Determinants of Pesticide Application: An Empirical Analysis with Theory of Planned Behaviour

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Purpose –This paper aims to investigate farmers' intentions to comply with pesticide application standards based on an extended Theory of Planned Behaviour (*TPB*).

Design/methodology/approach—Built on a *TPB* framework, it was examined how perceived behavioural control (*PBC*), behavioural goal, behavioural attitude, and subjective norm influenced farmers' intention to comply with pesticide application standards. Data of 986 farmers from five major agricultural provinces in China were collected following a stratified random sampling method. Structural equation modelling was employed for hypothesis testing and analysis.

Findings—The results showed that *PBC*, behavioural goal, behavioural attitude, and subjective norm had positive impacts on farmers' intention in abiding by the standards. Among them in determining farmers' intention towards compliance with pesticide application standards, farmers' *PBC* was found to be the most influential factor, while subjective norm was the least influential factor.

Originality/value—The results indicated that the traditional *TPB* constructs had significant correlations with farmers' intention to comply with pesticide standards, demonstrating the applicability of the *TPB* in the understanding of farmers' decision-making in a developing country context. It is suggested that psychological factors should be taken into consideration in studying farmers' decision-making.

Keywords Theory of planned behaviour, structural equation modelling, pesticide application practices

Paper type Research paper

1. Introduction

The detrimental effects of pesticide residues present in agricultural products have aroused concerns among the general public worldwide (De Krom and Mol, 2010; Wu and Hou, 2012). Pesticide residues can be largely attributed to improper practices of pesticide application (Van Asselt *et al*., 2010; Yang, 2003; Bourn and Prescott, 2002). It was suggested that application of more pesticides than nessersary has caused the presence of pesticide residues in foods (Ngowi *et al*., 2007). Currently, the application of pesticides is still essential to ensure agricultural productivity growth. Hence, a thorough understanding of farmers' intention to use pesticides in a safe manner is of interest to both policy makers and researchers.

Previous studies have generally focused on identifying the determinants of pesticide overuse. It was argued that farmers' intention to guarantee harvests by over-spraying and the absence of enforcement of pesticide regulations were two dominant factors contributing to farmers' pesticide overuse (Stadlinger *et al*., 2011; Marcoux and Urpelainen, 2011). Excessive use of pesticide was also ascribed to farmers' socio-economic status and farm characteristics, e.g. education attainment, gender, and limited access to technical support (Matthews, 2008; Jallow *et al*., 2017; Abhilash and Singh, 2009; Hruska and Corriols, 2002). Other factors, such as farmers' perceptions towards pesticide risks, also influenced farmers' pesticide overuse (Khan *et al*., 2015; Damalas and Hashemi, 2010; Liu and Huang, 2013).

Despite this extensive literature, a comprehensive theoretical framework is absent to understanding farmers' pesticide application. Specifically, existing literature failed to address the role psychological factors play in pesticide use (Escalada and Heong, 2012). As argued by Hansson *et al*. (2012), there has been little understanding of the psychological roots underlying farmers' decisions and behaviours. For instance, Grieshop *et al*. (1988) suggested that farmers' decisions on pest control were subjective and depended on psychological factors such as personal beliefs and perceptions. Put it differently, economic models alone cannot capture the complexity of farmers' motivation and behaviour (Lynne and Rola, 1988; Vanslembrouck *et al*., 2002; Gartrell and Gartrell, 1985). To provide a comprehensive picture of farmers' intention and behaviour, a psychological model is necessary.

The objective of this paper is to use the Theory of Planned Behaviour (*TPB*) to analyse the determinants affecting farmers' intentions to comply with standards of pesticide usage, which offers a theoretical foundation to study how psychological factors influence human behaviours. We aim to provide constructive policy recommendations to facilitate governments' amendments on pesticide application policies. The remainder of this study is organized as follows. Section 2 explains the theoretical framework and the associated hypotheses. Section 3 describes the survey design and measurement of variables. The methodology and results are presented in section 4. Finally, discussions, policy implications and limitations of this research are given in section 5.

2. Theoretical framework and hypotheses

2.1. *Theoretical framework*

The *TPB* (Ajzen, 1985; 1991) was developed upon the theory of reasoned action (Fishbein and Ajzen, 1975; Ajzen and Fishbein, 1980). The *TPB* states that intention is a necessary condition for planned behaviour (Ajzen and Madden, 1986), while behavioural intention is influenced by three psychological constructs, namely attitude, subjective norm and perceived behavioural control. Attitude refers to the degree to which a person appraises the behaviour in question (Beedell and Rehman, 2000; Wauters *et al*., 2010). Subjective norm is defined as the perceived social pressure to perform a pro-social behaviour, whereas perceived behavioural control refers to an individual's perception of his/her ability to perform that behaviour (Fishbein and Ajzen, 1975). According to *TPB*, the more an individual is favourable of his/her attitudes, subjective norm and perceived behavioural control, the stronger intention he/she has to perform a particular behaviour (Ajzen, 1991; Davis *et al*., 2002).

