Difficulty to deal with weeds
Have to buy machines	Cattle traders	Availability of qualified technical assistance
Have to hire employees		

Table 4A.4 – Questions used to elicited behavioral, normative, and control beliefs

Beliefs	Questions	
	Likelihood of each outcome (b)	Evaluation of each outcome (e)
Behavioral beliefs	How likely is it that, if you use improved natural grassland in at least part of your farm within the next year, you would [*outcome i*], (unlikely – likely)	How important is it that, if you use improved natural grassland in at least part of your farm within the next year, you would [*outcome i*], (unimportant – important)
	Normative expectations of each important other (n)	Motivation to comply with each important other (m)
Normative beliefs	How likely is it that the individual/group [*important other j*] would think that you should use improved natural grassland in at least part of your farm for the next year, (unlikely – likely)	How much do you care what the individual/group [*important other j*] think you should do on your farm, for example to use improved natural grassland in at least part of your farm within the next year, (not at all – very much)
	Likelihood of the presence of each factor (c)	Perceived power of each factor (p)
Control beliefs	How likely is it that [*factor k*] would be present to facilitate, or to prevent you to use improved natural grassland in at least part of your farm within the next year, (unlikely – likely)	How strongly would [*factor k*] facilitate or prevent you to use improved natural grassland in at least part of your farm within the next year? (very weak – very strong)

Table 4A.5 – Cronbach's α coefficient for TBP measurements and farmers' perceptions of relative risk attitude

Measurements	Cronbach's α coefficient
Intention	0.92
Direct attitude	0.88
Direct subjective norm	0.81
Direct perceived behavioral control	0.82
Indirect attitude	0.80
Indirect subjective norm	0.86
Indirect perceived behavioral control	0.80
Relative risk attitude	0.84

Table 4A.6 – Factor loading matrix for the goals, with factor loadings greater than 0.5 in bold

Item	Factor 1[a]	Factor 2[b]	Factor 3[c]
Belong to rural community	0.146	**0.764**	0.278
Be recognized as a top farmer	0.099	**0.813**	0.193
Be appreciated by society	0.161	**0.833**	-0.033
Avoid low/negative income	**0.556**	0.488	0.068
Guarantee land ownership/Maintain land ownership	**0.617**	0.368	0.083
Leave the business for the next generation	**0.718**	0.188	0.122
Improve the family and personal standard of living	**0.811**	0.151	0.130
Put children through school/university	**0.803**	0.138	0.011
Realize an income as high as possible	**0.717**	-0.088	0.146
Expand the business	**0.733**	0.033	0.107
Work in the countryside with animals and nature	**0.612**	0.267	0.338
Be your own boss	0.078	0.176	**0.893**
Continue family tradition	0.253	0.098	**0.835**
Conserve diversity of animals/plants and ecosystems on farm	**0.565**	0.276	0.428
Produce high quality food	**0.766**	0.255	0.182
Variance explained (%)	33.11	17.68	13.45
Invest in the farm without borrowing money[d]			
Farm to make money[d]			
Help to feed the world[d]			

a) Economic/social goal.

b) Status goal.

c) Lifestyle goal.

d) Items excluded either because of communalities ≤ 0.4 or because an item loaded higher than 0.5 in multiple factors.

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Chapter 5

Using Structural Equation Modelling to Identify Psychological Factors that Determine Brazilian Cattle Farmers' Intention to Use Improved Natural Grassland in Biome Pampa

J. A. R. Borges, A. G. J. M. Oude Lansink

Abstract

The biome *Pampa*, in Brazil, is under threat from the expansion of agriculture and overgrazing. Although several sustainable livestock farming innovations are currently available to farmers in the region, the adoption rate remains low. This paper uses the theory of planned behavior (TPB) to identify the psychological factors that influence farmers' intention to adopt improved natural grassland, an innovation that increases productivity at farm level and reduces damage to the environment. The TPB hypothesizes that adoption is driven by intention, which in turn is determined by three psychological constructs: attitude, subjective norm, and perceived behavioral control. Results show that the intention of farmers to use improved natural grassland was mainly determined by their perceptions about the social pressure to use this innovation (subjective norm), followed by their perceptions about their own capability (perceived behavioral control) to use this innovation, and their evaluation of the use of improved natural grassland (attitude). Results also suggest that social pressure influenced farmers' attitude and perceived behavioral control.

Keywords: Adoption; Biome Pampa; Farmers' decisions; Natural grassland; Structural equation modeling; Theory of planned behavior.

5.1 Introduction

Farmers in developing countries that use natural grasslands are facing requirements that are often contradictory. Farmers need to produce efficiently in order to be competitive, and at the same time they are increasingly required to not compromise the environment (Carvalho and Batello, 2009). In Brazil, natural grasslands located in the biome *Pampa* are the most important forage resource for almost 13 million cattle and 5 million sheep (Carvalho et al., 2008). Despite its economic and environmental importance, the *Pampa* biome is under threat because of the expansion of agriculture and overgrazing. For instance, the total area of natural grasslands in the southern region of Brazil, where the biome *Pampa* is located, decreased by 25 percent from 1970 to 1996, i.e. from 18.0 million to 13.7 million hectares (Overbeck et al., 2007). In addition, the original vegetation has been completely replaced in 54 percent of the biome *Pampa* (Overbeck et al., 2013). The consequences for the environment are landscape fragmentation, soil erosion, water pollution, and land degradation (Carvalho and Batello, 2009). As the biome *Pampa* has an economic function, with natural grasslands being a source of forage for cattle and sheep, it is necessary that all conservation initiatives are focused on sustainable livestock farming. Although different sustainable innovations are currently available to farmers in the region, the adoption rate remains low. Therefore, the focus of this research is on understanding the factors that drive farmers' intention to use improved natural grassland[9], an innovation that, when adopted by cattle farmers, is expected to increase productivity at farm level and reduce damage to the environment (Carvalho et al., 2006).

[9] Improved natural grassland is defined as an innovation where one (or both) of the following practices is applied to natural grassland: use of fertilizers and introduction of new forage species. This innovation increases the availability of natural grassland and means that farmers are more likely to keep feeding their cattle with natural grassland on their farms. Otherwise, farmers may destroy the natural grassland to grow artificial pasture or change the land use by introducing crops, such as soybeans.

Most of the previous studies on the adoption of innovations in agriculture use a random utility framework and identify the impact of factors on the adoption decision, such as farmers' socioeconomic characteristics (Borges et al., 2014a). Although the literature on adoption is vast, it is inconclusive about the determinants of adoption (Borges et al., 2014a; Knowler and Bradshaw, 2007; Prokopy et al., 2008), possibly due to the failure to appropriately account for the role of psychological factors. Indeed, Rehman et al. (2007) indicated that relatively little research has addressed the role of psychological factors in the adoption decision and Hansson et al. (2012) argued that there is little understanding of the psychological constructs underlying farmers' decisions and behaviors.

One approach to studying the role of psychological factors on the adoption decision is to use the theory of planned behavior (TPB), and its earlier version, the theory of reasoned action (TRA). Studies based on the TPB and TRA have been used to identify factors that influence farmers' conservation behavior (Beedell and Rehman, 2000; Beedell and Rehman, 1999; Lynne et al., 1995). The TBP and TRA have also been applied to understand farmers' decisions on the adoption of specific innovations, such as improved grassland (Martínez-García et al., 2013) and soil conservation practices (Wauters et al., 2010). The TPB assumes that intention is the best predictor of behavior. Intention is determined by three socio-psychological constructs: attitude, subjective norm, and perceived behavioral control. In general, farmers have a higher intention to adopt an innovation when they evaluate the outcomes of adopting the innovation as favorable (attitude), when they perceive a lot of social pressure to adopt (social norm), and when they feel that they are capable of implementing the practice on their farms (perceived behavioral control) (Borges et al., 2014b). Using the TPB, Fielding et al. (2005) explained the differences between two groups of Australian farmers: a group with a strong intention to manage the riparian zones on their farms and a group with a weak intention. They found that the difference between the groups could be explained by differences in their attitudes, subjective norm, and perceived behavioral control. Martínez-García et al. (2013) used the TRA to identify factors influencing the adoption of improved grassland management by Mexican dairy farmers. Their results showed that farmers' intentions were correlated with their attitudes and subjective norm. Borges et al. (2014b) used the TPB to understand

Brazilian cattle farmers' intentions to adopt improved natural grassland, and found that attitude, subjective norm, and perceived behavioral control were correlated with farmers' intentions. The methodology used by Martínez-García et al. (2013) and Borges et al. (2014b), however, does not enable all the hypotheses underlying the TPB to be tested. That is, using correlations, it is only possible to assess the relation between one construct and intention at a time. Furthermore, the relative importance of attitude, subjective norm, and perceived behavioral control cannot be assessed using correlations. A more suitable technique to analyze the TPB data is structural equation modeling (SEM), as SEM allows for the simultaneous estimation of all relations in the TPB model (Bleakley and Hennessy, 2012). The TPB has been applied and validated in a large number of studies in different fields (Chang, 1998), and therefore there is strong theoretical support for applying it in the context of the adoption of a sustainable innovation. An example of the application of SEM and TPB in the agricultural field is the study of Yazdanpanah et al. (2014). These authors used SEM to explain Iranian farmers' intentions to use water conservation practices. However, they could not validate the entire TPB model, as the perceived behavioral control construct was insignificant.

The objectives of this study are twofold. Firstly, to determine the effect of the three TPB constructs, attitude, subjective norm, and perceived behavioral control, on the intention of Brazilian cattle farmers to use improved natural grassland. Secondly, from a theoretical point of view, to explore the usefulness of the TBP in understanding the adoption of sustainable innovations in agriculture.

This paper contributes to the existing literature on the adoption of sustainable innovations in agriculture by empirically testing whether the TPB, a socio-psychological theory, is able to explain farmers' intention to use improved natural grassland. The results of this paper are expected to provide insight into the usefulness of the TPB as a theory for understanding farmers' intention and behavior in regard to the management of environmental resources. In the specific case of improved natural grassland in the biome *Pampa*, the results of this paper are expected to provide insights that can be helpful to policy makers. Results can be used to revise existing policies and design future policies to stimulate the adoption of improved natural grassland by cattle farmers.

5.2. Methodology

5.2.1 The theory of planned behavior (TPB)

The TPB assumes that human behavior originates from individuals' intentions to perform a specific behavior (Ajzen, 1991). Intention to act is the immediate determinant of behavior (Ajzen, 2005). In the TPB, intention (INT) is determined by three central socio-psychological constructs: attitude (ATT), subjective norm (SN), and perceived behavioral control (PBC). In this study, the intention of a farmer is defined as follows: a farmer anticipates using improved natural grassland, in at least part of the farm, within the next year. According to Beedell and Rehman (2000) and Wauters et al. (2010), attitude is the degree to which execution of the behavior is positively or negatively evaluated, subjective norm refers to a person's perception of the social pressure on them to perform or not perform the behavior, and perceived behavioral control is the perceived own capability to successfully perform the behavior. As a general rule, the intention to act is stronger when attitude and subjective norm are more favorable, and when perceived behavioral control is greater (Davis et al., 2002).

In the context of this paper, farmers have a higher intention to use improved natural grassland in the following circumstances: when they evaluate the use of this practice as more favorable (attitude), when they perceive social pressure to use this practice to be higher (subjective norm), and the more positive their perceptions about their own capability to implement this practice on their farms (perceived behavioral control). The conceptual model to be tested is presented in Figure 5.1. Three hypotheses were derived from the conceptual model:

H_1: Attitude has a positive influence on farmers' intention.

H_2: Subjective norm has a positive influence on farmers' intention.

