

Article

Intervention Strategies on the Wastewater Treatment Behavior of Swine Farmers: An Extended Model of the Theory of Planned Behavior

Ming-Yeu Wang ^{1,*}  and Shih-Mao Lin ²

¹ Department of BioBusiness Management, National Chiayi University, Chiayi City 60054, Taiwan

² Ministry of Health and Welfare, Taipei City 115204, Taiwan; maomao863@gmail.com

* Correspondence: mywang@mail.ncyu.edu.tw; Tel.: +88-69-5573-3635

Received: 19 July 2020; Accepted: 24 August 2020; Published: 25 August 2020



Abstract: Untreated swine wastewater pollutes rivers and harms the environment. The pollution can be minimized if swine farmers take wastewater treatment (WWT) action before the wastewater is discharged into rivers. Thus, the WWT behavior of swine farmers is key to environmental sustainability. However, WWT behavior, characterized by high costs and inconvenience, has received little attention from previous studies. Due to the high cost, some intervention strategies are helpful in ensuring that farmers behave in a pro-environmental manner. Therefore, this study compares the effects of two intervention factors, i.e., environmental knowledge and perceived effectiveness of enforcement, on the WWT behavior of swine farmers in Taiwan. The comparisons and empirical tests are based on an extended model of the theory of planned behavior (TPB). The findings reveal that all three classic factors in the TPB, i.e., attitude, subjective norms, and perceived behavioral control, had significant and positive effects on the intention of farmers to perform WWT behavior. Contradicting most previous studies, behavioral intentions did not have a significant effect on WWT behavior; however, perceived behavioral control did. The total effects of both intervention factors on WWT behavior were significant and positive. Moreover, the total effect of environmental knowledge was larger than that of the perceived effectiveness of enforcement. The findings suggest that a combination of the two strategies of increasing the environmental knowledge of individuals and enhancing the enforcement of environmental regulations will be helpful in inducing the sustained WWT behavior of farmers. Policy makers can allocate more resources to increasing farmers' environmental knowledge than to enhancing the enforcement of environmental regulations. Finally, future research directions are discussed.

Keywords: pro-environmental behavior; high-cost behavior; antecedent; wastewater management; environmental knowledge; environmental enforcement; policy intervention; swine farming; structural equation modeling

1. Introduction

In recent years, sustainable development has become an important and challenging issue. Thus, many countries have adopted several management instruments, such as regulatory punishment, to ensure that people behave in a pro-environmental manner. Livestock farming, including swine production, should not be an exception. However, many models of modern swine farming may pollute the ecological environment. Swine wastewater contains many organic contaminants, minerals, and hormones. If swine wastewater is directly discharged into rivers without proper treatment, the wastewater will harm the environment, causing microbial reproduction in rivers and deterioration of water quality, polluting farmlands, and affecting aquatic ecosystems [1]. Notably, livestock farming

is a human activity that is more than just a livestock growth process. Human beings decide whether to use drugs or what ingredients to use as feed. Therefore, in the swine industry, the behaviors of swine farmers are key to environmental sustainability.

The majority of recent studies on pro-environmental behavior have focused on investigating behavior related to recycling [2], tourism [3], and transportation [4]. Only a few studies have discussed behaviors related to swine farming. Moreover, recent studies of swine farming emphasize issues related to economic and environmental pillars, for example, the impact of livestock production systems on the environment, but less attention has been paid to human values. The environmental behaviors of swine farmers also involve human values. To date, little is known about the factors affecting the pro-environmental behaviors of swine farmers. Therefore, this study identifies the factors that may affect the wastewater treatment (WWT) behavior of swine farmers. Following Steg and Vlek [5], we hold that the identification of influencing factors is useful in implementing intervention strategies that intend to change human behaviors, thereby effectively reducing the impact of swine farming on the environment.

Previous studies have proposed several theoretical frameworks to explain the factors that influence human behaviors in specific contexts. One influential framework is the theory of planned behavior (TPB) proposed by Ajzen [6]. The TPB states that three factors, i.e., attitude, subjective norms, and perceived behavioral control (PBC), jointly determine an individual's behavioral intentions, and these factors can be used to predict whether an individual will ultimately perform a particular behavior. Given that the TPB has successfully explained various types of environmental behaviors, this study uses it to identify the factors that affect the WWT behavior of swine farmers.

Once the causal factors of WWT behaviors are identified, appropriate intervention strategies targeting the relevant factors can be applied to farmers to change their behaviors [5]. Intervention strategies can be divided into informational strategies and structural strategies [7]. Informational strategies are designed to change the prevalent motivations, perceptions, knowledge, and norms of individuals. Such strategies include increasing the environmental knowledge of individuals to heighten their awareness of environmental problems and the impact of their actions on the environment [5,8]. Structural strategies are designed to change the circumstances under which behavioral choices are made and include changing the availability and the actual costs and benefits of behavioral alternatives. Enforcing legal regulations and imposing certain types of punishments on those who violate them is one way to change the costs and benefits of behavioral alternatives, presenting one feasible structural strategy [5,8]. Many policy instruments for sustainability require action and enforcement by local governments. The extent to which these instruments actually work may depend on how strongly individuals perceive the effectiveness of government enforcement [9]. Therefore, based on the TPB and targeting the WWT behavior of swine farmers, this study includes two intervention factors representing two intervention strategies, i.e., environmental knowledge and perceived effectiveness of enforcement, in the TPB, and it investigates the effects of the two intervention factors on the WWT behavior of swine farmers. Identifying feasible interventions is helpful in encouraging swine farmers to engage in pro-environmental behaviors.

The swine industry has remained the core of Taiwan's livestock industry. Taking 2015 as an example, we note that the output value of swine reached 71.7 billion NT dollars, accounting for 43.77% of livestock products in Taiwan, and the output value of livestock products accounted for more than 30% of Taiwan's agricultural output [10]. Wastewater from swine farming has a substantial impact on the environment. Hog washing lots produce a large amount of wastewater. Moreover, Taiwan is located in a subtropical region. Additional water must be used to cool lots due to the heat of the summer. The government uses various management instruments to protect the environment, including increasing farmers' environmental knowledge through short-term training courses and strengthening the enforcement and control of regulations [11]. Therefore, understanding the factors and intervention strategies that affect swine farmers' WWT behavior is crucial to guide swine farmers to behave in a pro-environmental manner and to minimize the impact of swine farming on the environment.

In summary, the main objective of this study is to assess and compare the effects of two intervention strategies on the WWT behavior of swine farmers in Taiwan. The two intervention strategies are increasing farmers' environmental knowledge and enhancing the enforcement of environmental regulations. This study has three specific objectives. First, regarding the classic TPB model, this study examines the relationships among WWT behavior, behavioral intentions, and three cognitive antecedents (attitude, subjective norms, and PBC). Second, this study designs an extended TPB model for assessing intervention strategies. Last, using the extended TPB model, this study compares intervention strategies empirically.

This study contributes to the existing literature in three aspects. First, this study advances our understanding of the cognitive antecedents affecting the WWT behavior of swine farmers. In particular, the behavior is characterized by high cost and high constraint, characteristics not fully discussed in previous studies on pro-environmental behavior. Second, this study provides a novel framework to compare the effects of different intervention strategies. To capture the assertion of intervention strategies, the intervention factors are designed to affect the cognitive antecedents. By doing so, this study enables the classic TPB model to become a management tool for environmental policy. Last, this study uncovers the effects of two intervention strategies on pro-environmental behavior, which is useful for environmental policy making.

The remaining sections are organized as follows. Section 2 introduces our conceptual framework and hypotheses, which are grounded in studies of pro-environmental behavior using the TPB and studies of intervention strategies. Human behavior is context-dependent; thus, Section 2.2 briefly introduces the status of intervention strategies in Taiwan. Section 3 describes our sample and method. Section 4 reports the analytical results. The last section discusses the findings of the analysis and concludes with implications and research limitations.

2. Literature Review and Conceptual Framework

2.1. The Theory of Planned Behavior

The TPB provides a framework for investigating the factors that influence the behavioral choices of individuals. The framework conceptualizes the strength of behavioral intentions as an immediate antecedent of behavior, where intention captures how much of an effort people are willing to exert to perform a given behavior. Behavioral intentions have three cognitive antecedents: attitude, subjective norms, and PBC. Attitude refers to individuals' favorable or unfavorable beliefs about the consequences of a target behavior. Subjective norms capture the opinions of social reference groups regarding whether individuals should engage in a behavior. PBC involves the perceived ease or difficulty of performing a behavior [6,12]. Behavioral intentions fully mediate the effects of attitude and subjective norms on behavior, and PBC plays a dual role in the TPB. In situations where an individual has a very high degree of control over a behavior, behavioral intentions are a sufficient predictor of the individual exerting effort and taking actions to exhibit the behavior. In such situations, behavioral intentions fully mediate the effect of PBC on behavior. However, in situations where the action depends on certain nonmotivational factors, such as opportunities and resources, PBC can contribute to predicting the behavior through the partial mediating effect of behavioral intentions [6,12].