Recent studies have attempted to improve the predictive power of *TPB* by adding extra variables, such as past behaviours and habits (Chow and Mullan, 2010; McGilligan *et al*., 2009; Smith *et al*., 2007). Mazzocchi *et al*. (2006) integrated risk perception and trust into the TPB framework to analyse consumers' chicken purchasing behaviour after the outbreak of avian influenza. Bai *et al*. (2014) fitted the *TPB* into the Chinese context by replacing the subjective norm with 'face consciousness' and 'conformity consciousness'.

As an emerging area, *TPB* has been used in the context of agriculture to understand farmers' strategic and entrepreneurship (Bergevoet *et al*., 2004), conservation-related behaviour (Beedell and Rehman, 2000), adoption and investment of water-saving technologies (Lynne et al., 1995), as well as the intention to adopt organic farming activities (Läpple and Kelley, 2013).

Borges and Lansink (2016) suggested that farmers' intention to use improved natural grassland was mainly determined by subjective norm, followed by perceived behavioural control, and the attitude towards improved natural grassland. In an analysis of Belgian farmers' intention to adopt soil erosion control techniques, Wauters *et al*. (2010) found that the most influential factor was farmers' attitude towards such practices. This study applies an extended *TPB* to explore farmers' intention to comply with pesticide standards. Structural Equation Modeling (*SEM*) was used because farmers' intention and its psychological determinants are latent variables, i.e. the variables which exist but cannot be directly observed. *SEM* allows the measurement of latent variables and modelling of the relationships among the latent variables (Kline, 2015).

In this study, behavioural goal is taken as an additional construct to the *TPB*. Human beings are goal-oriented, self-motivated, and have the ability to think ahead (Binswanger, 1980; Locke and Bryan, 1969). Once a goal is set, it is printed in an individual's fringe of consciousness as a reference point that guides his or her mental and physical behaviours (Locke and Latham, 2006). Goals also help one to set priorities and to acquire information (Willock *et al*., 1999). Consequently, farmers aim to maximise profits, and to pursue other values such as security, honour, and social status (Han, 1995). Willock *et al*. (1999) identified five goals among Scottish farmers, i.e. success in farming, sustainability, high quality of life, high social status, and more off-farm activities. However, farmers' behavioural goals might differ across their economic status and the availability of resources (Kong, 1998). When basic survival needs are met, farmer's main goal will switch to increasing household income; when household income reaches a certain level, farmers will then pursuit higher quality of life or more leisure time (Gao *et al*., 2013).

Due to the fact that Chinese farmers generally have low income, we assume that profit maximisation is a dominant production goal. As a result, economic goals are our key concern when it comes to farmers' behaviour goals. Specifically, they are expected to comply with pesticide usage regulation in order to: (1) lower production costs by reducing pesticide use; (2) increase revenues by rising yield; or (3) increase crop prices by producing safer and better quality foods. Note that goals are rather general or even abstract, whereas objectives are more specific and are in terms of profitability and productivity (Zimmerer *et al*., 2005). In this study we refer to goals rather than objectives.

The *TPB* is an ideal framework to study farmers' pesticide usage for the following reasons. First, farmers' pesticide usage requires careful planning, which is a characteristic favourable to the application of the *TPB* (Krueger *et al*., 2000). Second, farmers' behaviours are not solely influenced by profit maximisation (Gasson, 1973). Finally, the *TPB* is easy to implement and is applicable to a wide range of behavioural domains (Leone *et al*., 1999). Consequently, the *TPB* is adopted to understand whether farmers' intention to comply with pesticide usage standards is shaped by beliefs, social pressures, perceived behavioural control, and behavioural goal. This study contributes to the understanding of pesticide usage behaviour by highlighting the role of psychological factors which should be taken into consideration in the study of farmers' intention and decisions.

2.2. Hypotheses

Perceived behavioural control

Perceived behavioural control (*PBC*) refers to a farmer's perception of his/her ability to comply with standards for pesticide application. *PBC* is largely constrained by the limited resources owned by farmers, e.g. land, capital, knowledge, ability, and technology (Zhou, 2006). Lin (1988) stated that farmers' decisions were restricted by their limited competence and tough economic conditions. Lacking time and expenses was reported as the main reasons for the limited adoption of protective equipment (Damalas *et al*., 2006). Furthermore, pesticide retailers and authorities may play important roles in providing information and guidance to facilitate farmers' pesticide selection and to increase their awareness of pesticide risks. In general, the greater the *PBC*, the more confident a farmer is to carry out a specific action. In the case of pesticide usage, farmers make evaluations of the consequences of pesticide overuse based on the exposure to technical guidance and their own and neighbours' experience. If a farmer has a better understanding of pesticides, he/she would be more likely to avoid improper pesticide usage. In contrast, if a farmer perceives himself/herself as lacking resources such as time, money and knowledge, he/she would have less intention to carry out the action. Du *et al*. (2014) found that safety regulations and information services provided by the government and pesticide retailers also enhanced farmers' *PBC*. Moreover, *PBC* was statistically related to sustainable agricultural activities (Fielding *et al*., 2008). Therefore, it is hypothesised that:

H1. *PBC* has a positive influence on farmers' intention to comply with standards of pesticide application.