H_3: Perceived behavioral control has a positive influence on farmers' intention.

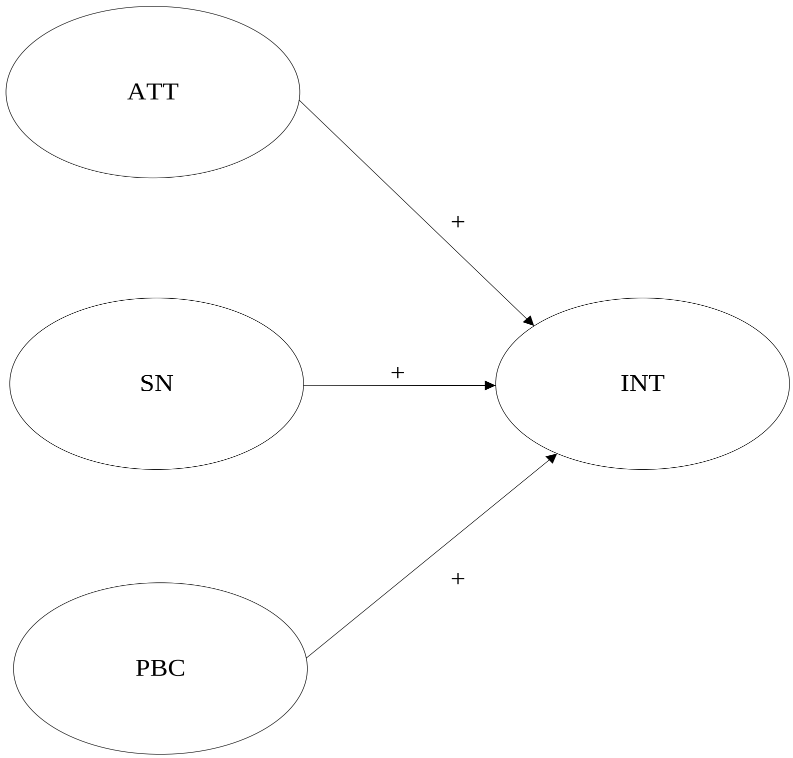

Figure 5.1. The TPB model to be tested. Adapted from Ajzen (2005).

5.2.2 Item measurements

The TPB constructs, attitude, subjective norm, and perceived behavioral control, can be elicited either directly, or indirectly from respondents' beliefs (Läpple and Kelley, 2013). For the purpose of this paper, direct measures were used, as they are sufficient to predict intention (Fishbein and Ajzen, 2010). Sixteen measured items were used to represent the four constructs of the TPB. The statements used to measure each item were based on the instructions of Fishbein and Ajzen (2010) and are shown in Table 5.1. They were measured using a seven-point scale anchored in the extreme points, with one being the most negative answer and seven being the most positive one. A seven-point scale was also used in other TPB studies (Borges et al., 2014b; de Lauwere et al., 2012; Wauters et al., 2010).

Table 5.1 –Statements and scales used for the measureable items, which represent the four TPB constructs

Item	Statement	Scale (1-7)
INT_1	I intend to use improved natural grassland in at least part of my farm within the next year.	definitely not-definitely yes
INT_2	How strong is your intention to use improved natural grassland in at least part of your farm within the next year.	very weak-very strong
INT_3	How likely is it that you will use improved natural grassland in at least part of your farm within the next year.	unlikely-likely
INT_4	I plan to use improved natural grassland in at least part of my farm within the next year (I know where and how I will do this).	strongly disagree-strongly agree
ATT_1	Using improved natural grassland in at least part of my farm within the next year is:	bad-good
ATT_2	Using improved natural grassland in at least part of my farm within the next year is:	disadvantageous-advantageous
ATT_3	Using improved natural grassland in at least part of my farm within the next year is:	unnecessary-necessary
ATT_4	Using improved natural grassland in at least part of my farm within the next year is:	unimportant-important
SN_1	Most people who are important to me think that I should use improved natural grassland in at least part of my farm within the next year.	strongly disagree-strongly agree
SN_2	Most people whose opinion I value would approve that I use improved natural grassland in at least part of my farm within the next year.	improbable-probable
SN_3	Most farmers like me will use improved natural grassland in at least part of their farm within the next year.	unlikely-likely
PBC_1	If I want to use improved natural grassland in at least part of my farm within the next year, I have sufficient knowledge.	definitely not- definitely yes
PBC_2	If I want to use improved natural grassland in at least part of my farm within the next year, I have sufficient resources.	definitely not- definitely yes
PBC_3	How confident are you that you could overcome barriers that prevent you to use improved natural grassland in at least part of your farm within the next year?	completely unconfident-completely confident
PBC_4	Using improved natural grassland in at least part of my farm within the next year is completely up to me.	disagree-agree
PBC_5	For me to use improved natural grassland in at least part of my farm within the next year is under my control.	not at all-completely

5.2.3 Sampling and survey

The population of farmers investigated in this study were small cattle farmers in the micro-region of *Campanha Central*, in Rio Grande do Sul state, Brazil. Four municipalities belong to this micro-region: Rosário do Sul, Santa Margarida do Sul, São Gabriel, and Santana do Livramento.

A list of small cattle farmers for each municipality was obtained from the governmental extension agency, which has a record of the majority of small cattle farmers in the micro-region. Using the farmers in the list as the target population, a random sample of 214 farmers was selected, representing 20 percent of the small cattle farmers in each municipality.

Before applying the survey, a pretest was carried out with ten farmers and two specialists, to ensure that the questions could be clearly understood. The final version of the survey consisted of five groups of questions: socioeconomic characteristics, questions based on the TPB, farmers' goals, relative risk attitude, and personality traits (only the TPB questions are addressed in this paper).

The farmers were contacted and invited to participate in the survey, either by telephone or during a visit to their farm. If the farmers were not found, or if they were unwilling to participate, then other farmers were randomly selected from the list. Upon acceptance, farmers were invited to fill out the survey face-to-face with one interviewer. The first author was one of the interviewers and four local interviewers were hired to help with the data collection. The interviewers were necessary to increase the response rate by providing instructions and guidance to farmers. The data collection took place from December 2013 until February 2014.

5.2.4 Data analysis

This study used the method of structural equation modeling (SEM) with latent constructs to analyze the data. To test our TPB model, we followed a two-step approach proposed by Anderson and Gerbing (1988). In the first step, confirmatory factor analysis (CFA) was used to obtain a satisfactory measurement model (MM). The second step was to develop and test the structural model (SM).

5.2.4.1 Measurement model (MM)

A visual diagram depicting the MM is shown in Figure 5.2. The MM contained the latent constructs: intention, attitude, subjective norm, and perceived behavioral control. CFA was used to test whether the measurable items reliably represented the proposed MM. By using multiple items to represent a latent construct, the measurement error of that construct is reduced and the statistical estimation of the relations between constructs is improved (Hair et al., 2010). All latent constructs were allowed to intercorrelate freely (Chang, 1998).

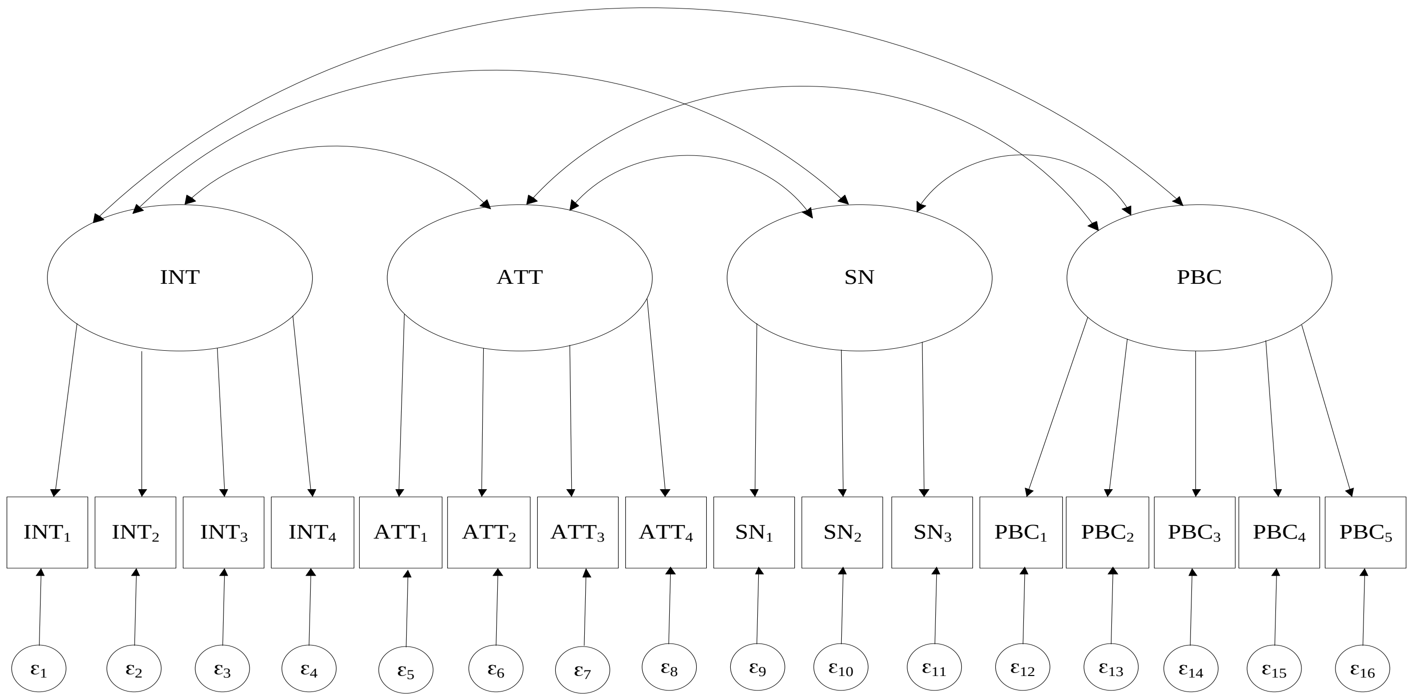

Figure 5.2. The measurement model (MM). A circle represents an error term, a square represents a measureable item, an ellipse represents a latent construct, a straight arrow represents a dependence relation and a curved arrow represents a correlational relation.

In the MM, all items were allowed to load on only one latent construct each. Moreover, the errors terms were not allowed to relate to any other item. The total number of unique variance and covariance was 136. In total, there were 34 parameters to be estimated, consisting of 12 factor loadings of the items (each first item was used as a normalizing constraint with value equal to 1), 16 error terms of the items, and 6 covariance terms among the latent constructs. Therefore, the MM was over identified, with 102 degrees of freedom.

To assess the construct validity of the MM, we examined the convergent and discriminant validity. Convergent validity was examined by checking the magnitude, direction, and statistical significance of the standardized factor loadings on each latent construct. In addition, the average variance extracted (AVE) and construct reliability (CR) were used to examine convergent validity. Discriminant validity was assessed by comparing the AVE estimates for each latent construct with the squared inter-construct correlations associated with that latent construct.

The MM validity was assessed by examining the overall goodness-of-fit (GOF) statistics. The GOF was assessed by checking the chi-square value, the root mean square error of approximation (RMSEA), the 90 percent confidence interval for RMSEA, the comparative fit index (CFI), the Tucker-Lewis index (TLI), and the standardized root mean squared residual (SRMR).

In addition to evaluating the MM validity, we checked the model diagnostics, as these may indicate potential improvements to the model or specific problems not detected by previous steps (Hair et al., 2010). The diagnostic measures, which we checked were the standardized residuals and modification indices.