The TPB successfully explains various pro-environmental behaviors and intentions of individuals, such as household recycling intention [13] and waste classification intention [14]. Prior empirical studies have also applied the TPB to investigate livestock farmers' behaviors with regard to animal welfare [15,16]. To strategically guide farmers' behavior, this study examines the effects of two possible intervention strategies on the WWT of swine farmers by including two intervention factors in the TPB. The first factor is environmental knowledge, which among all possible informational strategies represents the strategy of increasing the environmental knowledge of farmers. The second is perceived effectiveness of enforcement, which among all possible structural strategies represents the strategy of imposing enforcement and environmental regulatory monitoring. Moreover, interventions are more

effective to the extent that they target relevant determinants of behavior [8]. Thus, the intervention factors have several relationships among the determinants of the WWT behavior of swine farmers. Figure 1 shows the proposed conceptual model, and the following subsections discuss the hypothesized relationships among the factors in the conceptual model.

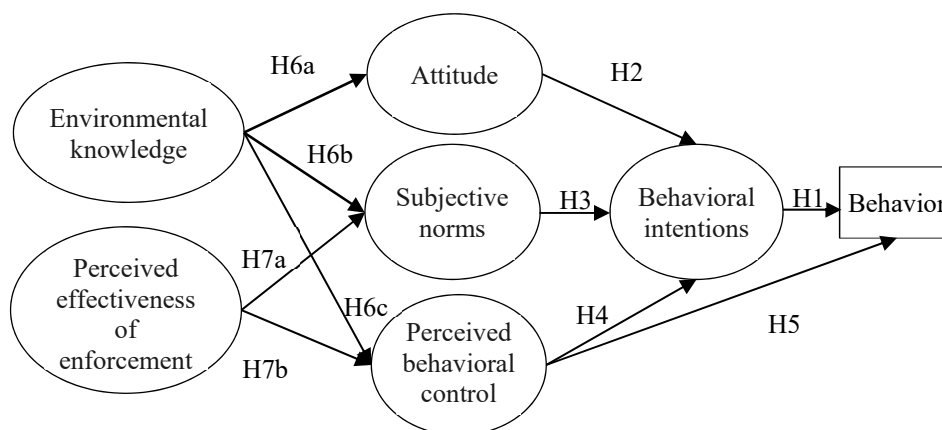


Figure 1. Research framework and hypotheses.

2.1.1. Behavioral Intentions

Behavioral intentions capture the motivations that influence a behavior and indicate how hard an individual is willing to try or how much effort a person will exert to perform a behavior. The TPB posits that behavioral intentions are reliable and effective predictors of actual behavior, and this theoretical assumption has been supported by previous empirical studies. For example, in meta-analysis studies of TPB applications, Bamberg and Möser [17] found that behavioral intentions explain an average of 27% of the variance in pro-environmental behaviors. Several studies of waste reduction confirm the influence of behavioral intentions on behavior, e.g., [18]. This study applies the TPB to investigate the determinants of performing WWT behavior; therefore, this study proposes the following:

Hypothesis 1 (H1). *The behavioral intentions of swine farmers to implement WWT have a positive effect on their WWT behavior.*

2.1.2. Attitude

The TPB assumes that three kinds of considerations, i.e., attitude, subjective norms, and PBC, guide human actions. Attitude refers to the degree to which a person has a favorable or unfavorable evaluation of a behavior. Attitudes influence behavioral intentions, which in turn shape people's actions. When a person believes that performing a certain behavior is likely to generate certain good results, his/her attitude towards this behavior will be more positive; in turn, the person will be more willing to perform that behavior. Therefore, the more favorable the attitude is, the stronger the individual's intention to perform the behavior in question [6,12].

Numerous empirical and meta-analyses confirm that attitudes are significant predictors of behavioral intentions [17]. Baumgart-Getz and Prokopy [19] reported a positive correlation between environmental attitude and behavioral intentions in a meta-analysis of 57 studies related to the best management practices adopted by farmers. Recent empirical studies consistently confirm the significant and positive effects of attitude on behavioral intentions, including Chinese contractors' behavioral intentions to reduce construction waste [18], Ethiopian farmers' behavioral intentions to adopt sustainable agricultural practices [20], and American farmers' behavioral intentions to improve water quality [21].

The discharge of swine wastewater has negative effects on the environment, for example, polluting rivers, blackening the land surrounding rivers, and causing such land to smell. If discharge occurs upstream of rivers, the discharge may feed into reservoirs and ultimately affect the daily drinking water of humans [22]. Preventing untreated swine wastewater from being discharged directly into rivers can eliminate these negative effects. This study argues that when farmers understand the good consequences of WWT, their attitude towards WWT treatment will be more positive, and in turn, they will have higher behavioral intentions to perform pollution prevention and WWT. Therefore, this study proposes the following:

Hypothesis 2 (H2). *The attitude of farmers towards swine WWT has a positive effect on their intentions to perform WWT behavior.*

2.1.3. Subjective Norms

The second predictor of intention formation in the TPB is subjective norms. Subjective norms are the perceived social pressure to perform or not perform a particular behavior, which depends on the likelihood that important referent individuals or groups approve or disapprove of performing the given behavior and the person's motivation to comply with the referent in question. Typical reference groups include parents, friends, and colleagues [6].

Previous studies of pro-environmental behaviors identify subjective norms as an essential antecedent of behavioral intentions. For example, subjective norms have a positive effect on farmers' behavioral intentions to use improved grassland management practices in Brazil and Mexico [23] and to adopt sustainable practices in paddy production in Malaysia [24].

Regarding soil and water systems, untreated swine wastewater is a serious pollution source. Such pollution harms neighbors surrounding piggeries and residents downstream of rivers; thus, discharge generates significant negative externalities. Previous studies have found that individuals' actions may be driven not only by narrow self-interest but also by the welfare of others, such as their local community or the natural environment [25,26]. Bishop et al. [27] found that both private and social costs affect farmers' behavioral intentions to adopt manure digester technology. Reimer et al. [28] also found that farmers are willing to reduce profits or increase costs because of "off-farm benefits" when considering water quality. The evidence shows that whether a farmer intends to perform WWT depends on the opinions of referents regarding whether (s)he should do so. Therefore, this study proposes the following:

Hypothesis 3 (H3). *The subjective norms of farmers regarding swine WWT have a positive effect on their intentions to perform WWT behavior.*

2.1.4. Perceived Behavioral Control

PBC refers to the perceived ease or difficulty of performing a behavior, and it is assumed to reflect past experience as well as anticipated impediments and obstacles. The more resources and opportunities individuals believe they possess and the fewer obstacles or impediments they anticipate, the greater their PBC should be. Furthermore, the greater the PBC is, the stronger the individual's intention to perform the behavior under consideration and the higher the individual's intention to engage in the behavior [6].

Previous studies have found that PBC has a positive significant effect on farmers' pro-environmental behavioral intentions [20] and other behavioral intentions, such as diversifying their agricultural production [29].

Swine WWT is not an activity that requires minor changes in lifestyle, such as recycling, saving energy, and buying fair trade foods. WWT is characterized by high behavioral costs and strong

constraints. WWT facilities are very expensive, and their operations require significant water and electricity expenditures. A low level of knowledge and skill with regard to facility operation and a lack of effective training may constrain farmers' intentions and behaviors with regard to engaging in WWT. Therefore, based on the TPB, this study proposes that PBC is a direct predictor of both behavioral intentions and actual behavior, and we hypothesize the following:

Hypothesis 4 (H4). *The PBC of farmers with regard to swine WWT has a positive effect on their intentions to perform WWT behavior.*

Hypothesis 5 (H5). *The PBC of farmers with regard to swine WWT has a positive effect on their WWT behavior.*

2.1.5. Environmental Knowledge

Fryxell and Lo [30] defined environmental knowledge as "a general knowledge of facts, concepts, and relationships concerning the natural environment and its major ecosystems". Mostafa [31] added that this type of knowledge also involves individuals' understanding of the core relationships that may impact the surrounding environment. Environmental knowledge represents an individual's knowledge and awareness of environmental problems and possible solutions to such problems. An increase in knowledge about environmental problems may increase an individual's concern and awareness [17,32].

In previous studies, the relationship between environmental knowledge and pro-environmental attitudes has shown contradictory results. Some studies report that knowledge results in changes in attitude, which in turn affect behavior [5]. The findings of Mostafa [31] indicated that environmental knowledge affects consumer attitudes towards buying green products, which in turn affects consumers' green purchase intentions. Yadav and Pathak [33] also found that consumers' green product purchase intentions can be predicted by environmental knowledge. On the other hand, Vicente-Molina et al. [34] distinguished two types of knowledge: subjective and objective. They found that students' subjective knowledge is important in explaining their pro-environmental behavior; however, objective knowledge is not significant. Similar to the nonsignificant result for the effect of objective knowledge on behavior, Paço and Lavrador [35] found a nonsignificant relationship between knowledge and attitudes towards energy consumption. The above contradictory results seem to indicate that the effect of environmental knowledge may depend on the research objects and behaviors in question.