Behavioural goal

Behavioural goal is defined as the goal farmers are expecting when complying with pesticide usage standards. Behavioural economists emphasized the roles of goals, attitudes, and other psychological factors in influencing farmers' decisions (Wilson, 1996). Most successful enterprises had entrepreneurial goals, e.g. an impressive brand image, large market shares, and a recognisable social image of enterprises. For instance, a food company which aims to lead the market will take initiatives to implement a variety of production criteria and regulations to guarantee the safety and quality of its products. Similarly, the farmers who pursue specific farming goals will adopt necessary agricultural practices. Bergevoet *et al*. (2004) concluded that Dutch dairy farmers were driven by both revenue and non-revenue goals which had notable impacts on their decision making. For instance, the goal to own a 'large and modern farm' was positively associated with farm size (i.e. the milk quota of a farm). Other studies also demonstrated that farmers' behavioural goal had positive impacts on their behavioural intention and actual behaviours (Jiang *et al*., 2012; Zhao and Zhang, 2009). Therefore, it is hypothesised that:

H2. Behavioural goal has a positive influence on farmers' intention to comply with standards of pesticide application.

Behavioural attitude

Behavioural attitude refers to both positive and negative attitudes that farmers display towards the compliance with pesticide application standards. It includes both cognitive and emotional evaluations (McGuire, 1969). Furthermore, it was studied extensively that attitudes had significance influences on behavioural intentions (Ajzen and Fishbein, 1980). In an application of TPB, Karppinen (2005) found that farmers' attitudes explained farmers' choices to produce safe foods. Pampel and van Es (1977) pointed out that the attitude towards profit maximization and sustainability determined the type of technological innovation adopted. Lynne and Rola (1988) have reported similar results. Zhou (2006) found that farmers who had favourable attitudes towards the quality and safety of vegetables were more likely to adopt quality control practices. Therefore, it is hypothesised that:

H3. Behavioural attitude has a positive influence on farmers' intention to comply with standards of pesticide application.

Subjective norm

Subjective norm refers to the social pressures perceived by farmers during pesticide usage. Farmers are expected to reconsider the consequences of improper pesticide usage in the presence of social norm that encourages better practices. Hence, they tend to perform pro-social behaviours under the pressure of peers. In the case of pesticide usage, farmers' actions are expected to be influenced by their relatives, friends, neighbours and government agencies. We consider both normative and informational influences from referents. The former relates to an individual's conformity with expectations of other individuals surrounding him/her (Homans, 1961). Farmers may be unwilling to comply with standards of pesticide usage in the beginning, but they may change their behaviours as a response to the social pressures from the people surrounding them. The latter refers to the credible information provided by informants (Burnkrant and Cousineau, 1975). It is crucial for farmers to make informed decisions. Farmers' perception of safe pesticide usage is expected to originate from the credible information provided by authorities. Therefore, it is hypothesised that:

H4. Subjective norm has a positive influence on farmers' intention to comply with standards of pesticide application.

Interaction effects

Interaction effects refer to the phenomenon that the influence of a latent psychological factor on intention might depend on other psychological factors. It is suggested that interaction effects between *PBC* and attitude are evident so that a positive attitude motivates an individual to perform certain behaviours, as he/she perceives a high degree of controllability over the behaviour (Ajzen, 1985; Ajzen and Driver, 1992; Eaglyand Chaiken, 1993). Other studies have also suggested that attitude might interact with subjective norms (Acock and Defleur, 1972; Grube *et al*., 1986). For instance, a farmer may develop a positive attitude when he/she feels that significant others expect him/her to comply with pesticide usage standards. The mutual interactions between the other latent psychological factors might also exist and are subject to empirical tests.

H5. Interaction effects among latent variables exist.