All guidelines and threshold values used to assess the construct validity, MM validity, and the diagnostic measures were based on Hair et al. (2010).

5.2.4.2 Structural model (SM)

Once a satisfactory measurement model had been obtained, we tested the structural model (SM). In structural modeling, a set of multiple regressions are estimated and the emphasis is on the nature and magnitude of the relations between latent constructs (Hair et al., 2010). Therefore, structural modeling is an appropriate tool for understanding the causal relations among the TPB constructs and to test the hypotheses underlying the TPB. The SM is shown in Figure 5.3.

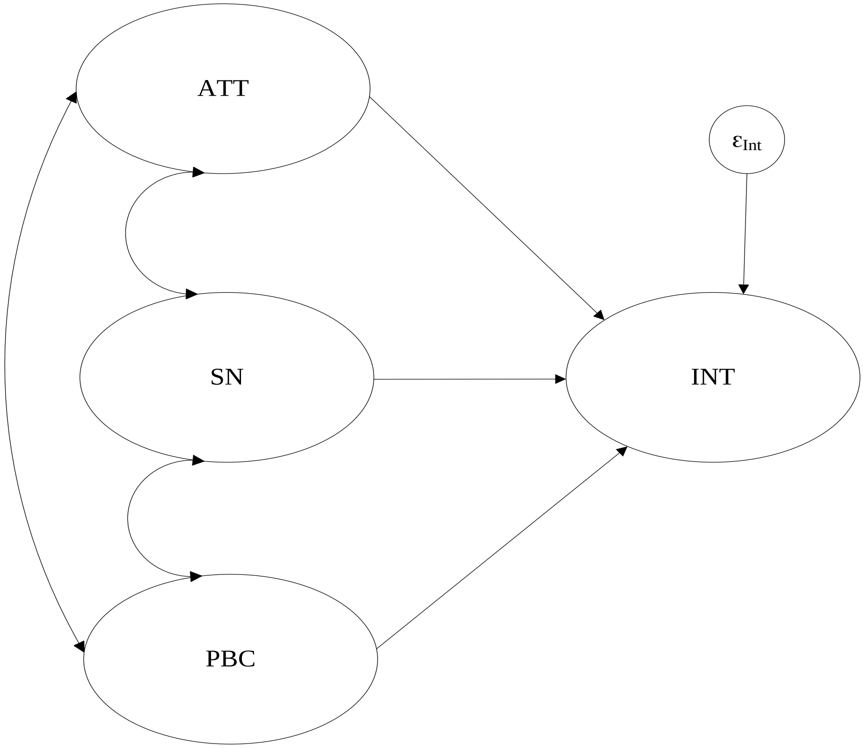

Figure 5.3. The structural model (SM). An ellipse represents a latent construct, a straight arrow represents a dependence relation, a curved arrow represents a correlational relation, and a circle represents an error term.

5.2.5 Data screening

Multivariate collinearity was assessed by running multiple regressions, each with a different item as the dependent variable and all the rest of the items as independent variables, and then checking the tolerance and variance inflation factor (VIF) for each regression (Kline, 2011). The items are presented in Table 5.1. We did not find any extreme multivariate collinearity.

Estimation in SEM with maximum likelihood (ML) assumes multivariate normality. Because it is difficult to assess all aspects of multivariate normality, we inspected the univariate distributions for each item, as this procedure is able to identify multivariate non-normality (Kline, 2011). In general, the items showed a negative skewness and positive kurtosis. Residuals versus predictors plots indicated linearity and homoscedasticity of the data.

Although the items showed a slight departure from normality, we did not expect this to be a problem for model estimation, as ML is fairly robust to violations of the normality assumption (Hair et al., 2010).

5.2.6 Socioeconomic characteristics of the sample

Most of the farmers in the sample were male (92.5 percent) and the average age was 56 years (standard deviation (SD) of 13.6 years). The farmers in the sample were experienced, with a mean experience of 31 years in farming (SD of 15.1 years). The mean farm size, measured as the number of hectares, was 78.8 (SD of 104.2 hectares). In terms of education level, the distribution of the highest level of education achieved by farmers in the sample was as follows: 1.9 percent had no formal schooling, 66.4 percent had incomplete elementary school, 7.9 percent had complete elementary school, 3.7 percent had incomplete high school, 14.5 percent had complete high school, 0.9 percent had an incomplete bachelor degree, 4.2 percent had a complete bachelor degree, and 0.5 percent had postgraduate studies.

5.3 Results

5.3.1 Summary statistics of the measured items

The mean and standard deviation of all the measured items and the correlations between all items are presented in Table 5A.1 in the Appendix 5. In general, farmers showed a positive intention to use improved natural grassland. The four items used to measure INT all had a mean of at least 4.62. The within-construct correlations for the INT items were high; the lowest correlation was 0.71. Farmers demonstrated a strong positive attitude towards the use of improved natural grassland, with all the ATT items having a mean higher than 6.0. The within-construct correlations for ATT items were generally high, varying from 0.57 to 0.75. The inter-construct correlations between the items measuring the INT and ATT constructs varied from 0.36 to 0.44.

Farmers indicated that they perceived a moderately high social pressure to use improved natural grassland. The three items used to measure SN showed a mean of at least 4.29. Within-construct correlations for SN items varied from 0.45 to 0.70. The inter-construct correlations among INT items and SN items were generally high, with just one correlation below 0.4.

Farmers demonstrated a slightly high level of perceived behavioral control over using improved natural grassland. The lowest mean for the items used to measure PBC was 3.94, with all the remaining PBC items having a mean close to 5.0. Within-construct correlations for PBC items were generally high. The lowest within-construct correlation was between PBC_1 and PBC_4, with a value of 0.26. In general, the inter-construct correlations among INT items and PBC items were lower compared with the inter-construct correlations of the INT items with ATT and SN items. The exception was the correlation between PBC_3 and the four INT items, these correlations varied from 0.48 to 0.57.

5.3.2 Measurement model (MM)

The first step in analyzing the MM was to check the convergent validity. The standardized factor loadings are presented in Table 5.2. All standardized factor loadings were significant and had the expected sign. The factor loadings for the INT and ATT items were above the minimum value of 0.7. For the SN items, only SN_3 was slightly below. In the PBC construct, four of the five factor loadings were below 0.7. The only average variance extracted (AVE) that did not exceed the minimum level of 50 percent was for the PBC construct. All construct reliabilities (CR) were above the minimum value of 0.7.

Table 5.2 – Standardized factor loadings for each item with standard errors between brackets, and the average variance extracted (AVE) and construct reliabilities (CR) for each construct in the measurement model (MM)

	INT		ATT		SN		PBC	
	INT_1	0.90 (0.02)	ATT_1	0.73 (0.04)	SN_1	0.91 (0.02)	PBC_1	0.61 (0.05)
	INT_2	0.90 (0.02)	ATT_2	0.84 (0.03)	SN_2	0.77 (0.03)	PBC_2	0.62 (0.05)
	INT_3	0.86 (0.20)	ATT_3	0.84 (0.03)	SN_3	0.68 (0.04)	PBC_3	0.87 (0.03)
	INT_4	0.82 (0.03)	ATT_4	0.86 (0.02)			PBC_4	0.64 (0.05)
							PBC_5	0.69 (0.04)
AVE (%)	75.7		66.9		62.7		47.7	
CR	0.92		0.89		0.83		0.82	

The second step was to assess discriminant validity. The correlations among the latent constructs and the squared correlations are presented in Table 5.3. All correlations among latent constructs were significant and larger than 0.5. To ensure discriminant validity the average variance extracted (AVE) for each construct should be greater than the squared inter-construct correlations associated with that construct. This test revealed a problem with the PBC construct, given that the squared correlation between PBC and SN was 0.54 and the AVE for the PBC construct was 0.47 (47.7 percent). This problem was addressed by re-estimating the MM, as explained in Section 5.3.3.

Table 5.3 – Latent construct correlation matrix of the measurement model (MM)

	INT	ATT	SN	PBC
INT	1	*0.30*	*0.50*	*0.41*
ATT	**0.54**	1	*0.29*	*0.33*
SN	**0.71**	**0.54**	1	*0.54*
PBC	**0.64**	**0.58**	**0.73**	1

Diagonal elements are construct variances; values in bold (below the diagonal) are correlations among the latent constructs; values in italic (above the diagonal) are squared inter-construct correlations. All correlations (in bold) among constructs were significant at $p = 0.001$.

The third step was to test the validity of the MM. The GOF statistics enable us to check whether the theory fits the data (Hair et al., 2010). The sample data are represented by the observed covariance matrix of the measured items, and the theory is represented by the estimated covariance matrix of the proposed MM (Hair et al., 2010). The GOF statistics shown in Table 5.4 compare the two covariance matrices.

The null hypothesis in the Chi-square (χ^2) test states that the observed covariance matrix is equal to the estimated covariance matrix. The χ^2 was 214.22 and the p value associated with this result was 0.0001. Thus, the null hypothesis was rejected, implying that the observed covariance matrix does not match the estimated covariance matrix. However, given the problems associated with using this test alone, other GOF statistics must also be analyzed (Hair et al., 2010).

The RMSEA was below the maximum threshold value of 0.08. However, the 90 percent confidence interval for RMSEA was slightly above the threshold of 0.08. The CFI and TLI were slightly below the minimum threshold value of 0.95 and the SRMR was well below the maximum threshold value of 0.08.

Table 5.4 – Overall goodness-of-fit (GOF) statistics of the measurement model (MM)

Fit statistics	Value
Chi-square (χ^2)	214.220 (p = 0.0001)
Degrees of freedom	102
Root mean square error of approximation (RMSEA)	0.074
90 percent confidence interval for RMSEA	0.061 – 0.088
Comparative fit index (CFI)	0.946
Tucker-Lewis index (TLI)	0.934
Standardized root mean squared residual (SRMR)	0.049

The last step was to check the diagnostic measures. Tables with the standardized residuals and modification indices are not presented in this paper, due to space limitations. In general, two standardized residuals were problematic, between INT_1 and INT_2 and between PBC_4 and PBC_5. The modification indices showed that the model could be improved by allowing correlations among the errors terms of the PBC items.

In summary, the results of the construct validity, the goodness-of-fit (GOF) statistics, and the diagnostic measures suggest that the MM could be improved, especially in the PBC construct. Therefore, we decided to re-specify and re-estimate the MM.

5.3.3 Re-specified measurement model[10](rMM)

The MM was re-estimated after eliminating the items PBC_1 and PBC_5. These two items were eliminated because they had factor loadings smaller than 0.7 and the modification indices suggested that the MM could be improved by focusing on these two items. We preferred to eliminate the items instead of allowing a correlation among the errors terms of

[10] In the re-specified MM, the total number of unique variance and covariance was 105. In total, there were 30 parameters to be estimated, consisting of 10 factor loadings of the items (each first item was used as a normalizing constraint with a value of 1), 14 error terms of the items, and 6 covariance terms among the latent constructs. Therefore, the MM was over identified, with 75 degrees of freedom.

the PBC construct, as this action would seriously question the construct validity (Hair et al., 2010).

The standardized factor loadings of the rMM are presented in Table 5.5. The factor loadings for the INT, ATT, and SN constructs, as well as their AVE and CR, did not change. In the PBC construct, the factor loadings for the items PBC_2 and PBC_4 were still below the minimum value of 0.7. However, the average variance extracted (AVE) slightly exceeded the minimum level of 50 percent. The construct reliability (CR) for the PBC construct decreased, but it was still above the 0.7 ideal value. Taken together, these results suggest convergent validity of the rMM.