Different from students and consumers, who are typically discussed in previous studies, swine farmers are our research object; additionally, the behavior in question is a high-cost and inconvenient behavior. Regarding waste reduction behavior, Li, Zuo, Cai and Zillante [18] found that behavior-related knowledge has a significant direct effect on behavior and an indirect effect via attitude. Among studies with farmers as the research object, Baumgart-Getz, Prokopy and Floress [19] performed a meta-analysis of the factors affecting the adoption of agricultural best management practices in the U.S. and found that knowledge was a positive significant predictor of adoption. Therefore, this study argues that the more knowledgeable about the environment swine farmers are, the more they know about the benefits and favorability of WWT with regard to the environment, and the more positive their attitudes towards this treatment behavior. Thus, this discussion leads to the following hypothesis:

Hypothesis 6a (H6a). *Farmers' environmental knowledge has a positive effect on their attitude towards swine WWT.*

Environmental knowledge means that an individual has the ability to identify the symbols, concepts, and behavioral patterns related to environmental protection [36]. This study argues that environmental knowledge enables farmers to understand environmental behaviors that are commonly approved and appreciated by society. This knowledge also increases farmers' awareness of environmental problems, thereby enhancing their altruistic and ecological values. Perceived social

pressure and ecological values prompt their subjective normative concerns to act in a pro-environmental manner. Therefore, this study proposes the following:

Hypothesis 6b (H6b). *Farmers' environmental knowledge has a positive effect on their subjective norms regarding swine WWT.*

A lack of environmental knowledge or information reduces people's perceptions of risk and severity, and this lack has been identified as an important obstacle to pro-environmental behavior [37]. Li et al. [18] showed evidence that behavior-related knowledge has a significant direct effect on behavior and an indirect effect via PBC. Therefore, this study proposes that farmers with more sufficient environmental knowledge are more aware of environmental issues and their root causes and that they will become more motivated to take action with regard to the environment in a more responsible manner [38]. As a result, they will be more willing to control their personal actions to overcome obstacles. This discussion leads to the following hypothesis:

Hypothesis 6c (H6c). *Farmers' environmental knowledge has a positive effect on their PBC with regard to swine WWT.*

2.1.6. Perceived Effectiveness of Enforcement

When acting in a pro-environmental manner is quite costly or difficult, it is challenging for individuals to take sustainable actions through their self-control alone [39]. In such situations, government interventions are crucial to shaping contextual factors that make behaving in a pro-environmental manner more attractive [9,40].

There are several types of policy interventions used by governments in an attempt to ensure that individuals behave in a pro-environmental manner. Among them, rule- or regulatory-based policy instruments are the most commonly applied [9]. Monitoring and enforcement are specific activities related to the implementation of environmental regulations [41,42]. Notably, environmental regulations can achieve the goal of ensuring that individuals act in a pro-environmental manner only when they are properly monitored and enforced by governments and the agencies responsible [42]. A stricter regulation without effective monitoring and enforcement for noncompliance may lead to a more undesirable result than that under the previous looser state of regulation [43].

Several studies provide evidence that the effectiveness of enforcement by governments is crucial for driving the compliance of individuals to reduce wastewater discharge. For example, Shimshack and Ward [44] found that fines for water pollutant violations had reduced violation rates across a studied state by approximately two-thirds in the year after fines were implemented. In a related study, Shimshack and Ward [45] found that when regulators issued fines to other factories, noncompliant factories typically responded to sanctions by emitting less than the legally permitted level. As a result, government enforcement efforts not only generate enforcement deterrent effects but also significantly increase overcompliance [46]. The evidence above indicates the crucial role of effective enforcement in shaping the norms for individuals to behave in a pro-environmental manner [9]. Therefore, this study proposes that when farmers perceive that the government effectively enforces environmental regulations, their motivation to comply to avoid being fined is increased, which in turn leads farmers to perceive higher social pressure to perform WWT. Therefore, this study proposes the following hypothesis:

Hypothesis 7a (H7a). *Farmers' perceived effectiveness of enforcement has a positive effect on their subjective norms regarding WWT behavior.*

Recent evidence demonstrates that a traditional regulatory structure with effective monitoring and enforcement remains a major driver of the environmental compliance decisions of many facilities [46]. For example, Earnhart [47] examined wastewater discharge by plants for the period 1990–1998;

the results showed that both inspection and enforcement threats significantly reduced wastewater discharge. Glicksman and Earnhart [48] studied similar data and found that the threat of inspection resulted in improved environmental performance. The above examples reveal that effective enforcement makes it possible to hand down some type of punishment in the face of legal and regulatory violations, which in turn emphasizes the actual costs and benefits of environmental behavior. Individuals usually choose the behaviors that incur the lowest cost. They weigh the benefits of noncompliance against the potential costs of regulatory punishment if their noncompliance is caught [46]. Therefore, when farmers perceive effective enforcement actions by governments, they realize that the cost of purchasing WWT facilities and maintaining operations is not high compared with the potential cost of regulatory punishment, which in turn leads to a perceived ease of performing WWT. Therefore, this study proposes the following hypothesis:

Hypothesis 7b (H7b). *Farmers' perceived effectiveness of enforcement has a positive effect on their PBC with regard to WWT behavior.*

All hypotheses above are presented in Figure 1.

2.2. Intervention Strategies in Taiwan

The Taiwanese government implements many instruments to improve the environmental knowledge of swine farmers. The following are two examples. First, practitioners in the field of animal husbandry in Taiwan are currently mostly specialized in livestock and poultry breeding, and they do not pay much attention to environmental regulations [49]. Therefore, the Farmers' Academy, a nonprofit organization that was founded by the Council of Agriculture (COA) of the Executive Yuan in 2011 and that aims to improve the quality of agricultural manpower, typically delivers environmental knowledge in training courses that cultivate agricultural managers and agricultural skills (see [50]). Second, the Environmental Protection Administration (EPA) of the Executive Yuan also provides training courses to improve practitioners' knowledge of and skills related to environmental protection [51].

In Taiwan, livestock wastewater, especially wastewater from swine farms, is a major source of pollution. For example, the Carlson trophic state index of a reservoir in southern Taiwan exceeds 70, which means the reservoir has been in a state of eutrophication for a long time. The source of pollution is swine wastewater from the upstream river [52]. Recently, with increasing awareness of environmental protection in Taiwan, piggeries raising more than 200 swine in Taiwan, accounting for approximately 57% of piggeries nationwide, have set up WWT facilities in accordance with a law passed in 2015 [53]. Considering that piggeries raising fewer than 200 swine are mostly owned by small farmers, the government has relaxed the standard and only requires farmers to report how the livestock manure and urine in their piggeries are handled or used [54]. The EPA has levied a fee for the prevention and control of water pollution in the livestock industry since 1 January 2017. According to preliminary statistics, approximately 7800 livestock farms meet levy requirements, and 90% of these farms are piggeries [55]. As a result, swine farmers are bound to improve their water pollution prevention, including purchasing or replacing WWT facilities and improving the environment surrounding their swine farms. However, such improvement increases the costs incurred by swine farms. Privately, some farmers may not be willing to comply with these regulations.

3. Research Design and Method

3.1. Framework and Measures

This study used the research framework depicted in Figure 1 to investigate the relationships among the factors affecting the WWT behavior of swine farmers. The framework contains six constructs. Table 1 presents their abbreviations, operational definitions, measurement items, and the references of

the items. Each item uses a 5-point Likert scale ranging from “strongly disagree” (1) to “strongly agree” (5) to measure farmers’ answers. The items for the attitude, subjective norm, and PBC constructs are designed following the guidelines of previous studies. Below, we illustrate the design of the items for two intervention factors and the dependent variable, i.e., WWT behavior.

This study used subjective (perceived/self-rated) knowledge to measure farmers’ environmental knowledge under the consideration that subjective knowledge has been commonly used in previous studies, e.g., Li, Zuo, Cai and Zillante [18] and Yadav and Pathak [33], and it successfully explains individuals’ pro-environmental behavior [34].

In the field of environmental policy, the term “enforcement” refers to activities that aim to ensure that individuals comply with environmental law [42]. The construct “perceived effectiveness of enforcement” refers to farmers’ perceptions of the effectiveness of enforcement activities. Based on the empirical results regarding the factors affecting a plant’s choice of pollution abatement effort [46], this study designs four measurement items, as shown in Table 1.