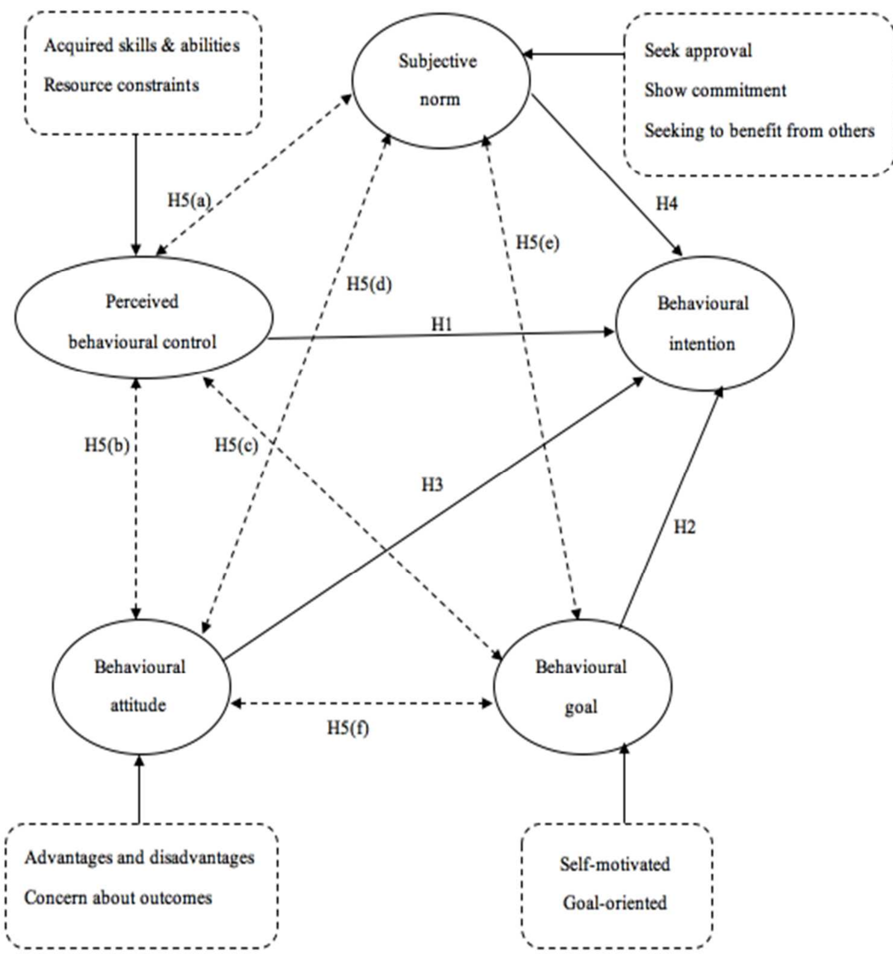

Figure 1: A theoretical model incorporating psychological factors that influence farmers' intentions to comply with pesticide use standards

Note: A solid line represents a dependence relationship and a dotted line represents a correlation relationship.

3. Method

3.1. Data collection and sample

Prior to the full survey, a preliminary questionnaire had been pre-tested by ten farmers and two specialists. The final questionnaire was composed of five sections, i.e. socio-economic characteristics, traditional *TPB* psychological factors, farmers' behavioural goals, risk perception, and personal traits. Face-to-face interviews were carried out with household heads to collect detailed information on their pesticide usage. A stratified random sampling approach was followed. Samples were selected from five major agricultural Chinese provinces where large amounts of pesticides were consumed, i.e. Henan, Shandong, Jiangsu, Zhejiang, and Heilongjiang. Four counties were randomly selected from each of the five provinces, leading to 20 counties. Next, five villages were randomly selected from each county. Finally, ten farmers from each of village were interviewed individually by an interviewer. The survey team was guided by local villagers with sound personal networks to ensure that the survey could be carried out smoothly. To ensure the credibility of farmers' responses, the survey team clearly explained to farmers their identity as university researchers prior to the interviewing. Additionally, unanswered questions were further explained and filled in by farmers to ensure a high response rate. While farmers might have under-reported their pesticide usage, we endeavoured to minimise the downward bias in two ways. First, interviewers received extensive training prior to the interviews. A guided dialogue was designed for the interviewers to avoid deliveries of any normative messages. Second, interviewers were asked to clearly explain their identity as researchers to ensure that farmers understood that the survey was anonymous and that their privacy will be protected.

In total, 1,000 questionnaires were distributed between February and March 2013, among which 993 questionnaires were returned. Seven invalid questionnaires were excluded, resulting in 986 valid responses. Table 1 summarises the details of the sampling strategy.

Table 1: Distribution of samples

Province	No. of counties	No. of villages	No. of samples
Shandong	4	5	183
Henan	4	5	196
Jiangsu	4	5	200
Zhejiang	4	5	199
Heilongjiang	4	5	208

3.2. Measurements of constructs

Following Fishbein and Ajzen (2010), 19 observed variables were used to measure the five psychological constructs. In line with previous *TPB* studies, all variables were measured using the five-point Likert scale (Läpple and Kelley, 2013; Bergevoet *et al*., 2004). The final questionnaire items used to measure each construct are listed in Table 2.

Table 2: Questions used to measure the psychological constructs

Notations	Questions	Scales (1-5)	Mean	S.D.
BI1	How likely is it that you will pay attention to pesticide residues in order to avoid food safety risks?	“Very unlikely” – “Very likely”	3.53	0.789
BI2	How likely is it that you will read the label carefully before spraying pesticides?	“Very unlikely” – “Very likely”	4.20	0.822
BI3	How likely is it that you will lower your pesticide usage in the next year?	“Very unlikely” – “Very likely”	3.55	0.925
BA1	To what extent are you concerned about the danger to agricultural products when there is pesticide residue left on them?	“Not at all” – “Very much”	3.42	0.929
BA2	To what extent do you agree that safe agricultural products would taste better?	“Strongly disagree” – “Strongly agree	3.73	0.660
BA3	To what extent do you agree that compliance with pesticide application standards would be beneficial to you?	“Strongly disagree” – “Strongly agree	3.69	0.735
BA4	To what extent do you agree that it's wise to comply with pesticide application standards?	“Strongly disagree” – “Strongly agree	3.80	0.839
BA5	To what extent do you agree that it would be reasonable to grow pollution-free, green and organic agricultural products?	“Strongly disagree” – “Strongly agree	3.81	0.814
SN1	To what extent are you influenced by your family members to comply with pesticide usage standards?	“Not at all” – “Very much”	3.25	1.012
SN2	To what extent are you influenced by your friends to comply with pesticide usage standard?	“Not at all” – “Very much”	2.90	1.002
SN3	To what extent are you influenced by other	“Not at all” – “Very	3.09	0.928