Table 5.5 – Standardized factor loadings for each item with standard errors between brackets, and the average variance extracted (AVE) and construct reliabilities (CR) for each construct in the re-specified measurement model (rMM)

	INT		ATT		SN		PBC	
	INT_1	0.90 (0.02)	ATT_1	0.73 (0.04)	SN_1	0.91 (0.02)	PBC_2	0.57 (0.05)
	INT_2	0.90 (0.02)	ATT_2	0.84 (0.03)	SN_2	0.77 (0.03)	PBC_3	0.94 (0.03)
	INT_3	0.86 (0.20)	ATT_3	0.84 (0.03)	SN_3	0.68 (0.04)	PBC_4	0.59 (0.05)
	INT_4	0.82 (0.03)	ATT_4	0.86 (0.02)				
AVE (%)	75.7		66.9		62.7		51.9	
CR	0.92		0.89		0.83		0.75	

The correlations among the latent constructs and the squared correlations for the rMM are presented in Table 5.6. All correlations among latent constructs were significant at the 5 percent critical level and larger than 0.5. Compared to the MM, the only correlations expected to change were the ones with the PBC construct. The correlation between INT and PBC remained the same as in the MM. On the other hand, the correlations between ATT and PBC and between SN and PBC decreased a little. In the rMM the average variance extracted (AVE) for PBC was slightly greater than the squared inter-construct correlations associated with that construct. Therefore, these results suggest discriminant validity of the model.

Table 5.6 – Latent construct correlation matrix of the re-specified measurement model (rMM)

	INT	ATT	SN	PBC
INT	1	*0.30*	*0.50*	*0.41*
ATT	**0.54**	1	*0.29*	*0.32*
SN	**0.71**	**0.54**	1	*0.51*
PBC	**0.64**	**0.57**	**0.72**	1

Diagonal elements are construct variances; values in bold (below the diagonal) are correlations among the latent constructs; values in italic (above the diagonal) are squared inter-construct correlations. All correlations (in bold) among constructs were significant at $p = 0.001$.

The null hypothesis in the Chi-square (χ^2) test was still rejected. The χ^2 of the rMM was 111.798 and the p value associated with this result was 0.0001. However, the other GOF statistics presented in Table 5.7 confirmed the model had improved.

Table 5.7 – Overall Goodness-of-Fit (GOF) Statistics of the Re-specified Measurement Model (rMM)

Fit statistics	Value
Chi-square (χ^2)	117.798 ($p = 0.0001$)
Degrees of freedom	75
Root mean square error of approximation (RMSEA)	0.055
90 percent confidence interval for RMSEA	0.037 – 0.073
Comparative fit index (CFI)	0.975
Tucker-Lewis index (TLI)	0.969
Standardized root mean squared residual (SRMR)	0.042

Tables with the standardized residuals and the modification indices for the rMM are not presented in this paper, due to space limitations. One standardized residual between INT_1 with INT_2 was still problematic. However, given the other tests, we decided to keep these items in the model. The modifications indices showed that the model would be improved by allowing covariance among items belonging to different constructs. However, allowing for this covariance, would violate the validity of the rMM.

5.3.4 Structural model (SM)

After obtaining the rMM, we estimated a SM to test the hypotheses underlying the TPB. The results for the SM are presented in Table 5.8. The regression coefficient of ATT on INT was positive and significant, and we therefore did not reject hypothesis H_1: Attitude has a positive influence on farmers' intention. The regression coefficient of SN on INT was also positive and significant, and we therefore did not reject hypothesis H_2: Subjective norm has a positive influence on farmers' intention. Moreover, the regression coefficient of PBC on INT was also positive and significant. This result meant that hypothesis H_3: Perceived behavioral control has a positive influence on farmers' intention, was not rejected. Together, ATT, SN, and PBC explained 66 percent of the variance in INT. The relative sizes of the regression coefficients indicated that SN was the main determinant of INT.

Table 5.8 compares the structural relations of the SM with the correlational relations of the rMM. The high correlation between SN and INT in the rMM was similar to the magnitude of the structural relation in the SM. However, the high correlation between ATT and INT was not confirmed by a structural relation of a similar magnitude. The dissimilarity between the results of the rMM and SM can be explained in the following way. Firstly, there is a high correlation between ATT and SN. This means that when SN increases, ATT also increases and vice versa. Secondly, the correlation between SN and INT is higher than the correlation between ATT and INT. If both these situations occur, then the SM estimates a higher regression coefficient for the structural relation SN and INT. This same pattern explains why the high correlation between PBC and INT in the rMM was not confirmed by a structural relation of a similar magnitude in the SM. In this case, the explanation is the high correlation between SN and PBC, combined with the lower correlation between PBC and INT compared to the SN and INT correlation. This correlation means that when SN is high, PBC is also high and vice versa.

Table 5.8 – Results of the structural model (SM) and comparison with the re-specified measurement model (rMM)

Structural model (SM)			Re-specified measurement model (rMM)		
Structural relations	Standardized parameter	*p* (value)	Correlational relations	Standardized parameter	*p* (value)
ATT→INT	0.18	.010	ATT correlated INT	0.54	.000
SN→INT	0.47	.000	SN correlated INT	0.71	.000
PBC→INT	0.20	.033	PBC correlated INT	0.64	.000
ATT correlated SN	0.54	.000	ATT correlated SN	0.54	.000
ATT correlated PBC	0.57	.000	ATT correlated PBC	0.57	.000
SN correlated PBC	0.72	.000	SN correlated PBC	0.72	.000

5.4. Discussion and concluding comments

5.4.1 Effect of TPB constructs on the intention of Brazilian cattle farmers to adopt improved natural grassland

Our results showed that the TPB constructs, attitude, subjective norm, and perceived behavioral control, positively affect the intention of Brazilian cattle farmers to use improved natural grassland. The regression coefficients of the SM indicated that the effects of attitude, subjective norm, and perceived behavioral control on farmers' intention were asymmetrical. In particular, the findings revealed that subjective norm had a larger influence than attitude and perceived behavioral control on farmers' intention to use improved natural grassland. This result illustrates the important role of social pressure and the opinions of others in Brazilian farmers' intentions. Martínez-García et al. (2013) explained that farmers may value the opinion of others because they seek approval or because they want to show commitment to values shared within their culture. Burton (2004) pointed out that individuals do not act independently of cultural and social influences, but are continually referring their behavior to an important reference group. Therefore, social pressure may motivate farmers to adopt an innovation, even if farmers have a negative attitude towards the behavior (Borges et al., 2014b).

Although subjective norm was the main determinant, attitude also influenced farmers' intention. That is, farmers' positive attitude towards improved natural grassland strengthened their intentions to use this innovation on their farms. Garforth et al. (2006) found the opposite effect in their study of English farmers' decisions on the use of techniques to improve oestrus detection in dairy herds. Their results, based on correlations, showed that attitude had a larger influence on intentions than subjective norm. This may be explained by the difference in cultures. Some cultures have a more collective tradition, which seems to be the case in Brazil, placing greater emphasis on the influence and opinion of other people, whereas other cultures have a more individualistic orientation (Ivancevich et al., 2005). Moreover, perceived behavioral control was also found to influence farmers' intention. That is, farmers' positive perceptions that they have the capability to implement this practice reinforce their intention.

The high correlations between the TPB constructs revealed that social pressure (subjective norm) was also positively associated with farmers' attitude and perceived behavioral control. Although the results are based on correlations, which do not allow us to confirm causality, it is likely that when social pressure (subjective norm) increases, farmers' attitude will also increase, meaning that farmers will evaluate the use of improved natural grassland as more favorable. Indeed, Han et al. (2010) found that social pressure had a positive influence on the formation of customers' attitude to visit a 'green' hotel. Likewise, it is likely that when social pressure (subjective norm) increases, farmers will perceive that they have a higher capability (perceived behavioral control) to use improved natural grassland on their farms.

These results provide insights that can be helpful to policy makers. The large effect of the subjective norm suggests that, in order to increase farmers' intention to use improved natural grassland in biome *Pampa*, it could be effective for governmental agencies and extension agents to explore opportunities to increase social pressure on farmers. For instance, extension agents could focus not only on disseminating information about this practice to farmers, but also to their families and the community. We expect that this strategy would lead to a direct and indirect increase in farmers' intention to use improved natural grassland. The direct impact occurs because if family and community members have more information about improved natural grassland, they are then more likely to increase social pressure on farmers to adopt. The indirect impact occurs because if farmers perceive a high social pressure on them to adopt this innovation, they are more likely to evaluate the innovation positively (attitude) and perceive that they have a higher capability (perceived behavioral control) to use it on their farms.

Although subjective norm had the largest effect on intention, our results also showed that attitude and perceived behavioral control had smaller positive effects on farmers' intention to adopt improved natural grassland. It is therefore expected that interventions designed to reinforce the favorable outcomes of improved natural grassland or increase farmers' capability to use this innovation, will also lead to higher levels of intention. A possible intervention is the practical demonstration of this innovation in the field, reinforcing the benefits of improved natural grassland and showing how to apply it in practice.

5.4.2 Applicability of the TBP framework for understanding the adoption of sustainable innovations in agriculture

Our results showed that the TBP is an appropriate framework, and the SEM an appropriate methodology, to study the adoption of sustainable innovations in agriculture. In the rMM, the latent constructs intention, attitude, subjective norm, and perceived behavioral control were reliably represented by the measurable items, especially the items for intention, attitude, and subjective norm. To obtain the satisfactory rMM, two items of the perceived behavioral control construct were excluded, because they had low factor loadings and large standardized residuals. An alternative approach to improve the MM without deleting the items, would be to allow for correlations among the errors terms of the perceived behavioral control items. Indeed, this approach was already used by other authors (Wang and Ritchie, 2012). However, allowing for correlation between errors terms could violate the assumption of good measurement (Hair et al., 2010).

The three constructs, attitude, subjective norm, and perceived behavioral control, had a strong predictive power for farmers' intention. This also indicates the applicability of the TPB to the domain of the adoption of sustainable innovations in agriculture. Our SM explained 66 percent of the variance in farmers' intention. Contrary to the results of Yazdanpanah et al. (2014), who did not find a significant effect of the PBC construct on farmers' intention regarding water conservation, our findings provide support for the TPB as a whole. That is, the SM did not reject the three hypotheses that the constructs attitude, subjective norm, and perceived behavioral control positively affect intention. In other domains, studies also validated the entire TPB model. For instance, Han et al. (2010), using SEM, also found that attitude, subjective norm, and perceived behavioral control explained customers' intention to stay at a 'green' hotel.

Because our research focused on the biome *Pampa* in Rio Grande do Sul, Brazil, the implications for policy makers and extension agents do not necessarily generalize to other regions. However, our results showed that the TPB is appropriate for studying farmers' intention to adopt a sustainable innovation, suggesting that future research could use this approach to study other sustainable innovations. It would be interesting to explore whether the effect of social pressure on intention found in this research also occurs in different countries and cultures. The theory and methodology could also be used to study the management of other environmental resources, such as watersheds, wetlands, and protection of landscapes with cultural value.

The analysis of indirect TBP measures is an additional research step that would improve the understanding of farmers' adoption behavior. The TPB assumes that attitude, subjective norm, and perceived behavioral control originate from behavioral, normative, and control beliefs, respectively (Hansson et al., 2012). Exploring the indirect measures would provide an understanding of which underlying beliefs are important and this information is useful for designing interventions (Bleakley and Hennessy, 2012). For instance, it would be possible to determine which groups of people have the most social pressure on farmers. This additional analysis could help policy makers to customize interventions even further, and therefore increase the efficacy of interventions.