The WWT behavior of swine farmers, the key dependent variable, is intended to capture how well swine farmers perform WWT behavior. This study operationalized the behavior variable as how well swine farmers behave in relation to the limits of the effluent standards set by the Taiwanese government. The limits on swine farm discharges are set as follows: (1) biochemical oxygen demand must be lower than 80 ppm, (2) chemical oxygen demand must be lower than 600 ppm, and (3) suspended solids must be lower than 150 ppm [56]. There are two main approaches to complying with these measures. One approach requires farmers to monitor and report their own activities. This form of self-monitoring is widely used in the field of environmental practice. In many countries, regulators substantially rely on the information provided by regulated individuals [57]. The second approach involves inspectors conducting visits to inspect facilities and to take emission samples [42]. Considering the time and cost, this study adopts the first approach, i.e., self-monitoring and reports. The questionnaire lists the discharge limits and requires swine farmers to self-assess and report the effluent level of their swine sites in relation to the limits. The effluent level in the questionnaire also uses a 5-point Likert scale ranging from “significantly underperform” (1) to “significantly outperform” (5) to measure the behavior of farmers.

Table 1. Constructs, operational definitions and measurement items.

<p>1. Environmental Knowledge (EK) Operational definition: The level of knowledge that a farmer believes that (s)he has about wastewater pollution prevention. Items [18,33,34]: EK1: I have a better understanding of environmental issues than other swine farmers. EK2: I fully understand the impact of swine wastewater on the environment. EK3: I can explain the methods of swine WWT and their benefits. EK4: I know how to abate river eutrophication.</p>
<p>2. Perceived Effectiveness of Enforcement (PEE) Operational definition: The perception of a swine farmer of the extent to which the government enforces environmental protection policies. Items [42,46]: PEE1: Our government tries hard to detect whether discharged wastewater violates regulations. PEE2: Our government has sufficient manpower and a sufficient budget to detect whether discharged wastewater violates regulations. PEE3: The government can definitely identify the source of pollution.</p>
<p>3. Attitude (ATT) Operational definition: The degree to which a farmer feels inclined to perform WWT after evaluating its positive and negative consequences. Items [58]: ATT1: I think it is worthwhile to invest in pollution prevention and WWT facilities. ATT2: I think my swine farms must achieve a high level of pollution prevention and treatment. ATT3: I think that discharged swine wastewater should meet the effluent standards.</p>

Table 1. Cont.

4. Subjective Norms (SNs)

Operational definition: The degree to which a farmer believes that reference groups and social pressure influence his/her behavior and decisions.

Items [29,58]:

SN1: People who are very important to me think that a swine farm should perform pollution prevention.

SN2: My friends and relatives think that a piggery should perform WWT.

SN3: My neighbors think that a piggery should perform WWT.

5. Perceived Behavioral Control (PBC)

Operational definition: The degree to which a farmer perceives that implementing WWT is easy for him/her.

Items [29,58,59]:

PBC1: I have enough ability to perform swine WWT.

PBC2: I think it is easy to perform swine WWT.

PBC3: I have sufficient resources to perform swine WWT.

6. Behavioral Intentions (BIs)

Operational definition: The degree to which a swine farmer is willing to perform WWT.

Items [29,60]:

BI1: I will ensure that my piggery continuously performs WWT.

BI2: I will do my best to perform WWT.

BI3: I am willing to adopt better WWT facilities.

3.2. Data Collection

Swine farmers in Taiwan are the population in question. However, there is no established list of Taiwanese swine farmers that can be used to conduct random sampling. Given this situation, this study collected data based on cluster sampling. In Taiwan, swine farmers can obtain many benefits by joining the Swine Industrial Development Association, such as being notified of new government policies, obtaining government subsidies, and obtaining market and industrial information. Therefore, the majority of swine farmers join the association for the benefits. This study selected the Chiayi Swine Industrial Development Association as a cluster and surveyed all the farmer members of the Association when the Association held its General Assembly in May 2018. We administered questionnaires on site. Any farmer willing to complete the questionnaire could obtain a reward of protective clothing. A total of 552 questionnaires were administered, of which 136 valid questionnaires were recovered: the valid recovery rate was 24.6%. On the day of the General Assembly, some farmers expressed that an online electronic questionnaire would be easier to fill out; thus, we sent 114 electronic questionnaires to them via email and obtained 85 valid responses: the valid recovery rate was 75.4%. For swine farmers who were not members of the Association, we compiled a list of such farmers using two databases: the Animal Genetic Resources Information Network in Taiwan (<https://www.angrin.tlri.gov.tw/>) and the Taiwanese Network Piggery (<https://pigbase.angrin.tlri.gov.tw/pigfarm/farm.htm>). After removing invalid information, such as incomplete information, no address, and duplicate addresses, 229 questionnaires were mailed to farmers, and 9 valid questionnaires were recovered. The valid recovery rate was 3.9%. In total, 230 valid questionnaires were obtained. The survey was conducted from 28 May 2018 to 28 June 2018. Hair Jr et al. [61] suggested a minimum sample size of 150 if a model has seven constructs or less, modest communalities, and no under-identified constructs. Our valid sample size is 230, which exceeds the suggested size.

A demographic profile of the included farmers is presented in Table 2. The low percentage of female respondents is in line with the situation in Taiwanese swine farming. More than 60% of the respondents had received higher education at the college level or above. The respondents' ages ranged from 19 to 84 years, with a mean and standard deviation of 46.2 and 14.5 years, respectively. Their experience in swine farming ranged from 1 to 60 years, with a mean and standard deviation of 17.6 and 13.0 years, respectively.

Table 2. Demographic profile of the respondents.

Characteristic	Category	Number of Farmers	Percentage
Gender	Male	197	85.7
	Female	33	14.3
Education	Junior high school or lower	26	11.3
	Senior high school	61	26.5
	University and college	119	51.7
	Master's and doctoral	24	10.4

The Taiwanese swine farming business can be divided into two types: boar breeding and hog raising. In the retrieved samples, 35 (15.2%) and 47 (20.4%) respondents participated in boar breeding and hog raising, respectively. Most farmers participated in both, accounting for 141 (61.3%) farmers. The remaining 7 (3.0%) farmers participated in experimental and internship piggeries. The respondents raised an average of 2332 pigs, with a standard deviation of 3284 pigs. The median number of swine raised was 1200, showing that the scale of the swine farms of the respondents is positively skewed. Considering that the scale of swine farms may also affect WWT behavior, this study included and treated the logarithm of the number of swine raised as a control variable.

Regarding the effluent level of the swine farms evaluated by the respondents, 14 (6%) farms significantly outperform, 51 (22%) farms outperform, 139 farms (60%) just meet, 23 (10%) farms underperform, and 3 (1.3%) farms significantly underperform the regulatory limits.

3.3. Data Analysis Method

When designing our questionnaire, a review of the literature and interviews with experts and swine farmers were undertaken to ensure the content validity of our constructs and items. After collecting the data, the skewness and kurtosis coefficients were used to assess the normality of each measurement item. The results reveal that the deviation of each item from normality was not severe because all the observed skewness and kurtosis coefficients were below 3 and 10, respectively [62].

This study used structural equation modeling (SEM) to evaluate the model and to test the hypotheses. When conducting SEM, this study adopted the two-stage process suggested by Hair Jr, Black, Babin, and Anderson [61], i.e., a measurement model, followed by a structural model. The measurement model was used to assess the adequacy of the measurement items and latent constructs. Confirmatory factor analysis (CFA) was conducted to assess whether the data fit the proposed measurement model and the reliability and validity of the constructs. The structural model was used to test the causal relationships between the independent and dependent variables. Maximum-likelihood estimation was used in the analysis. The packages for analyzing the data include SPSS and AMOS.

4. Results

4.1. Measurement Model: Reliability and Validity

When conducting CFA, multiple indices were used to evaluate the overall model fit. The normed chi-squared (χ^2/DF) was 2.323, which fell in the acceptable range of 1–3. The root mean square error of approximation (RMSEA) was 0.076, which is less than the acceptable level of 0.08 [63]. The goodness-of-fit statistic (GFI) and the adjusted goodness-of-fit statistic (AGFI) were 0.877 and 0.830, respectively. Although the GFI and AGFI values do not exceed the value of 0.9 typically suggested by several studies, Baumgartner and Homburg [64] and Doll and Xia [65] suggested that values above 0.8 are acceptable. The incremental fit index (IFI) and the comparative fit index (CFI) were 0.939 and 0.938, respectively, which were both above 0.9. The parsimonious normed fit index (PNFI) and the parsimony goodness-of-fit index (PGFI) were 0.719 and 0.633, respectively, exceeding the acceptable

level of 0.5. The standardized root mean square residual (SRMR) was 0.056, less than the suggested level of 0.08 [66]. Thus, the measurement model fits the data well.

This study used Cronbach's α and ordinal theta to measure the internal consistency between measurement items. As shown in Table 3, both the α values and the ordinal theta ranged from 0.849 to 0.903, indicating very good reliability because all α values were above the suggested level of 0.8 [62].

Table 3. Results of convergent validity and reliability.