	farmers to comply with pesticide usage standards?	much”		
SN4	To what extent are you influenced by the government to comply with pesticide usage standards?	“Not at all” – “Very much”	3.26	1.110
PBC1	You have the knowledge and skills to regulate pesticide application on your farm.	“Strongly disagree” – “Strongly agree	2.91	1.064
PBC2	To what extent does the government supervise your pesticide application practices?	“Very little” – “Very much”	3.62	1.154
PBC3	To what extent do you agree that having technical guidance on pesticide spray on your farm has a strong regulatory impact on your behaviour?	“Strongly disagree” – “Strongly agree	3.39	1.177
PBC4	It's totally up to me whether I regulate my pesticide application.	“Strongly disagree” – “Strongly agree	3.65	1.132
BG	To what extent do you agree that you produce safe agricultural products in order to			
BG1	…lower the production cost?	“Strongly disagree” – “Strongly agree	3.82	0.697
BG2	…increase the total revenue?	“Strongly disagree” – “Strongly agree	3.60	0.742
BG3	…increase the product price?	“Strongly disagree” – “Strongly agree	3.82	0.709

3.3. Description of the sample

Table 3 shows the social-demographic characteristics of the 986 respondents. Overall, 85.7% of the respondents were younger than 60 years old with nearly half (41.6%) between 46 and 60 years. More than half (59.8%) of the respondents were males, reflecting the fact that pesticide spray was generally done by males. A majority of respondents (94.2%) were married and a large proportion of the respondents (78.9%) only had junior high-school or lower education.

Table 3: Sample characteristics (*N*=986)

Characteristics	Item response and score	% sample	Mean	S.D.
Gender	“Male” = 1	59.84	1.40	0.490

	"Female" = 2	40.16		
	"<18 years old" = 1	0.91		
	"18-25 years old" = 2	7.61		
Age	"26-45 years old" = 3	35.60	3.61	0.855
	"46-60 years old" = 4	41.58		
	"≥61 years old" = 5	14.30		
	"Primary school and below" = 1	29.92		
	"Junior high school" = 2	48.99		
Educational level	"Senior high school" = 3	15.52	2.00	0.908
	"Junior college" = 4	2.64		
	"College and above" = 5	2.93		

4. Validation of measurements

4.1. Exploratory factor analysis

In the first stage, *SPSS* (version 18) was employed to conduct an exploratory factor analysis, which is a useful tool to validate measurements for latent variables (Beran and Violato, 2010). It is a common practice to use exploratory factor analysis in the first stage to explore the possible indicators for latent variables and then use the validated indicators in subsequent *SEM* analysis. A similar practice was followed in several *TPB* studies as well (see among others Bai *et al.*, 2014; Verbeke and Vackier, 2005). Additionally, exploratory factor analysis allows the tests of data suitability by conducting sampling adequacy tests, namely Kaiser-Meyer-Olkin (*KMO*) test and Bartlett's sphericity test. *KMO* returned a value of 0.821 and the approximate Chi-square from Bartlett's sphericity test was highly significant ($p<0.001$), suggesting that the data collected were suitable for factor analysis and that the null hypothesis was rejected. Oblique rotation method was applied to determine the number of items allocated to each factor (Fabrigar *et al.*, 1999). The rotated factor loading matrix is illustrated in Table 4. Finally, five factors were identified and 19 items were obtained.

4.2. Reliability and validity

Test validity has two components, namely content validity and construct validity. Content validity refers to the representativeness and appropriateness of the measurement methods, i.e. whether indicators reflect the characteristics of the latent variables (Wang and Wang, 2012). During the conceptualisation of the questionnaire, we considered how previous studies measured the five latent variables to ensure content validity (Bai *et al*., 2014; Fielding *et al*., 2008). Construct validity refers to the degree to which the indicators can measure the constructs. A factor analysis was conducted to evaluate construct validity. The results showed that factor loadings were all greater than 0.5, indicating that the constructs had satisfactory construct validities.

The reliability of a psychological construct shows whether its measurement is consistent and stable (Wang and Wang, 2012). This study tested the reliability of the five exploratory factors by observing the Cronbach's α coefficient. A Cronbach's α coefficient higher than 0.6 indicates that the measurements can be used to represent the constructs (Borges *et al*., 2014; Bruijnis *et al*., 2013). The results of reliability and construct validity tests are summarised in Table 4. The Cronbach's α of all five factors ranged from 0.646 to 0.858, indicating a relatively high internal consistency.