Acknowledgment

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Appendix 5

Table 5A.1 – Mean, standard deviation (SD), and correlations of the measured items

	INT_1	INT_2	INT_3	INT_4	ATT_1	ATT_2	ATT_3	ATT_4	SN_1	SN_2	SN_3	PBC_1	PBC_2	PBC_3	PBC_4	PBC_5
INT_1	1															
INT_2	0.82	1														
INT_3	0.77	0.77	1													
INT_4	0.71	0.73	0.73	1												
ATT_1	0.41	0.40	0.43	0.41	1											
ATT_2	0.41	0.36	0.38	0.36	0.66	1										
ATT_3	0.42	0.37	0.37	0.38	0.57	0.69	1									
ATT_4	0.42	0.38	0.41	0.44	0.58	0.71	0.75	1								
SN_1	0.57	0.57	0.57	0.51	0.43	0.33	0.42	0.39	1							
SN_2	0.51	0.47	0.45	0.47	0.40	0.36	0.45	0.50	0.70	1						
SN_3	0.44	0.46	0.45	0.38	0.27	0.16	0.28	0.24	0.64	0.45	1					
PBC_1	0.29	0.26	0.35	0.35	0.31	0.24	0.30	0.34	0.35	0.30	0.25	1				
PBC_2	0.30	0.31	0.32	0.24	0.22	0.15	0.18	0.22	0.33	0.31	0.31	0.51	1			
PBC_3	0.57	0.48	0.55	0.50	0.45	0.44	0.44	0.46	0.60	0.58	0.46	0.52	0.54	1		
PBC_4	0.36	0.32	0.35	0.37	0.32	0.29	0.27	0.32	0.35	0.42	0.37	0.26	0.38	0.54	1	
PBC_5	0.36	0.36	0.43	0.34	0.37	0.29	0.31	0.36	0.42	0.51	0.31	0.50	0.43	0.54	0.59	1
Mean	4.86	4.89	4.62	4.73	6.27	6.28	6.02	6.25	5.25	5.33	4.29	4.99	3.94	4.87	4.99	5.00
SD	1.75	1.73	1.76	1.83	0.95	0.91	1.12	1.01	1.47	1.48	1.60	1.58	1.70	1.50	1.84	1.59

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Chapter 6

General discussion

J. A. R. Borges

6.1 Introduction

Beef production on natural grasslands potentially allows for sustainable development in biome Pampa, Rio Grande do Sul (RS), Brazil. However, cattle farmers have managed the natural grasslands using practices that result in overgrazing, low productivity and low farm income. Farmers in the region converted natural grasslands from beef production into more profitable activities, such as cash crops. As this conversion and overgrazing have caused environmental problems in biome Pampa, farmers have been stimulated by the government, extension services and research centers to use livestock innovations that increase beef productivity without damaging the environment. However, the adoption rate of these innovations is still low. One of the available innovations is improved natural grassland. The overall objective of this research was to explore factors determining cattle farmers' intention to adopt improved natural grassland in the biome Pampa, Rio Grande do Sul, Brazil. This research uses the theory of planned behavior (TPB) to understand the underlying psychological constructs that influence farmers' adoption decisions.

The overall objective was split into four specific objectives. Chapter 2 provided an overview of variables that have been used in the literature to understand farmers' decision to adopt an innovation and the influence of these variables on the adoption decision. Variables are identified by reviewing studies based on utility maximization and the theory of planned behavior. Chapter 3 identified the role of attitude, subjective norm, and perceived behavioral control in the intention of farmers to use improved natural grassland and identifies the role of farmers' beliefs as drivers of their attitude, subjective norm, and perceived behavioral control. Chapter 4 identified groups of farmers with different levels of intention to use improved natural grassland and analyzes whether the differences in the level of farmers' intention are associated with socio-psychological factors, socioeconomic characteristics, goals, and relative risk attitude. Chapter 5 determined the effect of attitude, subjective norm, and perceived behavioral control on the intention of Brazilian cattle farmers to use improved natural grassland.

6.2 Theoretical issues

In this study, the theory of planned behavior (TPB) was used to explore factors determining cattle farmers' intention to adopt improved natural grassland. This theory has been used in studies on agriculture to improve the understanding of the factors that influence farmers' decisions (Edward-Jones, 2006). Furthermore, the TPB is useful because its provide a structured and theoretically rational, replicable methodology and it can identify the underlying causes of farmers' intentions (Beedell and Rehman, 2000).

However, the focus only in TPB constructs brings along limitations for this thesis. One important theoretical issue that was not considered in this thesis was the role of past behavior. Although in the questionnaire applied to our sample there were questions to measure past behavior, such as if farmers were already using improved natural grassland as well as their experience with this innovation, these variables could not be included in the analysis, because farmers' responses were inconsistent. A measure of past behavior could have added to this thesis, because previous TPB studies found that past behavior better predicts future behavior than a measure of intention (Sheeran, 2002).

Another issue that was not considered in this thesis is the dynamic process of the decision to adopt. The TPB constructs are snap-shots of the farmers' intention in time (Beedell and Rehman, 2000). As farmers' intention to use improved natural grassland were measured for next year, the ideal approach would be to apply another survey one year later among the same farmers to analyze whether farmers who showed intention to adopt the innovation do really use it on their farms. A research with time series data would also show whether attitudes, subjective norm and perceived behavioral control change over time.

Another limitation is that the measurement of the TPB constructs is open to acquiescence biases, which is the tendency of respondents to agree with statements regardless their content. (Beedell and Rehman, 2000).

6.3 Methodological issues

The methodology used in Chapter 3 did not enable testing all hypotheses underlying the TPB. That is, using correlations, it was only possible to assess the relation between one psychological construct and intention at a time. Therefore, the relative importance of attitude, subjective norm, and perceived behavioral control could not be assessed using the methodology of Chapter 3. These issues were taken into account in Chapter 5, where structural equation modeling (SEM) was used. SEM enabled assessing the relative importance of attitude, subjective norm and perceived behavioral control on intention, overcoming the shortcoming of Chapter 3. In addition, SEM allowed to check for the covariance between attitude, subjective norm and perceived behavioral control, which is an advantage over the methodologies used in Chapter 3 and Chapter 4, where these constructs were assumed to be independent from each other.

Another methodological challenge in this thesis was to reliably represent the constructs. That is, how to assure that the items used to measure intention, attitude, subjective norm and perceived behavioral control ‘truly’ represent these latent constructs. One way is by requiring construct validity, which is the extent to which a set of measured items actually reflects the theoretical latent construct those items are designed to measure (Hair et al., 2010). Two components of construct validity are: convergent validity and discriminant validity. When items used to measure a single construct share a high proportion of variance, then there is convergent validity (Hair, et al., 2010). Discriminant validity is the extent to which a construct is truly distinct from other constructs (Hair et al, 2010). In Chapter 3 and Chapter 4, the constructs intention, attitude, subjective norm and perceived behavioral control were represented by the means of the indicators that were used to measure them. To check the reliability of the scales, Cronbach’s alpha was used. However, Cronbach’s alpha is only one way among others to check reliability, and reliability is only one of the indicators of convergent validity. Therefore, convergent validity was only partially checked in Chapter 3 and Chapter 4. Other ways of assuring convergent validity are available when confirmatory factor analysis is used. In addition, in Chapter 3 and Chapter 4, discriminant validity was not assessed. These issues were considered in Chapter 5, where confirmatory factor analysis (CFA) was used to test whether the measurable items reliably represented the constructs intention, attitude, subjective norm and perceived behavioral, assuring convergent and discriminant validity. In addition, CFA eliminated the need to summate scales and use the mean to represent a construct, because SEM computes latent construct scores for each respondent (Hair et al., 2010).

Given these advantages, SEM is a more suitable technique for analyzing TPB data than correlations. However, SEM is very demanding in terms of sample size. Therefore, given the relatively small size of the sample used in this study, it was not possible to include beliefs in the SEM model. The role of beliefs was assessed in Chapter 3 and Chapter 4.

In Chapter 4, cluster analysis enabled testing whether farmers differ in their levels of intention to use improved natural grassland, and if they differ, which factors explain this difference. This is an advantage of the methodology used in Chapter 4 compared to the methodologies in Chapter 3 and Chapter 5, where farmers were assumed to be a homogeneous group regarding their intention to use improved natural grassland. Previous studies have used a similar approach, but researchers have used an arbitrary cut-off value to divide groups of farmers with different levels of intention. For instance, Fielding et al. (2005) divided farmers in groups with strong and weak intention to use an innovation by using a median split. That is, farmers who had values for intention questions below the median were classified as farmers with weak intention and the farmers who had values for intention above the median were classified as farmers with strong intention. The approach in Chapter 4 is different and overcame the shortcoming of using an arbitrary cut-off value. Based on theory, it was assumed that farmers have higher intention if they have higher attitude, higher subjective norm and higher perceived behavioral control. Therefore, attitude, subjective norm and perceived behavioral control were used as grouping variables in a cluster analysis and intention was used as a confirmatory variable to check whether the identified groups of farmers in the cluster analysis indeed differ in their level of intention.

In Chapter 5, we assumed that the errors terms of the items used to measure the TPB constructs were uncorrelated. However, if a farmer is already engaged in the use of improved natural grassland, his or her experience with the innovation may have increased the farmer's intention to use it in the next year, as well as the farmer's attitude towards the use of the innovation. In this case, the errors terms of the items used to measure intention and attitude would not be uncorrelated, resulting in endogeneity.

6.4 Synthesis of results

This section synthesizes the results of the thesis presented in Chapters 2 to 5.

Using different methodologies Chapters 3 and 5 confirmed the initial TPB hypothesis that farmers' intention to use improved natural grassland is influenced by the three TPB psychological constructs: farmers' evaluation of the use of improved natural grassland (attitude), their perceptions about the social pressure to use this innovation (subjective norm), and their perceptions about their own capability to use this innovation (perceived behavioral control). Chapter 3 showed that the highest correlation was between intention and subjective norm, followed by intention and perceived behavioral control and intention and attitude. The same pattern was found in Chapter 5, where the regression coefficients of the structural model revealed that the intention of farmers to use improved natural grassland was mainly determined by subjective norm, followed by perceived behavioral control and attitude. These results illustrate the important role of social pressure and the opinions of others in Brazilian farmers' intentions to adopt improved natural grassland. Farmers may value the opinion of others because they seek approval or because they want to show commitment to values shared within their culture. Burton (2004) pointed out that individuals do not act independently of cultural and social influences, but are continually referring their behavior to an important reference group. Therefore, social pressure may motivate farmers to adopt an innovation, also if farmers have a negative attitude towards the behavior. In contrast, Garforth et al. (2006), in a study of English farmers' decisions on the use of techniques to improve oestrus detection in dairy herds, found that attitude had a larger influence on intentions than subjective norm. This may be explained by the cultural differences between Brazil and the UK. Some cultures have a more collective tradition, which seems to be the case in Brazil, placing greater emphasis on the influence and opinion of other people, whereas other cultures have a more individualistic orientation (Ivancevich et al., 2005).

In Chapter 5, the high correlations between the TPB constructs revealed that social pressure (subjective norm) was positively associated with farmers' attitude and perceived behavioral control. It is likely that when social pressure (subjective norm) increases, farmers' attitude will also increase. This means that farmers will evaluate the use of improved natural grassland more favorably. Also Han et al. (2010) found that social pressure had a positive influence on the formation of customers' attitude to visit a 'green' hotel. Likewise, it is likely that when social pressure (subjective norm) increases, farmers will perceive that they have a higher capability (perceived behavioral control) to use improved natural grassland on their farms.