Construct	Item	Factor Loading	SMC	Cronbach's α	Ordinal Theta	Composite Reliability	AVE
EK	EK1	0.837	0.701	0.903	0.903	0.904	0.703
	EK2	0.866	0.751				
	EK3	0.878	0.771				
	EK4	0.769	0.591				
PEE	PEE1	0.79	0.624	0.876	0.876	0.877	0.705
	PEE2	0.864	0.746				
	PEE3	0.862	0.744				
ATT	ATT1	0.802	0.643	0.863	0.863	0.863	0.677
	ATT2	0.832	0.692				
	ATT3	0.834	0.695				
SNs	SN1	0.934	0.872	0.866	0.870	0.872	0.698
	SN2	0.854	0.730				
	SN3	0.701	0.491				
PBC	PBC1	0.826	0.682	0.849	0.854	0.856	0.665
	PBC2	0.772	0.596				
	PBC3	0.846	0.715				
BIs	BI1	0.866	0.750	0.871	0.873	0.876	0.702
	BI2	0.879	0.772				
	BI3	0.764	0.584				

Construct validity was assessed in terms of convergent validity and discriminant validity. First, as shown in Table 3, the standardized factor loading estimates of the measurement items ranged from 0.701 to 0.934. All values exceeded the ideal level of 0.5 [61]. Regarding indicator reliability, the squared multiple correlation (SMC) values indicate that each latent construct captured at least 50% of each item's variance, except in the case of item SN4. Nevertheless, the SMC of SN4 was 0.49, which is quite close to 0.5. The average variance extracted (AVE) values of each construct ranged from 0.665 to 0.705, and all values exceeded the 50% rule of thumb [61]. Construct reliability was measured using composite reliability. The composite reliability values ranged from 0.856 for PBC to 0.904 for environmental knowledge. These values exceeded the suggested threshold of 0.7, suggesting adequate reliability [67]. Taken together, the evidence from the loading estimates, SMC, AVE, and construct reliability supports the convergent validity and internal consistency of our measurement model.

Second, Table 4 shows that the square root of the AVE for each construct (diagonal values) is greater than the interconstruct correlations associated with that construct (values below the diagonal), representing adequate discriminant validity. In summary, the theoretical model shows adequate validity (convergent and discriminant) and reliability.

Table 4. Discriminant validity results.

Construct	EK	PEE	ATT	SNs	PBC	BIs
EK	0.839 *					
PEE	0.064	0.839				
ATT	0.598	0.013	0.823			
SNs	0.503	0.125	0.764	0.835		
PBC	0.483	0.335	0.532	0.495	0.815	
BIs	0.621	0.154	0.701	0.721	0.496	0.838

* The numbers in bold are the square root of the AVE.

In survey-based empirical works, the potential existence of common method bias (CMB) must be assessed when the data used to measure different exogenous and endogenous constructs come from the same respondent [68]. To evaluate the risk of CMB, we conducted Harman's single-factor test [69], which consists of running an exploratory factor analysis of the items of the main constructs of the study. The results show that four factors had eigenvalues higher than 1, and the first factor accounted for approximately 38% of the total variance. Therefore, we conclude that CMB was not a serious enough threat to discredit our interpretations of the analyses.

4.2. Structural Model: Hypothesis Testing

After verifying the measurement model, we used the structural model to test the proposed hypotheses. The values of the fit indices of the structural model were as follows: $\chi^2/DF = 2.139$, RMSEA = 0.071, GFI = 0.874, AGFI = 0.830, IFI = 0.937, CFI = 0.936, PNFI = 0.722, PGFI = 0.762, and SRMR = 0.059. All indices fell in the acceptable ranges, indicating that the proposed theoretical framework shown in Figure 1 fits the data well.

This study also tested the classic TPB model proposed by [6]. The values of the model fit indices presented a good model fit: $\chi^2/DF = 1.889$, RMSEA = 0.062, GFI = 0.934, AGFI = 0.892, IFI = 0.969, CFI = 0.969, PNFI = 0.659, PGFI = 0.569, and SRMR = 0.0373. Then, two models (those of our proposed framework and the TPB) were compared in regard to their explanatory power. The findings show that the variance in behavior explained by our proposed framework (adjusted $R^2 = 0.230$) was higher than that explained by the classic TPB model (adjusted $R^2 = 0.218$), suggesting that the model including two intervention factors explained WWT behavior better than the classic TPB model. The variance in behavioral intentions explained by our proposed framework (adjusted $R^2 = 0.612$) was also higher than that explained by the classic TPB model (adjusted $R^2 = 0.595$); therefore, our model has improved explanatory power in regard to behavioral intentions of WWT. The findings support the inclusion of environmental knowledge and perceived effectiveness of enforcement in the classic TPB model when investigating high-cost and highly constrained pro-environmental behaviors.

Table 5 and Figure 2 present the results of the proposed hypotheses. The standardized path coefficient from BIs to behavior was -0.026 and was not statistically significant at the 0.05 level. Thus, H1 was not supported. The paths from ATT ($\beta = 0.356, p < 0.005$), SNs ($\beta = 0.346, p < 0.005$), and PBC ($\beta = 0.173, p < 0.05$) to BIs were statistically significant, supporting H2, H3, and H4. Thus, ATT, SNs, and PBC significantly affect WWT BIs. The path from PBC to behavior was significant ($\beta = 0.477, p < 0.001$), supporting H5 and indicating that PBC had a significant positive effect on WWT behavior. The paths from EK to ATT ($\beta = 0.615, p < 0.001$), SNs ($\beta = 0.504, p < 0.001$), and PBC ($\beta = 0.523, p < 0.001$) were all significant; thus, H6a, H6b, and H6c were supported, revealing that EK had a significant effect on ATT, SNs, and PBC with regard to WWT behavior. The paths from PEE to SNs ($\beta = 0.117, p < 0.05$) and PBC ($\beta = 0.251, p < 0.001$) supported H7a and H7b, indicating that the effects of PEE on SNs and PBC were significant. The logarithm of the number of swine raised was a control variable in the proposed framework. The findings indicate that the variable affected neither farmers' WWT behavior nor their BIs given that the coefficients of the paths from Ln(Scale) to behavior and BIs were not significant. In summary, all the hypotheses proposed by this study were supported, except for H1 regarding the effect of BIs on behavior.

Table 5. Hypothesis testing results.

Hypothesis	Path	Standardized Estimate	S.E.	C.R.	<i>p</i>	Supported (<i>p</i> < 0.05)
H1	BIs → Behavior	−0.026	0.1	−0.32	0.749	No
H2	ATT → BIs	0.356	0.1	3.015	0.003	Yes
H3	SNs → BIs	0.346	0.112	3.228	0.001	Yes
H4	PBC → BIs	0.173	0.059	2.473	0.013	Yes
H5	PBC → Behavior	0.477	0.088	5.612	<0.001	Yes
H6a	EK → ATT	0.615	0.089	8.216	<0.001	Yes
H6b	EK → SNs	0.504	0.074	6.487	<0.001	Yes
H6c	EK → PBC	0.523	0.093	6.719	<0.001	Yes
H7a	PEE → SNs	0.117	0.037	2.226	0.026	Yes
H7b	PEE → PBC	0.251	0.057	3.917	<0.001	Yes
Control variable	Ln(Scale) → BIs	−0.05	0.019	−1.012	0.311	
Control variable	Ln(Scale) → Behavior	−0.092	0.029	−1.553	0.120	

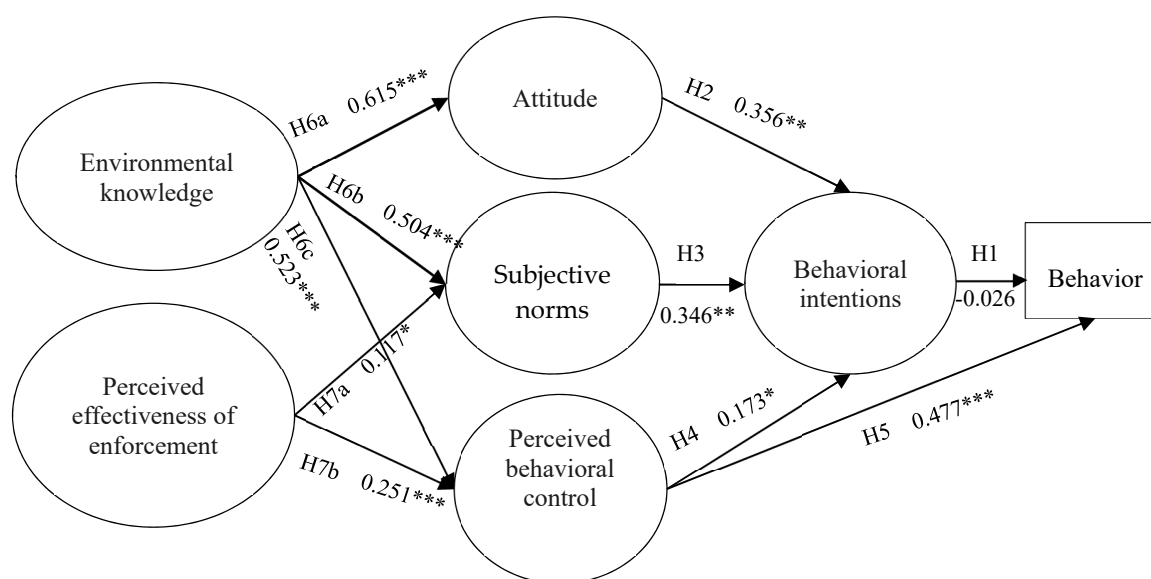


Figure 2. Test results of the research model. Note: * denotes $p < 0.05$; ** denotes $p < 0.01$; *** denotes $p < 0.001$.