Table 4: Reliability and construct validity tests

Latent constructs	Items	Reliability	Construct validity		
		Cronbach α	Factor loadings	Guttman Split-half	Variance contribution rate
Behavioural intention (*BI*)	*BI1*	0.646	0.615	0.646	53.784
	BI2		0.544		
	BI3		0.673		
Behavioural attitude (*BA*)	*BA1*	0.781	0.658	0.743	54.188
	BA2		0.597		
	BA3		0.689		
	BA4		0.745		
	BA5		0.808		
Subjective norm (*SN*)	*SN1*	0.750	0.847	0.689	58.247
	SN2		0.810		
	SN3		0.770		

	SN4		0.599		
Perceived behavioural control (*PBC*)	*PBC1*	0.858	0.736	0.849	70.231
	PBC2		0.851		
	PBC3		0.866		
	PBC4		0.820		
Behavioural goal (*BG*)	*BG1*	0.688	0.722	0.675	61.748
	BG2		0.752		
	BG3		0.794		

4.3. The measurement model

In the next stage, a confirmatory factor analysis was carried out using the maximum likelihood procedure in SEM. In this study, seven conventional model-fit statistics are chosen, namely Chi-square/degrees-of-freedom (χ^2/df), goodness-of-fit (*GFI*), adjusted goodness-of-fit (*AGFI*), standardised root mean square error of approximation (*RMSEA*), comparative fit index (*CFI*), incremental fit index (*IFI*), and normed fit index (*NFI*). Generally, values greater than 0.9 for *GFI*, *AGFI*, *CFI*, *IFI*, *NFI* indicate acceptable model fits (Bagozzi *et al*., 1991). Moreover, a *RMSEA* value less than 0.05 is necessary (Browne and Cudeck, 1993). The recommended minimum cut-off values and the observed values in our study are presented in Table 5. The overall model-fit statistics is χ^2/df =1.701, which is less than the cut-off value (3.0) suggested by Carmines and Mciver (1981). The other model-fit statistics also demonstrated reasonably good model-fit.

Table 5: Goodness-of-fit test statistics

Fit index	χ^2/df	*GFI*	*CFI*	*RMSEA*	*AGFI*	*IFI*	*NFI*
Suggested value	<3	>0.9	>0.9	<0.05	>0.9	>0.9	>0.9
Observed value	1.701	0.966	0.966	0.042	0.948	0.967	0.948
Conclusion	Accepted	Good fit	Good fit	Good fit	Good fit	Good fit	Good fit

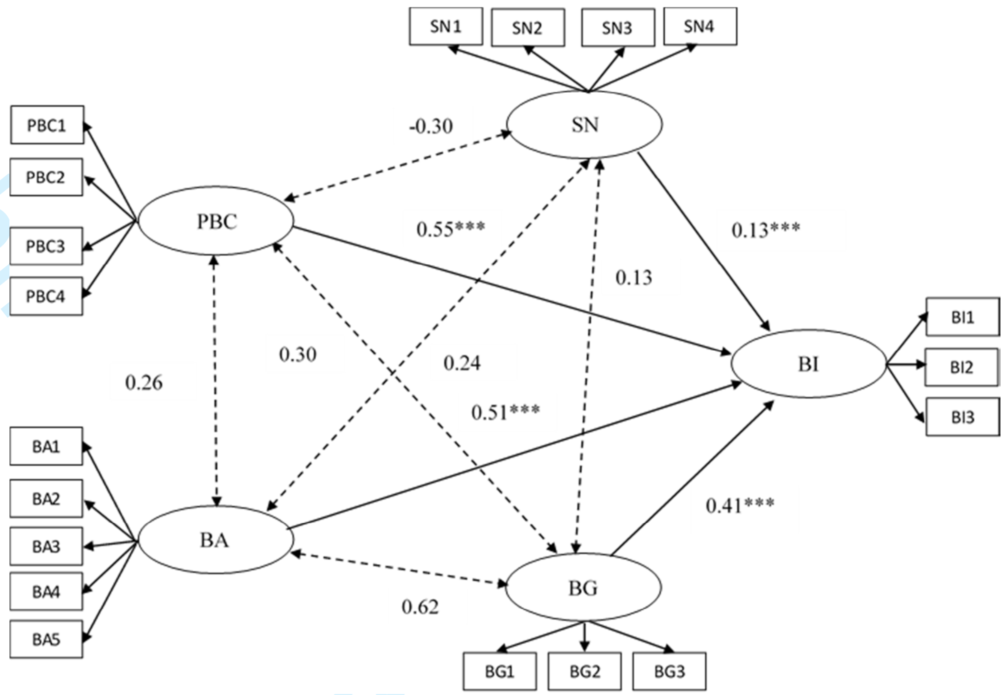

Figure 2. Path diagram of *SEM*.

Note: *** p< 0.01.

4.4. Path analysis of the structural model

Path analysis represents the causal relationships and correlations among latent variables. It can be used to assess the significance of a path (Wright, 1920). Table 6 shows the results of *SEM* estimated using *AMOS*, based on the sample of 986 farmers. The standardised path coefficients of *PBC*, *BG*, *BA*, and *SN* are 0.55 (p<0.01), 0.41 (p<0.01), 0.51 (p<0.01) and 0.13 (p<0.10), respectively, indicating that *PBC* has the largest influence on farmers' intention to comply with pesticide usage standards, whereas *SN* has the lowest influence.

The positive and significant correlation between *BI* and *PBC* (0.55, p<0.01) indicates that farmers' perceptions about their compliance capabilities was an important factor to promote their *BI*. The results implied that farmers' intention to comply pesticide application standards was closely related to the supervision and technical support provided by the government.

The results also accord hypothesis *H2* because a positive and significant correlation between *BG* and *BI* (0.41, p<0.01) was reported. That means that farmers complied with pesticide application standards to achieve their goals, i.e. reducing production costs, raising yield, and increasing market prices of their products.