Results from Chapter 2 showed that different studies measured TPB psychological constructs in different ways. These results confirmed Burton's (2004) argument that in many TPB studies it is doubtful whether researchers actually measure the TPB constructs. To overcome the measurement issues, the questionnaire applied to our sample was designed following the recommendations of Fishbein and Ajzen (2010), the authors who developed TPB. In addition, Burton (2004) pointed out that most studies that use the TPB to study farmers' decisions and behaviors focused only on attitude, and did not measure subjective norm and perceived behavioral control. This issue was also considered in designing the questionnaire to collect data about these two constructs. It was found then that subjective norm and perceived behavioral control were more important than attitude in influencing farmers' intention to use improved natural grassland (Chapter 5).

Results of Chapter 3 were in line with the results of the review in Chapter 2, i.e. in TPB studies, correlations between the psychological constructs are significant in most cases. One reason that may explain this result is that most of the questions used to measure the TPB constructs are similar; for example questions used to measure intention are similar to the questions used to measure attitude. As a result, positive correlation among TPB constructs is very likely *a priori*.

In Chapter 3, the drivers of attitude, subjective norm and perceived behavioral control were identified. Farmers evaluate improved natural grassland more positively (attitude) the more likely and more important they believe that this innovation allows them to increase number of animals per hectare, to have pasture available throughout the year, to increase pasture resistance, to decrease feeding costs, to prevent soil erosion, and to increase the weight of the cattle. These are the behavioral beliefs that drive attitude. Farmers perceive a higher social pressure (subjective norm) upon them to use improved natural grassland the more likely they believe that family, friends, neighbor farmers, cattle traders, workers in the place where they buy their inputs, extension agents, and government support them in their decision to adopt and the more they evaluate the opinion of these groups of people. These are normative beliefs that drive subjective norm. Farmers perceive that they have a higher capability (perceived behavioral control) to use improved natural grassland the more likely and the more strongly they believe that they have sufficient knowledge about the innovation, have sufficient skills to deal with this practice and have access to qualified technical assistance. These are the control beliefs that drive perceived behavioral control.

Chapter 3 and 5 did not investigate differences in the level of intention between groups of farmers and the possible factors that could explain these differences. Chapter 4 used cluster analysis to identify groups of farmers with different levels of intention to use improved natural grassland. Results suggested two groups of farmers: farmers that were willing and farmers that were unwilling to use improved natural grassland. Results showed that compared to unwilling farmers, willing farmers evaluated the use of improved natural grassland on their farms more favorably (attitude), they felt a greater social pressure to adopt this innovation (social norm), and they reported a higher capability (perceived behavioral control) to use improved natural grassland. Willing and unwilling farmers also differed in terms of their behavioral, normative, and control beliefs. The two groups did not differ in most socioeconomic characteristics, but did differ in their goals and relative risk attitudes. Willing farmers had higher economic/social and status goals, and were intrinsically motivated to use improved natural grassland. Unwilling farmers had a higher self-reported risk aversion than willing farmers. A result of Chapter 4 that is complementary to results on Chapter 3 is that ‘availability of governmental credit’ was an important control belief for unwilling farmers. This control belief was not correlated to perceived behavioral control on Chapter 3. This result suggests that the intention of unwilling farmers to adopt improved natural grassland could be increased by the governmental provision of credit.

A general result of the research chapters in this thesis is that more than 50% of the respondents showed a positive intention to use improved natural grassland on their farms next year. This result seems to contradict the low adoption rate of this innovation in the region. Several reasons may explain this apparent contradiction. Firstly, as explained in section 6.2, we measured farmers' intention to use improved natural grassland next year. Secondly, the theory of planned behavior assumes that intentions are the most important predictor of behavior; however this theory also recognizes that people may not always have sufficient control over performing the behavior to actually enact their intentions (Ajzen, 1991). Therefore, farmers may have the intention to use improved natural grassland, but still do not adopt it in practice. A third reason is that certain behaviors are more likely to be controlled by "habits" than by conscious intentions (Triandis, 1980). Hence, farmers may have intention to adopt an innovation, but they do not adopt it because they keep doing the way that they usually do.

6.5 Policy implications

Results in Chapters 4 and 5 show that it could be effective for governmental agencies and extension agents to explore opportunities to increase social pressure (subjective norm) on farmers. For instance, extension agents could focus not only on disseminating information about this practice to farmers, but also to their families and the community (according to results in Chapter 4 and 5). In Chapter 5, results suggest that this strategy would lead to a direct and indirect increase in farmers' intention to use improved natural grassland. The direct impact occurs when family and community members have more information about improved natural grassland, in which case they are more likely to increase social pressure on farmers to adopt. The indirect impact occurs when farmers perceive a high social pressure on them to adopt this innovation, in which case they are more likely to evaluate the innovation positively (attitude) and perceive that they have a higher capability (perceived behavioral control) to use it on their farms. Results in Chapter 4 also suggest that this strategy would lead to a direct and indirect increase in farmers' intention to use improved natural grassland. The direct impact occurs because farmers are motivated to comply with the opinion of extension agents. The indirect impact occurs because family members that have more information about improved natural grassland are more likely supporting farmers in their decision to adopt. Results in Chapter 3 suggest that family, friends, neighbor farmers, cattle traders, workers in the place where farmers buy their inputs, extension agents, and government could be used as channels to disseminate information about this practice to the farmers.

Results in Chapter 5 also show that interventions designed to emphasize the outcomes of using improved natural grassland or increase farmers' capability to use this innovation, lead to a higher intention of farmers to adopt improved natural grassland. Results of Chapter 3 suggest that informing farmers that improved natural grassland allows them to (1) increase number of animals per hectare, (2) to have pasture available throughout the year, (3) to increase pasture resistance, (4) to decrease feeding costs, (5) to prevent soil erosion, and (6) to increase the weight of the cattle, could increase their intention to use this innovation. Results in Chapter 3 also suggest that when farmers intention to use improved natural grassland is higher when they believe that they have sufficient knowledge about improved natural grassland, sufficient skills to deal with this innovation, and access to qualified technical assistance. A possible intervention is the practical demonstration of this innovation in the field, reinforcing the benefits of improved natural grassland and showing how to apply it in practice.

6.6 Future research

This thesis focused on the psychological factors that influence farmers' decisions to adopt an innovation. However, psychological factors are only a single category of variables that influence farmers' adoption decisions. Edward-Jones (2006) pointed out that there are at least five sets of variables that impinge on farmers' decisions: farmer characteristics, household characteristics, farm structure, the wider social environment and the characteristics of the innovation to be adopted. Hence, future research should consider potential interactions among variables in these groups and the TPB constructs. For instance, based on utility maximization studies, results in Chapter 2 suggest variables that could improve the understanding of farmers' adoption decision, such as the risk associated with an innovation, and the degree of risk-aversion of the decision maker. Such an integrated approach would add to the complexity of the research, but could improve the understanding of the factors influencing farmers' adoption decision. For this purpose, an extension of the TBP, called the reasoned action approach provides a suitable framework (Fishbein and Ajzen, 2010). In addition to the TPB variables, the reasoned action approach considers background factors, such as the socioeconomic characteristics of the decision-maker. The idea behind this theory is that background factors affect the TPB psychological constructs.

On the basis of latest scientific findings, this thesis assumed that improved natural grassland increases productivity at farm level. However, the actual increase at farm level was not measured. In addition, the profitability of this innovation was not considered. Future research can study the actually observed contribution of improved natural grassland to productivity and profitability at farm level.

A promising direction for future research on farmers' decisions and behaviors is also to collect data in a controlled environment, such as a laboratory. This method of collecting data allows researchers to manipulate variables, which can point to causes of farmers' decisions and behaviors.

Results in Chapter 3 showed the behavioral, normative and control beliefs that are the drivers of farmers' attitude, subjective norm and perceived behavioral control. However, correlations only allow for assessing one the relation between a belief and its respective psychological construct at a time. Furthermore, the relative importance of each belief on influencing attitude, subjective norm, and perceived behavioral control could not be assessed using the methodology of Chapter 3. The in-depth analysis of beliefs, similar to the methodology used in Chapter 5, is an additional research step that would improve the understanding of farmers' adoption behavior. Exploring the beliefs would provide an understanding of which underlying beliefs are important and this information is useful for designing interventions (Bleakley and Hennessy, 2012). For instance, it would be possible to determine which groups of people put the highest social pressure on farmers.

6.7 Main conclusions

The main conclusions of this thesis are:

- Explanatory variables used in utility maximization studies mostly have an insignificant effect on the adoption decision, and when the effects are significant, the sign of the effect is inconsistent across studies (Chapter 2).
- Correlations between the variables used in TPB studies are significant in most cases, but the variables are operationalized differently across studies (Chapter 2).
- Farmers evaluate improved natural grassland more positively (attitude), the more likely and more importantly they believe that this innovation allows them to increase the number of animals per hectare, to have pasture available throughout the year, to increase pasture resistance, to decrease feeding costs, to prevent soil erosion, and to increase the weight of the cattle (Chapter 3).
- Farmers perceive a higher social pressure (subjective norm) upon them to use improved natural grassland the more likely they believe that family, friends, neighbor farmers, cattle traders, workers in the place where they buy their inputs, extension agents, and government support them in their decision to adopt and the more they evaluate the opinion of these groups of people (Chapter 3).
- Farmers perceive that they have a higher capability (perceived behavioral control) to use improved natural grassland the more likely and the more strongly they believe that they have sufficient knowledge about the innovation, have sufficient skills to deal with this practice and have access to qualified technical assistance (Chapter 3).

- Farmers that are willing to use improved natural grassland on their farms evaluated this innovation more favorably (attitude), felt a greater social pressure to use this innovation (social norm), and reported a higher capability (perceived behavioral control) to use improved natural grassland than farmers that were unwilling to use this innovation (Chapter 4).
- Farmers that are willing to use improved natural grassland had a lower risk aversion, higher economic/social and status goals, and were more intrinsically motivated to use improved natural grassland than farmers that were unwilling to use this innovation (Chapter 4).
- Intention of farmers to use improved natural grassland is mainly determined by their perceptions about the social pressure to use this innovation (subjective norm), followed by their perceptions about their own capability (perceived behavioral control) to use this innovation, and their evaluation of the use of improved natural grassland (attitude) (Chapter 3 and 5).
- Social pressure (subjective norm) is positively correlated with farmers' perceptions about their own capability to use improved natural grassland (perceived behavioral control), and their evaluation of the use of this innovation (attitude) (Chapter 5).

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Summary

Beef production under natural grasslands potentially allows for sustainable development in biome Pampa, Rio Grande do Sul (RS), Brazil. However, cattle farmers have managed the natural grasslands using practices that result in overgrazing, low productivity and low farm income. Farmers in the region converted natural grasslands from beef production into more profitable activities, such as cash crops. As this conversion and overgrazing have caused environmental problems in biome Pampa, farmers have been stimulated by the government, extension services and research centers to use livestock innovations that increase beef productivity without damaging the environment. However, the adoption rate is still low. One of the available innovations is improved natural grassland. The overall objective of this research was to explore factors determining cattle farmers' intention to adopt improved natural grassland in the biome Pampa, Rio Grande do Sul, Brazil. This research uses the theory of planned behavior (TPB) to understand the underlying psychological constructs that influence farmers' adoption decisions. The TPB hypothesizes that the adoption of an innovation is driven by the intention to use it, which in turn is determined by three socio-psychological constructs: attitude, subjective norm, and perceived behavioral control. These constructs are derived from behavioral, normative and control beliefs, respectively. The overall objective was pursued in chapters 2 to 5.