The standardized path coefficients in Table 5 indicate the causal linkage between the two constructs in a path. Regarding the classic factors in the TPB, surprisingly, BIs had a nonsignificant effect on behavior. In contrast, PBC had a large and significant effect on behavior ($\beta = 0.477$). Moreover, the effect of ATT on BIs ($\beta = 0.356$) was slightly greater than that of SNs on BIs ($\beta = 0.346$). The effect of PBC on BIs was relatively small ($\beta = 0.173$).

Regarding the first intervention factor, EK, the coefficients reveal that EK had the greatest direct effect on ATT ($\beta = 0.615$), followed by PBC ($\beta = 0.523$) and SNs ($\beta = 0.504$). The other intervention factor, PEE, had only relatively weak direct effects on PBC ($\beta = 0.251$) and SNs ($\beta = 0.117$).

To identify the total effects of the two intervention factors, a bootstrap test was performed at a 95% confidence interval with 5000 bootstrap samples. Table 6 shows the total effect of each exogenous factor on WWT behavior after standardizing all variables. Both intervention factors had a significant total effect on WWT behavior, with a p value less than 0.01. The total effect of EK (0.237) was greater than the effect of PEE (0.117).

Table 6. Total effects of factors on wastewater treatment behavior.

Factors	Point Estimate	Bias-Corrected Confidence Interval		
		Lower	Upper	p-Value
EK	0.237	0.147	0.336	0.001
PEE	0.117	0.048	0.199	0.006
ATT	−0.009	−0.087	0.049	0.670
SNs	−0.009	−0.072	0.031	0.568
PBC	0.472	0.329	0.602	0.001
BIs	−0.026	−0.165	0.13	0.751

5. Discussion and Conclusions

5.1. Discussion

This subsection discusses the findings related to the classic TPB model and the effects of the two intervention factors.

5.1.1. Discussion of the Classic TPB Model

The results suggest that PBC was the direct determinant of WWT behavior; on the other hand, behavioral intentions had a nonsignificant direct effect. This nonsignificant direct effect contradicts most previous findings but is in line with [70]. The nonsignificant relationship between WWT behavior and behavioral intentions may result from behavioral characteristics. Most previous studies have examined behavior requiring minor changes in lifestyle, such as recycling and saving energy. However, WWT behavior is characterized by significant behavioral costs since WWT facilities and daily operations require large expenditures, which directly reduce farm earnings. This result appears to indicate that PBC directly determines the behavioral choice in a situation of high-cost and highly constrained behavior and that behavioral intentions are not sufficiently powerful to drive farmers to perform WWT behavior. When farmers perceive that they can control WWT behavior and are capable of undertaking WWT behavior, they will perform this behavior regardless of how much or how little they actually want to do it.

The three classic factors of the TPB, i.e., attitude, subjective norms, and PBC, all significantly affect behavioral intentions, revealing that more positive attitudes, stronger subjective norms, and greater PBC lead to stronger intentions among farmers to perform WWT behavior. These significant results are in line with those of many previous studies on pro-environmental behaviors, such as contractors' intentions to adopt waste reduction behavior [18] and farmers' intentions to use sustainable practices [20].

Moreover, the magnitude of these effects is, in order, ATT, followed by SNs and PBC. Discharging untreated wastewater generates significant negative externalities, and farmers' attitudes play a primary role in motivating swine farmers to perform WWT behavior.

5.1.2. Discussion of the Intervention Factors

Environmental knowledge had a significant direct effect on the attitude, subjective norms, and PBC of swine farmers, in turn becoming a positive and significant predictor of farmers performing WWT behavior. The results indicate that a deeper knowledge of environmental issues and how to solve them positively affects farmers, inducing them to take actions to protect the environment. The findings are in line with those of many previous studies, such as Vicente-Molina and Fernández-Sáinz [34].

The perceived effectiveness of enforcement had a significant direct effect on PBC, indicating that swine farmers will have greater control over their wastewater discharge and perform this treatment behavior when they perceive that monitoring and enforcement actions are very effective. Therefore, regulatory enforcement ensures that environmental regulations have a strong deterrent effect. Additionally, the perceived effectiveness of enforcement had a significant direct effect on subjective norms. That is, the higher the effectiveness of environmental regulatory monitoring and

enforcement that farmers perceived, the higher the extent of their compliance with environmental regulations, and the greater the norms with regard to WWT according to which swine farmers are judged. The findings reveal that environmental monitoring and enforcement can generate a substantial general deterrent effect. Effective enforcement not only increases the compliance of swine farms but also reduces the discharge of untreated wastewater at other farms and facilities in the regulatory jurisdiction under the pressure of subjective norms. As a result, the compliance area continues to expand [46]. Combining the above two effects, perceived effectiveness of enforcement becomes a significant and positive antecedent explaining the WWT behavior of swine farmers, which is confirmed by the significant total effect of the perceived effectiveness of enforcement on WWT behavior.

Environmental knowledge had a greater effect on WWT behavior than perceived effectiveness of enforcement given that the total effects of EK and PEE were 0.237 and 0.117, respectively. The result indicates that environmental knowledge is more effective than regulatory enforcement in encouraging pro-environmental actions. The strategy of increasing the environmental knowledge of individuals can affect their mindsets without actually changing the external context in which their choices are made. The strategy of enforcement changes contextual factors when individuals make decisions on alternatives. This finding appears to indicate that compared with changing the external context in which an individual is situated, an individual's internal knowledge can shape his/her pro-environmental behavior more effectively. Zsóka et al. [71] found a similar phenomenon in which people's information-seeking with regard to environmental issues is shaped more by internal factors than by external factors.

5.2. Conclusion

The findings in this study have two theoretical implications and one managerial implication. Regarding the theoretical implications, first, the extended TPB model designed in this study is capable of examining intervention strategies, which enables the classic TPB model to become a management tool for environmental policy. Second, improving individuals' environmental knowledge is an informational strategy tool. Steg and Vlek [5] stated that informational strategies are especially effective when pro-environmental behavior is relatively convenient and not very costly and when individuals do not face severe external constraints on such behavior. The WWT behavior discussed in this study is costly and highly constrained. The significant effect of environmental knowledge suggests that the informational strategy of improving the environmental knowledge of individuals is useful even under a situation in which the behavior is costly and highly constrained. Regarding managerial implications, the findings reveal that an individual's internal knowledge can shape his/her pro-environmental behavior more effectively than external factors.

Based on the findings, this study provides four practical suggestions. First, given the significance of environmental knowledge, this study suggests that short-term training course providers should increase the content related to environmental protection. For example, in Taiwan, such content can be increased in training courses on swine production management sponsored and held by the government every year. Furthermore, education plays a fundamental role in solving environmental problems in the long term. Compared to profit maximization, educators should pay more attention to the topic of environmental sustainability in the farm management curriculum. Second, considering the significance of the perceived effectiveness of enforcement, this study suggests that regulators should invest resources in environmental monitoring and enforcement. A small investment can induce changes in farmers' WWT behavior and achieve a large improvement in environmental quality. Third, a combination of two strategies associated with the two factors, i.e., increasing individuals' environmental knowledge and enhancing enforcement, will be beneficial for inducing sustained WWT behavior. Last, compared to monitoring and enforcement actions, resources should be allocated to increasing individuals' environmental knowledge.

5.3. Limitations and Directions for Future Research

This study has two limitations. First, there is no established list of population members in Taiwan, so cluster sampling is the only probability sampling method that can be applied. However, this study could not interview all the swine farmers in our selected cluster because of our limited power. Second, the level of WWT behavior in this study is based on the self-reporting of the respondents, so the survey results may have a degree of social expectation bias.

This study found that behavioral intentions had no significant effect on WWT behavior. This result contradicts the results of many previous studies. Future research should retest and establish a causal relationship between influencing factors and pro-environmental behaviors characterized by high costs, high inconvenience, and high operational knowledge.

This study extends the TPB by comparing two intervention strategies. However, there are various intervention strategies that managers can select, such as persuasion strategies and commitment strategies [5]. Future studies should test other strategies and compare their performance in guiding individuals to act in a pro-environmental manner.