Hypothesis *H3* is supported because *BA* had a positive and significant correlation with *BI* (0.51, $p<0.01$). This indicates that farmers were more likely to comply when they paid more attention to food safety issues and were more aware of the importance of safe agricultural products.

Lastly, the standardised path coefficient of *SN* was 0.13, confirming hypothesis *H4*. The rationale is that a farmer's intention was highly influenced by the farmer's relatives, friends, and neighbours. This is parallel to the theory that social pressures motivate farmers to use pesticide properly (Borges *et al*., 2014).

Table 6: SEM path coefficients

Paths	Coefficients	S.E.	Critical ratios	Standardised path coefficients	Significance levels
Structural model					
BI<---PBC	0.547	0.030	7.772	0.55	***
BI<---BG	0.209	0.065	4.129	0.41	***
BI<---BA	0.512	0.066	4.973	0.51	***
BI<---SN	0.128	0.042	1.897	0.13	0.058
Interactions					
PBC<-->BG	0.144	0.019	7.464	0.30	***
BG<-->BA	0.194	0.017	11.509	0.62	***
PBC<-->BA	0.128	0.020	6.367	0.26	***
BA<-->SN	0.079	0.014	5.682	0.24	***
BG<-->SN	0.042	0.013	3.163	0.13	***
PBC<-->SN	-0.015	0.018	-0.850	-0.30	0.395
Measurement models					
PBC1<---PBC	0.621	0.037	20.211	0.62	***
PBC2<---PBC	0.812	0.040	27.272	0.81	***
PBC3<---PBC	0.904	0.042	29.146	0.90	***
PBC4<---PBC	0.768	——	——	0.77	
BG1<---BG	0.534	0.048	14.074	0.53	***
BG2<---BG	0.655	0.053	16.551	0.66	***
BG3<---BG	0.777	——	——	0.78	
BA1<---BA	0.506	0.061	13.372	0.51	***
BA2<---BA	0.648	0.049	15.265	0.65	***
BA3<---BA	0.730	0.055	17.133	0.73	***
BA4<---BA	0.643	0.049	19.221	0.64	***
BA5<---BA	0.704	——	——	0.70	
SN1<---SN	0.820	0.079	18.217	0.82	***
SN2<---SN	0.779	0.075	18.227	0.78	***
SN3<---SN	0.624	——	——	0.62	

SN4<---SN	0.445	0.072	11.868	0.45	***
BI1<---BI	0.290	0.080	7.693	0.29	***
BI2<---BI	0.280	0.079	7.905	0.28	***
BI3<---BI	0.395	——	——	0.40	

Notes: ***p<0.01.

4.5. Interaction effects among latent variables

Table 6 indicates that most interaction effects among latent variables are in line with expectation. The paired interactions between *BA* and *PBC* (0.26, p<0.01), between *BA* and *SN* (0.24, p<0.01), between *BG* and *PBC* (0.30, p<0.01), between *BG* and *SN* (0.13, p<0.01), and between *BA* and *BG* (0.62, p<0.01) had significance levels less than 0.01, partly supporting hypothesis *H5*. In addition, we found that the interaction between *BG* and *BA* (0.62) is the greatest among all. In contrast, the mutual interactions between the other pairs of latent variables were smaller. Those farmers with high *BG* while also had positive attitudes towards compliance behaviour and a higher *PBC* were more likely to comply with pesticide application standards. Next, a farmer with positive attitudes towards compliance behaviour increased his/her intention to comply even further if he/she also received pressures from his/her significant others. Also, the farmers who showed positive attitudes towards compliance behaviour were more willing to comply if the compliance was also supported by their *SN*. Finally, a farmer were even more willing to comply if he/she had a *SN* that favoured a proper use of pesticide requires conditional on that the farmer also had the ability to master pesticide application.

4.6. Factor loading of the measurement models

Factor loadings manifest the impacts of observed variables on latent variables. The most influential factor for *PBC* was *PBC3* (0.90), i.e. the availability of technical assistance. This implied that farmers were more likely to have higher *PBC* if they were provided with technical assistance. When it comes to the measurement of *BG*, product price was the most influential factor with a standardised coefficient of 0.78. The result indicated that farmers were more likely to comply with pesticide usage standards if they have put more weight on the selling prices of their products. For *BA*, the factor loading of *BA3* was the highest (0.73) among all indicators. The rationale was that they were more likely to comply if they have perceived that their compliance was beneficial to them. Finally, the most influential indicator for *SN* was the influence from family members (factor loading 0.82). This implied that farmers' family members had the largest influences on their intentions to comply with pesticide application standards.

5. Conclusions and policy recommendations

This study aimed at examining the major factors determining farmers' intentions to comply with pesticide application standards under an extended framework of *TPB* estimated by means of structural equation modelling. We considered psychological factors including attitudes, subjective norms, perceived behavioural control and behavioural goal. Overall, the results supported previous findings that it is important to consider psychological factors to fully understand farmers' decisions (Lynne and Rola, 1988).