Chapter 2 provides an overview of which variables have been used in the literature to understand farmers' decision to adopt an innovation and the influence of these variables on the adoption decision. Variables were identified by reviewing studies based on utility maximization (UM) and the theory of planned behavior (TPB). Results from the UM studies showed that the explanatory variables mostly have an insignificant effect on the adoption decision. When the effects were significant, the sign of the effect was inconsistent across studies. Results from the TPB studies showed that correlations between the psychological constructs used in this type of model were significant in most cases. However, most variables were only used in one or two studies and it was therefore not possible to detect a clear pattern across studies that used the TPB model.

In Chapter 3, Spearman rank correlation coefficients were estimated to explore the correlation of attitude, subjective norm, and perceived behavioral control with the intention of farmers to use improved natural grassland and to understand the role of farmers' beliefs as drivers of their attitude, subjective norm, and perceived behavioral control. Results showed that attitude, subjective norm, and perceived behavioral control were all positively and significantly correlated with intention. The intention of farmers to use improved natural grassland was therefore correlated with farmers' evaluation of the use of improved natural grassland (attitude), their perceptions about the social pressure to use this innovation (subjective norm), and their perceptions about their own capability (perceived behavioral control). The more positively farmers evaluate improved natural grassland (attitude), the more likely and more important they believe that this innovation allows them to increase the number of animals per hectare, to have pasture available throughout the year, to increase pasture resistance, to decrease feeding costs, to prevent soil erosion, and to increase the weight of the cattle. These are the behavioral beliefs that drive attitude. The higher farmers perceive social pressure (subjective norm) to use improved natural grassland, the more likely they believe that family, friends, neighbor farmers, cattle traders, workers in the place where they buy their inputs, extension agents, and government support them in their decision to adopt and the more they evaluate the opinion of these groups of people. These are the normative beliefs that drive subjective norm. The more farmers perceive that they have a higher capability (perceived behavioral control) to use improved natural grassland, the more likely and the more strongly they believe that they have sufficient knowledge about the innovation, have sufficient skills to deal with this practice and have access to qualified technical assistance. These are the control beliefs that drive perceived behavioral control.

Chapter 4 used cluster analysis to identify groups of farmers with different levels of intention to use improved natural grassland. Two groups of farmers were identified: farmers that were willing and farmers that were unwilling to use improved natural grassland. Mann-Whitney tests and independent sample t-tests were used to analyze whether the differences in the level of farmers' intention were associated with socio-psychological factors, socioeconomic characteristics, goals, and relative risk attitude. Results showed that, compared to unwilling farmers, willing farmers evaluated the use of improved natural grassland on their farms more favorably (attitude), they felt a greater social pressure on them to adopt this innovation (social norm), and they reported a higher capability (perceived behavioral control) to use improved natural grassland. Willing and unwilling farmers also differed in their behavioral beliefs concerning the outcomes of using improved natural grassland, their normative beliefs concerning important others, and their control beliefs concerning factors that could facilitate or inhibit the use of improved natural grassland. The two groups did not differ in most of their socioeconomic characteristics, but did differ in their goals and relative risk attitudes. Willing farmers had higher economic/social and status goals, and were more intrinsically motivated to use improved natural grassland. Unwilling farmers had a higher self-reported risk aversion than willing farmers.

In Chapter 5, structural equation modeling was used to determine the effect of attitude, subjective norm and perceived behavioral control on farmers' intention to use improved natural grassland. Results showed that the intention of farmers to use improved natural grassland was mainly determined by their perceptions about the social pressure to use this innovation (subjective norm), followed by their perceptions about their own capability (perceived behavioral control) to use this innovation, and their evaluation of the use of improved natural grassland (attitude). Results also show that subjective norm is positively correlated with farmers' attitude and perceived behavioral control.

Overall, results from Chapter 3 to 5 suggested two main strategies to increase farmers' intention to use improved natural grassland. First, increase social pressure on farmers to use this innovation. For instance, extension agents could focus not only on disseminating information about this practice to farmers, but also to their families and the community. Family, friends, neighbor farmers, cattle traders, workers in the place where farmers buy their inputs, extension agents, and government could be used as channels to disseminate information about this practice to the farmers. Second, interventions designed to emphasize the benefits of using improved natural grassland or increase farmers' capability to use this innovation, lead to a higher intention of farmers to adopt improved natural grassland. Results suggest that informing farmers that improved natural grassland allows them to increase number of animals per hectare, to have pasture available throughout the year, to increase pasture resistance, to decrease feeding costs, to prevent soil erosion, and to increase the weight of the cattle, increase their intention to use this innovation. Results also suggest that when farmers believe that they have sufficient knowledge about improved natural grassland, sufficient skills to deal with this innovation, and access to qualified technical assistance, their intention to use improved natural grassland is higher. A possible intervention is the practical demonstration of this innovation in the field, reinforcing the benefits of improved natural grassland and showing how to apply it in practice.

Chapter 6 presented a synthesis of the chapters and discussed the overall findings of this thesis. It also discussed research limitations and implications for policy makers and researchers.

Based on the results of this thesis, the main conclusions are:

- Explanatory variables used in utility maximization studies mostly have an insignificant effect on the adoption decision, and when the effects are significant, the sign of the effect is inconsistent across studies (Chapter 2).
- Correlations between the variables used in TPB studies are significant in most cases, but the variables are operationalized differently across studies (Chapter 2).
- The more positively farmers evaluate improved natural grassland (attitude), the more likely and more importantly they believe that this innovation allows them to increase the number of animals per hectare, to have pasture available throughout the year, to increase pasture resistance, to decrease feeding costs, to prevent soil erosion, and to increase the weight of the cattle (Chapter 3).
- The higher farmers perceive social pressure (subjective norm) to use improved natural grassland, the more likely they believe that family, friends, neighbor farmers, cattle traders, workers in the place where they buy their inputs, extension agents, and government support them in their decision to adopt and the more they evaluate the opinion of these groups of people (Chapter 3).
- The more farmers perceive that they have a higher capability (perceived behavioral control) to use improved natural grassland, the more likely and the

more strongly they believe that they have sufficient knowledge about the innovation, have sufficient skills to deal with this practice and have access to qualified technical assistance (Chapter 3).

- Farmers that are willing to use improved natural grassland on their farms evaluated this innovation more favorably (attitude), felt a greater social pressure to use this innovation (social norm), and reported a higher capability (perceived behavioral control) to use improved natural grassland than farmers that were unwilling to use this innovation (Chapter 4).
- Farmers that are willing to use improved natural grassland had a lower risk aversion, higher economic/social and status goals, and were more intrinsically motivated to use improved natural grassland than farmers that were unwilling to use this innovation (Chapter 4).
- Intention of farmers to use improved natural grassland is mainly determined by their perceptions about the social pressure to use this innovation (subjective norm), followed by their perceptions about their own capability (perceived behavioral control) to use this innovation, and their evaluation of the use of improved natural grassland (attitude) (Chapter 3 and 5).
- Social pressure (subjective norm) is positively correlated with farmers' perceptions about their own capability to use improved natural grassland (perceived behavioral control), and their evaluation of the use of this innovation (attitude) (Chapter 5).

Samenvatting

De productie van rundvlees op natuurlijke graslanden maakt duurzame ontwikkeling mogelijk in de biotoop Pampa, Rio Grande do Sul (RS), Brazilië. Echter, de door de veehouders gebruikte praktijken hebben geleid tot overbegrazing, lage productiviteit en lage landbouwinkomens. Boeren in de regio hebben natuurlijke graslanden voor rundvleesproductie omgezet in meer winstgevende activiteiten, zoals akkerbouwgewassen. Omdat deze conversie en overbegrazing milieuproblemen veroorzaakt hebben in de biotoop Pampa, zijn de boeren gestimuleerd door de overheid, voorlichtingsdiensten en onderzoekscentra om innovaties toe te passen die de productiviteit van de rundvleesproduktie te verbeteren zonder schade te veroorzaken aan het milieu. Echter, de adoptiegraad van deze innovaties door boeren is nog steeds laag. Eén van de beschikbare innovaties is: verbeterd natuurlijke graslanden. De algemene doelstelling van dit onderzoek was om factoren te verkennen die bepalend zijn voor de intenties van veehouders om natuurlijke graslanden toe te passen in de biotoop Pampa. Dit onderzoek maakt gebruik van de theorie van gepland gedrag (TPB) om de onderliggende psychologische constructen te begrijpen die adoptiebeslissingen van boeren beïnvloeden. De TPB veronderstelt dat de adoptie van een innovatie wordt gedreven door de intentie om het te gebruiken, die op zijn beurt wordt bepaald door drie sociaal-psychologische constructen: attitude, subjectieve normen en de waargenomen gedragscontrole. Deze constructen zijn afgeleid van gedrags-, normatieve en controle overtuigingen, respectievelijk. De algemene doelstelling is in de hoofdstukken 2 tot en met 5 uitgewerkt.

Hoofdstuk 2 geeft een overzicht van de variabelen die zijn gebruikt in de literatuur over besluitvorming van boeren ten aanzien van de adoptie van een innovatie en de invloed van deze variabelen op de adoptie. Variabelen werden geselecteerd op basis van een review van studies die gebruik maken van nutsmaximalisatie theorie (UM) en de theorie van gepland gedrag (TPB). De resultaten van de UM studies toonden aan dat de verklarende variabelen veelal een onbeduidend effect hebben op de adoptie beslissing. Wanneer de effecten

significant waren, was de richting van het effect inconsistent onder de onderzochte studies. Resultaten van de onderzochte TPB studies toonden aan dat correlaties tussen de gebruikte psychologische constructen in dit type model significant waren in de meeste gevallen. Echter, de meeste psychologische constructen waren alleen gebruikt in één of twee studies en het is dus niet mogelijk een duidelijk patroon detecteren in de TPB studies.

In hoofdstuk 3 werden Spearman correlatiecoëfficiënten geschat om de correlatie tussen attitude, subjectieve norm, en waargenomen gedragscontrole, en de intentie van de boeren om verbeterde natuurlijke graslanden te verkennen. Ook werden correlaties gebruikt om de invloed van overtuigingen van boeren te begrijpen die hun attitude, subjectieve norm en de waargenomen gedragscontrole sturen. De resultaten toonden aan dat de attitude, subjectieve norm en de waargenomen gedragscontrole allemaal positief en significant gecorreleerd waren met intentie. De intentie van de boeren om verbeterde natuurlijke graslanden te gebruik werd daarom ook gecorreleerd met de beoordeling door boeren van het gebruik van verbeterde natuurlijke graslanden (attitude), hun percepties over de sociale druk om deze innovatie (subjectieve norm) te gebruiken, en hun percepties over hun eigen vermogen (waargenomen gedragscontrole) om deze innovatie te gebruiken. Hoe positiever boeren verbeterde natuurlijke graslanden (attitude) beoordeelden, hoe groter de kans en hoe sterker zij geloven dat deze innovatie hen in staat stelt om het aantal dieren per hectare te verhogen, om weide beschikbaar hebben het hele jaar door, om de robuustheid van de weide te verhogen, om de voerkosten te verlagen, bodemerosie te voorkomen en het gewicht van het vee te verhogen. Dit zijn de geïdentificeerde gedragsovertuigingen die de attitude sturen. Hoe hoger boeren sociale druk (subjectieve norm) voelen om verbeterde natuurlijke graslanden te gebruiken, hoe groter de kans is dat ze geloven dat familie, vrienden, boeren in de omgeving, veehandelaren, werknemers in de plaats waar ze hun inputs kopen, voorlichters, en de overheid hen ondersteunen in hun beslissing, en hoe meer gewicht ze toekennen aan de mening van deze groepen mensen. Dit zijn de normatieve overtuigingen die de subjectieve normen van de boeren bepalen. Hoe meer boeren ervaren dat zij in staat zijn (waargenomen gedragscontrole) om verbeterde natuurlijke graslanden te gebruiken, hoe groter de kans en hoe sterker ze geloven dat zij over voldoende kennis over de innovatie, over voldoende vaardigheden om te gaan met deze praktijk en toegang hebben tot gekwalificeerde technische assistentie. Dit zijn de controle-overtuigingen die de waargenomen gedragscontrole bepalen.