Author Contributions: Conceptualization by M.-Y.W. and S.-M.L.; formal analysis by M.-Y.W. and S.-M.L.; investigation by M.-Y.W. and S.-M.L.; data curation by S.-M.L.; writing by M.-Y.W.; supervision by M.-Y.W.; and funding acquisition by M.-Y.W. All authors have read and agreed to the published version of the manuscript.

Funding: This paper is funded by the Ministry of Science and Technology of Taiwan to National Chiayi University [grant numbers MOST 106-2410-H-415-045].

Conflicts of Interest: The authors declare no conflict of interest.

References

- Cheng, D.; Ngo, H.H.; Guo, W.; Chang, S.W.; Nguyen, D.D.; Liu, Y.; Wei, Q.; Wei, D. A critical review on antibiotics and hormones in swine wastewater: Water pollution problems and control approaches. *J. Hazard. Mater.* **2020**, *387*, 121682. [[CrossRef](#)] [[PubMed](#)]
- Thi Thu Nguyen, H.; Hung, R.-J.; Lee, C.-H.; Thi Thu Nguyen, H. Determinants of Residents' E-Waste Recycling Behavioral Intention: A Case Study from Vietnam. *Sustainability* **2019**, *11*, 164. [[CrossRef](#)]
- Joo, Y.; Seok, H.; Nam, Y. The Moderating Effect of Social Media Use on Sustainable Rural Tourism: A Theory of Planned Behavior Model. *Sustainability* **2020**, *12*, 4095. [[CrossRef](#)]
- Zhang, L.; Sheng, L.; Zhang, W.; Zhang, S. Do Personal Norms Predict Citizens' Acceptance of Green Transport Policies in China. *Sustainability* **2020**, *12*, 5090. [[CrossRef](#)]
- Steg, L.; Vlek, C. Encouraging pro-environmental behaviour: An integrative review and research agenda. *J. Environ. Psychol.* **2009**, *29*, 309–317. [[CrossRef](#)]
- Ajzen, I. The theory of planned behavior. *Organ. Behav. Hum. Decis. Process.* **1991**, *50*, 179–211. [[CrossRef](#)]
- Messick, D.M.; Brewer, M.B. *Solving Social Dilemmas: A Review*; Sage: Beverly Hills, CA, USA, 1983; Volume 4.
- Abrahamse, W.; Steg, L.; Vlek, C.; Rothengatter, T. A review of intervention studies aimed at household energy conservation. *J. Environ. Psychol.* **2005**, *25*, 273–291. [[CrossRef](#)]
- Dawkins, E.; André, K.; Axelsson, K.; Benoist, L.; Swartling, Å.G.; Persson, Å. Advancing sustainable consumption at the local government level: A literature review. *J. Clean. Prod.* **2019**, *231*, 1450–1462. [[CrossRef](#)]
- COA. Output value of agriculture, forestry, fishery and livestock products. In *Overview of Agricultural Statistics*; Council of Agriculture Executive Yuan, Ed.; Council of Agriculture: Taipei, Taiwan, 2017; Volume 2017.
- EPA. *Environmental White Paper*; Environmental Protection Administration Executive Yuan, Ed.; Environmental Protection Administration: Taipei, Taiwan, 2016.
- Ajzen, I. From intentions to actions: A theory of planned behavior. In *Action Control*; Kuhl, J., Beckmann, J., Eds.; Springer: Berlin/Heidelberg, Germany, 1985; pp. 11–39.
- Wan, C.; Shen, G.Q.; Yu, A. The role of perceived effectiveness of policy measures in predicting recycling behaviour in Hong Kong. *Resour. Conserv. Recycl.* **2014**, *83*, 141–151. [[CrossRef](#)]
- Tian, M.; Pu, B.; Chen, Y.N.; Zhu, Z.A. Consumer's Waste Classification Intention in China: An Extended Theory of Planned Behavior Model. *Sustainability* **2019**, *11*, 6999. [[CrossRef](#)]

15. Bruijnjs, M.; Hogeveen, H.; Garforth, C.; Stassen, E. Dairy farmers' attitudes and intentions towards improving dairy cow foot health. *Livest. Sci.* **2013**, *155*, 103–113. [[CrossRef](#)]
16. de Lauwere, C.; van Asseldonk, M.; van't Riet, J.; de Hoop, J.; ten Pierick, E. Understanding farmers' decisions with regard to animal welfare: The case of changing to group housing for pregnant sows. *Livest. Sci.* **2012**, *143*, 151–161. [[CrossRef](#)]
17. Bamberg, S.; Möser, G. Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour. *J. Environ. Psychol.* **2007**, *27*, 14–25. [[CrossRef](#)]
18. Li, J.; Zuo, J.; Cai, H.; Zillante, G. Construction waste reduction behavior of contractor employees: An extended theory of planned behavior model approach. *J. Clean. Prod.* **2018**, *172*, 1399–1408. [[CrossRef](#)]
19. Baumgart-Getz, A.; Prokopy, L.S.; Floress, K. Why farmers adopt best management practice in the United States: A meta-analysis of the adoption literature. *J. Environ. Manag.* **2012**, *96*, 17–25. [[CrossRef](#)]
20. Zeweld, W.; Van Huylbroeck, G.; Tesfay, G.; Speelman, S. Smallholder farmers' behavioural intentions towards sustainable agricultural practices. *J. Environ. Manag.* **2017**, *187*, 71–81. [[CrossRef](#)]
21. Floress, K.; García de Jalón, S.; Church, S.P.; Babin, N.; Ulrich-Schad, J.D.; Prokopy, L.S. Toward a theory of farmer conservation attitudes: Dual interests and willingness to take action to protect water quality. *J. Environ. Psychol.* **2017**, *53*, 73–80. [[CrossRef](#)]
22. Willems, J.; van Grinsven, H.J.M.; Jacobsen, B.H.; Jensen, T.; Dalgaard, T.; Westhoek, H.; Kristensen, I.S. Why Danish pig farms have far more land and pigs than Dutch farms? Implications for feed supply, manure recycling and production costs. *Agric. Syst.* **2016**, *144*, 122–132. [[CrossRef](#)]
23. Borges, J.A.R.; Oude Lansink, A.G.J.M.; Marques Ribeiro, C.; Lutke, V. Understanding farmers' intention to adopt improved natural grassland using the theory of planned behavior. *Livest. Sci.* **2014**, *169*, 163–174. [[CrossRef](#)]
24. Terano, R.; Mohamed, Z.; Shamsudin, M.N.; Latif, I.A. Factors Influencing Intention to Adopt Sustainable Agriculture Practices among Paddy Farmers in Kada, Malaysia. *Asian J. Agric. Res.* **2015**, *9*, 268–275. [[CrossRef](#)]
25. Czap, N.V.; Czap, H.J.; Khachatryan, M.; Lynne, G.D.; Burbach, M. Walking in the shoes of others: Experimental testing of dual-interest and empathy in environmental choice. *J. Socio-Econ.* **2012**, *41*, 642–653. [[CrossRef](#)]
26. Van Vugt, M. Averting the tragedy of the commons: Using social psychological science to protect the environment. *Curr. Dir. Psychol. Sci.* **2009**, *18*, 169–173. [[CrossRef](#)]
27. Bishop, C.P.; Shumway, C.R.; Wandschneider, P.R. Agent Heterogeneity in Adoption of Anaerobic Digestion Technology: Integrating Economic, Diffusion, and Behavioral Innovation Theories. *Land Econ.* **2010**, *86*, 585–608. [[CrossRef](#)]
28. Reimer, A.P.; Thompson, A.W.; Prokopy, L.S. The multi-dimensional nature of environmental attitudes among farmers in Indiana: Implications for conservation adoption. *Agric. Hum. Values* **2012**, *29*, 29–40. [[CrossRef](#)]
29. Senger, I.; Borges, J.A.R.; Machado, J.A.D. Using the theory of planned behavior to understand the intention of small farmers in diversifying their agricultural production. *J. Rural. Stud.* **2017**, *49*, 32–40. [[CrossRef](#)]
30. Fryxell, G.E.; Lo, C.W.H. The Influence of Environmental Knowledge and Values on Managerial Behaviours on Behalf of the Environment: An Empirical Examination of Managers in China. *J. Bus. Ethics* **2003**, *46*, 45–69. [[CrossRef](#)]
31. Mostafa, M.M. A hierarchical analysis of the green consciousness of the Egyptian consumer. *Psychol. Mark.* **2007**, *24*, 445–473. [[CrossRef](#)]
32. Kollmuss, A.; Agyeman, J. Mind the Gap: Why do people act environmentally and what are the barriers to pro-environmental behavior? *Environ. Educ. Res.* **2002**, *8*, 239–260. [[CrossRef](#)]
33. Yadav, R.; Pathak, G.S. Young consumers' intention towards buying green products in a developing nation: Extending the theory of planned behavior. *J. Clean. Prod.* **2016**, *135*, 732–739. [[CrossRef](#)]
34. Vicente-Molina, M.A.; Fernández-Sáinz, A.; Izagirre-Olaizola, J. Environmental knowledge and other variables affecting pro-environmental behaviour: Comparison of university students from emerging and advanced countries. *J. Clean. Prod.* **2013**, *61*, 130–138. [[CrossRef](#)]
35. Paço, A.; Lavrador, T. Environmental knowledge and attitudes and behaviours towards energy consumption. *J. Environ. Manag.* **2017**, *197*, 384–392. [[CrossRef](#)] [[PubMed](#)]
36. Laroche, M.; Bergeron, J.; Barbaro-Forleo, G. Targeting consumers who are willing to pay more for environmentally friendly products. *J. Consum. Mark.* **2001**, *18*, 503–520. [[CrossRef](#)]
37. Devitt, C.; O'Neill, E.; Waldron, R. Drivers and barriers among householders to managing domestic wastewater treatment systems in the Republic of Ireland; implications for risk prevention behaviour. *J. Hydrol.* **2016**, *535*, 534–546. [[CrossRef](#)]