The traditional *TPB* variables had significant correlations with the intentions of farmers to comply with pesticide application standards, confirming the applicability of *TPB* in analysing farmers' decision making in a developing country context. The results also demonstrated the role of an additional factor integrated into the *TPB*, i.e. behavioural goal, which provides further insights into farmers' pesticide usage behaviour. Farmers' intention was influenced by significant others' opinions, behavioural goal, and perceived behavioural control. An interesting finding is that farmers' *PBC* was found to be the most influential factor to determine farmers' intentions to comply with pesticide application standards. This is in line with another study that examined Florida strawberry farmers' willingness to adopt and to invest in water technology. In contrast, Wauters *et al.* (2010) found that *PBC* was not a significant factor in affecting farmers' decisions to adopt soil conservation practices. One possible explanation could be that pests caused extensive damages to agricultural production, which caused farmers to be more risk-averse. Next, the *TPB* analysis revealed that the lack of qualified technical assistance was a significant obstacle constraining farmers' intentions to comply pesticide application standards. This highlights a significant strength of the *TPB* analysis that identifies which psychological factors are the main barriers. This research suggests that interventions are necessary to foster farmers' behavioural control. Technical guidance is a useful tool to enhance farmers' control over pesticide application and to promote the usage of pesticides in line with recommended standards.

This study also showed that *SN* only had a marginal effect in explaining farmers' intention which was consistent with the findings reported in Xu *et al*. (2016) who looked at farmers' adoption decisions towards genetically modified rice. One possible explanation could be that individuals are unwilling to openly admit how others influenced their own attitudes, practices, and behaviours. Another possible explanation could be that complying with pesticide application standards is not supported by social norm. Nevertheless, the results showed that *SN* interacted with *BA* in influencing farmers' behaviour, indicating that social norm works better when it is coupled with a better attitude towards compliance. In addition, further analysis revealed that the pressure from farmers' family members had a the most influence in shaping their *SN*.

The importance of *BG* in affecting farmers' compliance was supported in our study, consistent with the findings from Bergevoet *et al*. (2004) and Willock *et al*. (1999). This finding is also in line with previous suggestions that the relationship of *BG* with intention varied across attitudes (Perugini and Conner, 2000). Furthermore, we revealed that product prices had the strongest effect on *BG*. The results demonstrated that farmers would focus on the additional value generated from agricultural products with higher quality and safety standards. This shows that with a rapid development in China's rural market economy Chinese farmers are not merely farm crop producers but also market suppliers who put heavy weight on product prices.

BA also significantly correlated with farmers' intention to comply. Garforth *et al*. (2004) stated that farmers' attitudes towards technology strongly influenced their intentions to adopt. Similarly, Martínez-García *et al*. (2013) discovered that there was a positive correlation between attitudes towards and the intention to use improved grassland among small farmers in Mexico. Furthermore, Bruijnis *et al.* (2013) also found a positive correlation between the attitudes of Dutch farmers and their intentions to adopt the innovation to improve the health of dairy cows. Our results echoed with the above studies. Additionally, our results also suggested that a favourable attitude towards compliance was mostly influenced by farmers' perceived benefits.

In addition to the expected major effects, four significant interaction effects were observed. These interaction effects indicated that *PBC*, *BA*, *SN*, and *BG* had indirect effects on intention by facilitating the other latent variables. However, additional evidence for these interactive effects should be explored further.

This study provides several insights for policy makers. Firstly, the fact that *PBC* had the greatest influence on farmers' intention to comply with pesticide application standards implied that farmers' compliance may be hampered by farmers' limited abilities. Government agencies should help farmers to overcome these obstacles by providing farmers with technical guidance and designing long-term collaborative programmes that support, develop, and foster sense of control among farmers. Secondly, this study showed that attitudes were significant predictors of compliance behaviour. It is essential to provide farmers with training to change their attitudes towards compliance. Thirdly, this study supported the role of subjective norms. In order to increase farmers' intentions to use pesticides properly, government agencies should increase social pressures on farmers. This can be done by promoting proper use of pesticides not only to farmers, but also to their families and communities. Greater public awareness on proper pesticide usage is expected to impose greater social pressures for farmers to comply. Lastly, this study revealed that behavioural goal also played a role in promoting farmers' intentions to comply with pesticide application standards. Therefore, a market mechanism should be established such that safe agricultural products are sold at higher prices. A limitation of the present study is that it has focused on farmers' intentions rather than their actual pesticide spray actions. This should be investigated by future research.

Notes

1. Farmer's intentions may be affected by crop type as well as other factors including competing farmers, farming characteristics including age, education level, farm size etc. However, due to the diversity of crops that have been cultivated by the farmers, it is infeasible to conduct sub-group analysis according to crop type. Farmer and farm characteristics were also not included in the conceptual model.

2. Both causal relations and correlations can be estimated by SEM. The two concepts look similar but are inherently different. Take the theoretical model in Figure 1 as an example. The solid lines represent casual relationships. The arrow from BA to BI indicates the casual impact from BA on BI. In contrast, the doted lines (with double-headed arrows) represent correlation relationships. PBC correlates with BA. We have made clear distinctions to "casual relationships" and "correlations" in the results.

3. Petroni and Braglia (2000): Bartlett's Test of Sphericity is based on the correlation matrix. Its null hypothesis is that the correlation matrix is an identity matrix.

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