Hoofdstuk 4 gebruikte clusteranalyse om groepen boeren identificeren met verschillende niveaus van intenties om verbeterde natuurlijke graslanden te gebruiken. Twee groepen van boeren werden geïdentificeerd: boeren die wel bereid waren en boeren die niet bereid waren om verbeterde natuurlijke graslanden te gebruiken. Mann-Whitney testen en onafhankelijke sample t-testen werden gebruikt om de verschillen in het niveau van de intenties tussen deze groepen te analyseren. De verschillen werden geassocieerd met sociaal-psychologische factoren, sociaaleconomische kenmerken, doelen en relatieve risicohouding. De resultaten toonden aan dat, in vergelijking met onwillige boeren, de bereidwillige boeren het gebruik van verbeterde natuurlijk grasland op hun bedrijf gunstiger (attitude) evalueerden, vonden dat er een grotere sociale druk op hen werd uitgeoefend om deze innovatie (sociale norm) te gebruiken, en vonden dat ze een hoger vermogen (waargenomen gedragscontrole) hadden om verbeterde natuurlijke graslanden te gebruiken. Bereidwillige en niet-bereidwillige boeren verschilden ook in hun gedragsovertuigingen met betrekking tot de resultaten van het gebruik van verbeterde natuurlijke graslanden, hun normatieve opvattingen over belangrijke personen in hun omgeving, en hun gedragscontrole met betrekking tot factoren die het gebruik van verbeterde natuurlijke graslanden bevorderen dan wel remmen. De twee groepen verschilden alleen ten aanzien van hun doelen en relatieve risico houdingen. Bereidwillige boeren hadden hogere economische / sociale en statusdoelen, en waren meer intrinsiek gemotiveerd om verbeterde natuurlijke graslanden te gebruiken. Niet-bereidwillige boeren hadden een hogere door henzelf gerapporteerde risicoaversie dan bereidwillige boeren.

In hoofdstuk 5 werd Structural Equation Modeling gebruikt om het effect van de attitude, subjectieve norm en waargenomen gedragscontrole te bepalen op de intentie van boeren om verbeterde natuurlijke graslanden te gebruiken. De resultaten toonden aan dat de intentie van de boeren om verbeterde natuurlijke graslanden te gebruiken voornamelijk werd bepaald door hun percepties over de sociale druk om deze innovatie toe te passen (subjectieve norm), gevolgd door hun percepties over hun eigen vermogen (waargenomen gedragscontrole) om deze innovatie te gebruiken, en hun beoordeling van het gebruik van verbeterde natuurlijke graslanden (attitude). De resultaten tonen ook aan dat de subjectieve norm een positieve correlatie vertoont met de attitude en waargenomen gedragscontrole van boeren.

De resultaten uit hoofdstuk 3 tot en met 5 suggereren twee belangrijke strategieën om de intentie van boeren om verbeterde natuurlijke graslanden gebruiken te verhogen. Ten eerste, het verhogen van sociale druk op boeren om deze innovatie te gebruiken. Voorlichters moeten zich niet alleen richten op de landbouwers voor het verspreiden van informatie over deze praktijk, maar ook op hun gezinnen en de gemeenschap waarin de boeren wonen. Familie, vrienden, boeren in de omgeving, veehandelaren, werknemers in de plaats waar de boeren hun inputs kopen, voorlichters, en de overheid kunnen worden gebruikt als kanalen om informatie over deze praktijk aan de boeren te verspreiden. Ten tweede, interventies ontworpen om de voordelen van het gebruik van verbeterde natuurlijke graslanden te benadrukken of om het vermogen van boeren te verhogen om deze innovatie te gebruiken, leiden tot een hogere intentie van de boeren om verbeterde natuurlijke graslanden toe te passen. De resultaten suggereren dat de landbouwers een hogere intentie hebben om verbeterd natuurlijk grasland te gebruiken naarmate ze vinden dat deze innovatie hen in staat stelt om het aantal dieren te verhogen per hectare, om weide beschikbaar hebben het hele jaar door, om de robuustheid van de weide te verhogen, om de voerkosten te verlagen, om bodemerosie te voorkomen, en om het gewicht van de veestapel te vergroten. De resultaten suggereren ook dat boeren een hogere intentie hebben om een verbeterde natuurlijke graslanden te gebruiken wanneer ze geloven dat ze over voldoende kennis van verbeterd natuurlijk grasland beschikken, voldoende vaardigheden hebben om om te gaan met deze innovatie, en toegang hebben tot gekwalificeerde technische hulp. Mogelijke maatregelen om de adoptie te vergroten is het demonstreren van deze innovatie op praktijkbedrijven en het vergroten van de voordelen van verbeterde natuurlijke graslanden.

Hoofdstuk 6 presenteerde een synthese van de resultaten uit de hoofdstukken 2 tot en met 5, en bediscussieerde de implicaties van dit proefschrift voor beleidsmakers en onderzoekers.

De belangrijkste conclusies op basis van de resultaten van dit proefschrift zijn:

- Verklarende variabelen gebruikt in nutsmaximalisatie studies hebben veelal een onbeduidend effect op de adoptiebeslissing, en wanneer de effecten significant zijn, is de richting van het effect inconsistent tussen de studies (hoofdstuk 2).

- Correlaties tussen de variabelen die in TPB studies gebruikt worden zijn significant in de meeste gevallen, maar de variabelen zijn verschillend geoperationaliseerd in de studies (hoofdstuk 2).

- Hoe positiever boeren verbeterde natuurlijke graslanden waarderen (attitude), hoe groter de kans en hoe meer ze geloven dat deze innovatie hen in staat stelt om het aantal dieren per hectare te verhogen, om weide beschikbaar hebben het hele jaar door, om de robuustheid van de weide te verhogen, om de voerkosten te verlagen , bodemerosie te voorkomen en het gewicht van het vee te verhogen (hoofdstuk 3).

- Hoe hoger boeren sociale druk (subjectieve norm) voelen om verbeterde natuurlijke graslanden te gebruiken, hoe groter de kans dat ze geloven dat familie, vrienden, buren boeren, veehandelaren, werknemers in de plaats waar ze hun inputs kopen, voorlichters, en de overheid hen ondersteunen hun beslissing en hoe meer waarde ze hechten aan de mening van deze groepen mensen (Hoofdstuk 3).

- Hoe meer boeren ervaren dat zij in staat zijn (waargenomen gedragscontrole) om verbeterde natuurlijke graslanden te gebruiken, hoe groter de kans en hoe sterker ze geloven dat zij beschikken over voldoende kennis over de innovatie en over voldoende vaardigheden om deze innovatie te gebruiken, en toegang hebben tot gekwalificeerde technische hulp (Hoofdstuk 3).

- Boeren die bereid zijn om een verbeterde natuurlijke graslanden gebruiken op hun bedrijf beoordeelden deze innovatie gunstiger (attitude), voelden een grotere sociale druk om deze innovatie (sociale norm) te gebruiken, en rapporteerden een hoger vermogen (waargenomen gedragscontrole) om verbeterde natuurlijke graslanden te gebruiken dan boeren die niet bereid zijn om deze innovatie te gebruiken (hoofdstuk 4).

- Boeren die bereid zijn om verbeterde natuurlijke graslanden te gebruiken hebben een lagere risico-aversie, hogere economische/sociale en statusdoelstellingen, en waren meer intrinsiek gemotiveerd om een verbeterde natuurlijke graslanden te gebruiken dan boeren die niet bereid om deze innovatie te gebruiken (hoofdstuk 4).

- De intentie van de boeren om verbeterde natuurlijke graslanden te gebruiken wordt voornamelijk bepaald door hun percepties over de sociale druk om deze innovatie toe te passen (subjectieve norm), gevolgd door hun percepties over hun eigen vermogen (waargenomen gedragscontrole) om deze innovatie te gebruiken, en hun beoordeling van het gebruik van verbeterde natuurlijke graslanden (attitude) (hoofdstuk 3 en 5).

- Sociale druk (subjectieve norm) is positief gecorreleerd met de percepties van boeren over hun eigen vermogen om verbeterde natuurlijke graslanden te gebruiken (waargenomen gedragscontrole), en hun beoordeling van het gebruik van deze innovatie (attitude) (hoofdstuk 5).

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João Augusto Rossi Borges

Curriculum Vitae

João Augusto Rossi Borges was born in Vacaria, Rio Grande do Sul, Brazil, on November 7, 1983. He graduated in Veterinary Sciences at Universidade de Passo Fundo in 2006. In 2007 and 2008, he got two MBAs in Agribusiness Management, one at Universidade de Passo Fundo and the other at Fundação Getúlio Vargas. In 2009 and 2010, he followed an MSc program in Agribusiness at Universidade Federal do Rio Grande do Sul. In 2011, he worked as substitute professor at Agricultural Education and Rural Extension Department, Universidade Federal de Santa Maria, teaching rural economy, rural extension and farm management courses. In 2012, he was granted a scholarship from the Brazilian government and enrolled in the PhD of Business Economics Group, Wageningen University. During the PhD program, he followed different economics and econometrics courses, and was a visiting scholar for three months at Cornell University, USA.

List of Publications

Borges, J.A.R.; Oude Lansink, A.G.J.M.; Marques, C.M.; Lutke, V. Understanding farmers intention to adopt improved natural grassland using the theory of planned behavior. Livestock Science, v. 169C, p. 163-174, 2014.

Borges, J.A.R.; Emvalomats, G.; Oude Lansink, A.G.J.M. Adoption of Innovation in Agriculture: A Critical Review of Economic and Psychological Models. Under review.

Borges, J.A.R.; Oude Lansink, A.G.J.M. The role of Socio-psychological Factors, Socioeconomic Characteristics, Goals, and Relative Risk Attitude in Farmers' Intention to use Improved Natural Grassland. Under review.

Borges, J.A.R.; Oude Lansink, A.G.J.M. Identifying Psychological Factors that Determine Brazilian Cattle Farmers' Intention to Use Improved Natural Grassland in Biome Pampa. Under review.

João Augusto Rossi Borges

Wageningen School of Social Sciences (WASS)

Completed Training and Supervision Plan

Name of the learning activity	**Department/Institute**	**Year**	**ECTS***
A) Project related competences			
Economic Models, AEP 30806	WUR	2012	6
Advanced Econometrics, AEP 60306	WUR	2012	6
Organization of Agribusiness, BEC 31306	WUR	2012	6
Behavioural and Experimental Economics, ECH 51306	WUR	2013	6
B) General research related competences			
Introduction course	WASS	2012	1
Scientific Publishing	WGS	2012	0.3
Techniques for Writing and Presenting a Scientific Paper	WGS	2013	1.2
C) Career related competences/personal development			
Writing Research Proposal	Business Economics Group (BEC), WUR	2012	6
Participation PhD meetings	BEC, WUR	2012-2015	2
Tutoring practical sections in the course 'Decision Science II'	BEC, WUR	2014	1
Tutoring practical sections in the course 'Food Safety Economics'	BEC, WUR	2014	1
Tutoring practical sections in the course 'Advanced Agricultural Business Economics'	BEC, WUR	2014	1
Total			**37.5**

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