38. Barber, N.; Taylor, C.; Strick, S. Wine consumers' environmental knowledge and attitudes: Influence on willingness to purchase. *Int. J. Wine Res.* **2009**, *1*, 59–72. [CrossRef]
39. Shortle, J.S.; Ribaud, M.; Horan, R.D.; Blandford, D. Reforming Agricultural Nonpoint Pollution Policy in an Increasingly Budget-Constrained Environment. *Environ. Sci. Technol.* **2012**, *46*, 1316–1325. [CrossRef] [PubMed]
40. Wolff, F.; Schönherr, N. The impact evaluation of sustainable consumption policy instruments. *J. Consum. Policy* **2011**, *34*, 43–66. [CrossRef]
41. Beunen, R.; van der Knaap, W.G.M.; Biesbroek, G.R. Implementation and integration of EU environmental directives. Experiences from The Netherlands. *Environ. Policy Gov.* **2009**, *19*, 57–69. [CrossRef]
42. Tosun, J. Environmental Monitoring and Enforcement in Europe: A Review of Empirical Research. *Environ. Policy Gov.* **2012**, *22*, 437–448. [CrossRef]
43. Cohen, M.A. Monitoring and Enforcement of Environmental Policy. 1998, Volume 12018, p. 63. Available online: <https://ssrn.com/abstract=120108> (accessed on 22 March 2020).
44. Shimshack, J.P.; Ward, M.B. Regulator reputation, enforcement, and environmental compliance. *J. Environ. Econ. Manag.* **2005**, *50*, 519–540. [CrossRef]
45. Shimshack, J.P.; Ward, M.B. Enforcement and over-compliance. *J. Environ. Econ. Manag.* **2008**, *55*, 90–105. [CrossRef]
46. Gray, W.B.; Shimshack, J.P. The Effectiveness of Environmental Monitoring and Enforcement: A Review of the Empirical Evidence. *Rev. Environ. Econ. Policy* **2011**, *5*, 3–24. [CrossRef]
47. Earnhart, D. Regulatory factors shaping environmental performance at publicly-owned treatment plants. *J. Environ. Econ. Manag.* **2004**, *48*, 655–681. [CrossRef]
48. Glicksman, R.L.; Earnhart, D. The comparative effectiveness of government interventions on environmental performance in the chemical industry. *Stanf. Environ. Law J.* **2007**, *26*, 317–371.
49. *Plan of Resource Recovery and Management of Livestock Waste*; Council of Agriculture Executive Yuan, Ed.; Council of Agriculture: Taipei, Taiwan; Volume 2020, pp. 109–112. Available online: <https://www.coa.gov.tw/ws.php?id=2508879> (accessed on 15 March 2020). (In Chinese)
50. Training Courses of Farmer Academy. Available online: <https://academy.coa.gov.tw/> (accessed on 15 March 2020).
51. *Environmental White Paper 2018*; Environmental Protection Administration Executive Yuan, Ed.; 2019. Available online: <https://www.epa.gov.tw/Page/7C2D9BA3EB15D2FA> (accessed on 15 March 2020). (In Chinese)
52. *Environmental Water Quality Monitoring Annual Report 2018*; Environmental Protection Administration Executive Yuan, Ed.; 2019. Available online: <https://wq.epa.gov.tw/Code/Report/ReportShow.aspx?ID=78> (accessed on 15 March 2020).
53. *Environmental White Paper 2016*; Environmental Protection Administration Executive Yuan, Ed.; Environmental Protection Administration: Taipei, Taiwan, 2017. Available online: <https://www.epa.gov.tw/Page/7C2D9BA3EB15D2FA> (accessed on 15 March 2020). (In Chinese)
54. *Swine Industry Wastewater Management Plan*; Environmental Protection Administration Executive Yuan, Ed.; Taipei; 2019. Available online: https://water.epa.gov.tw/Page2_9.aspx (accessed on 15 March 2020). (In Chinese)
55. *EPA Levies Fees for Water Pollution Prevention on Livestock Farming*; Environmental Protection Administration: Taipei; 2017. Available online: http://enews.epa.gov.tw/enews/fact_Newsdetail.asp?InputTime=1060105105426 (accessed on 15 March 2020).
56. *Effluent Standards: Table 8*; Environmental Protection Administration Executive Yuan, Ed.; Environmental Protection Administration; 2019; Volume 8. Available online: <https://oaout.epa.gov.tw/law/EngLawQuery.aspx> (accessed on 15 March 2020).
57. Read, P.; Fernandes, T. Management of environmental impacts of marine aquaculture in Europe. *Aquaculture* **2003**, *226*, 139–163. [CrossRef]
58. Wan, C.; Shen, G.Q.; Choi, S. Experiential and instrumental attitudes: Interaction effect of attitude and subjective norm on recycling intention. *J. Environ. Psychol.* **2017**, *50*, 69–79. [CrossRef]
59. Han, H.; Hsu, L.-T.; Sheu, C. Application of the Theory of Planned Behavior to green hotel choice: Testing the effect of environmental friendly activities. *Tour. Manag.* **2010**, *31*, 325–334. [CrossRef]
60. Ha, H.Y.; Janda, S. Predicting consumer intentions to purchase energy-efficient products. *J. Consum. Mark.* **2012**, *29*, 461–469. [CrossRef]
61. Hair, J.F., Jr.; Black, W.C.; Babin, B.J.; Anderson, R.E. *Multivariate Data Analysis*, 7th ed.; Pearson Education Inc.: Upper Saddle River, NJ, USA, 2010.
62. Kline, R.B. *Principles and Practice of Structural Equation Modeling*, 3rd ed.; The Guilford Press: New York, NY, USA, 2011.

63. McDonald, R.P.; Ho, M.-H.R. Principles and practice in reporting structural equation analyses. *Psychol. Methods* **2002**, *7*, 64–82. [[CrossRef](#)]
64. Baumgartner, H.; Homburg, C. Applications of structural equation modeling in marketing and consumer research: A review. *Int. J. Res. Mark.* **1996**, *13*, 139–161. [[CrossRef](#)]
65. Doll, W.J.; Xia, W.; Torkzadeh, G. A Confirmatory Factor Analysis of the End-User Computing Satisfaction Instrument. *MIS Q.* **1994**, *18*, 453–461. [[CrossRef](#)]
66. Hu, L.T.; Bentler, P.M. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Struct. Equ. Model. Multidiscip. J.* **1999**, *6*, 1–55. [[CrossRef](#)]
67. Bagozzi, R.P.; Yi, Y. On the evaluation of structural equation models. *J. Acad. Mark. Sci.* **1988**, *16*, 74–94. [[CrossRef](#)]
68. Podsakoff, P.M.; MacKenzie, S.B.; Lee, J.-Y.; Podsakoff, N.P. Common method biases in behavioral research: A critical review of the literature and recommended remedies. *J. Appl. Psychol.* **2003**, *88*, 879–903. [[CrossRef](#)] [[PubMed](#)]
69. Podsakoff, P.M.; Organ, D.W. Self-Reports in Organizational Research: Problems and Prospects. *J. Manag.* **1986**, *12*, 531–544. [[CrossRef](#)]
70. Zhu, J.-L.; Li, J.-R. Construction Personnel Attitude and Behavior on Construction Waste Minimization. *J. Civ. Eng. Manag.* **2012**, *29*, 39–44.
71. Zsóka, Á.; Szerényi, Z.M.; Széchy, A.; Kocsis, T. Greening due to environmental education? Environmental knowledge, attitudes, consumer behavior and everyday pro-environmental activities of Hungarian high school and university students. *J. Clean. Prod.* **2013**, *48*, 126–138. [[CrossRef](#)]



© 2020 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<http://creativecommons.org/licenses/by/4.0/>).