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Conservation technology adoption decisions and the theory of planned behavior ☆

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Abstract

This study of water saving technology adoption and technology investment behavior for Florida strawberry farmers represents an application of the Theory of Planned Behavior. It is compared with the Theory of Reasoned Action, and the Theory of Derived Demand. The focus is on perceived control in the decisions, first, to become an adopter of conservation technology, and, second, to invest more capital in the technology. The results lend credence to the Planned Behavior Theory but also support Derived Demand Theory, in that actual financial capability (actual control) is found important. To predict technology adoption we may need to account for both perceived and actual control. Unfettered government control of farmer technology decisions could be counterproductive, suggesting technology policy may need to include a mix of moral suasion and incentives with more modest controls.

1. Introduction

The agricultural technology diffusion/adoption research tradition has historically been to view farmers as voluntaristic decision makers (Van Es, 1984), i.e., to assure that farmers have virtually full control over the

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decision to invest in agricultural technology. This view served researchers and US policy makers well at an earlier time when less control was being exerted over farm-level decision making. It also supports the main economic paradigm, which presumes full volition on the part of the farmer to choose technologies within the bounds of a cost/capital constraint (see Feder and Umali, 1993).

With contemporary concerns in the US over pesticide and fertilizer pollution, soil erosion and water waste, farmers are subjected to more scrutiny and control by government agencies. Florida farmers complain of "micro-management" by state government. De facto technology standards are often specified, e.g., irrigation efficiency standards of 80 percent (compared to 50–60 percent in practice). These standards can be met only with certain kinds of technologies. In some cases, irrigation technology mandates are even more directed and specific, e.g., "use drip irrigation" (and, in one case, "use the brand X micro drip device"). Staff are given authority to force compliance with technology standards. Agency staff also act to persuade farmers, based on perceptions of what is in the public interest, and thus indicate the social norm for farmer action.

This paper explores the influence of perceived control on the decision, first, to switch from being a nonadopter to being an adopter of a water saving irrigation technology, and, second, once an adopter, the influence of perceived control on how much capital is actually invested. We separate out the influence of actual control on the same decisions. We found only one other test of this Theory of Planned Behavior for investment decisions, by East (1993, p. 339), who argues it should prove useful in explaining a variety of commercial decisions, including investments.

2. The theory of planned behavior

The Theory of Planned Behavior adds perceived control to the Theory of Reasoned Action (Ajzen and Fishbein, 1980), the latter encompassing attitude (A) toward and the subjective norm (SN) of the behavior (B) as key variables under conditions of complete volitional control. In addition, perceived behavioral control (PBC) is viewed as affecting both intention (I) and behavior (Ajzen, 1988; Ajzen, 1991). The concept accounts for perceptions about the "availability of requisite opportunities and resources" (Ajzen, 1991; p. 182), which may differ from actual control (AC) (Beck and Ajzen, 1991; p. 287).

The model becomes

$$B \sim I = \gamma_1 \sum_{i=1}^{s} b_i e_i + \gamma_2 \sum_{j=1}^{t} n_j m_j + \gamma_3 \sum_{k=1}^{v} c_k p_k,$$

$$= \gamma_1 A + \gamma_2 \mathrm{SN} + \gamma_3 \mathrm{PBC}, \quad (1)$$

where b_i = a behavioral belief ($i = 1,...,11$) directed at the target behavior, in this case, adopting water saving technology; e_i = the evaluation of the consequences ($i = 1,...,11$) from adopting water saving technology; $A = \sum_i b_i e_i$, the summation of the products of behavioral beliefs and evaluations; n_j = normative belief j ($j = 1,...,11$) pertaining to the perceived subjective norm for this target behavior; m_j = motivation to comply j ($j = 1,...,11$), in effect, another evaluation in this case directed at the referent group; $\mathrm{SN} = \sum_j n_j m_j$, the (perceived) subjective norm regarding what is appropriate technology adoption behavior; c_k = control belief k ($k = 1,2$) about perceived control over the decision to adopt technology; p_k = perceived power of the particular control factor ($k = 1,2$) to facilitate or inhibit performance of the behavior, another evaluative component; $\mathrm{PBC} = \sum_k c_k p_k$,, the perceived behavioral control over the decision to become an adopter of conservation technology, and then in the case of the adopter to invest more heavily in the technology. And, with actual control

$$= \gamma_1 A + \gamma_2 \mathrm{SN} + \gamma_3 \mathrm{PBC} + \gamma_4 AC \quad (2)$$

For this application, behavior (B) is measured with a zero for the non-adopter, and with dollars invested in the water saving technology by the adopter. The attitude (A) and subjective norm (SN) parts represent the original Theory of Reasoned Action as developed by Fishbein (see Fishbein and Ajzen, 1975). Recently, Ajzen (1991) added perceived behavioral control (PBC) and renamed it the Theory of Planned Behavior, which recognized there is probably a continuum that tends from total control and full volition with no constraints to a complete lack of control and no volition. This theory suggests there may be an intermediate point for many behaviors (Godin et al., 1993, p. 82).

The reason that Ajzen (1991, p. 181) added perceived behavioral control to the model was to overcome its limitations when "dealing with behaviors over which people have incomplete volitional control" due, for example, to current abilities, or to currently available financial resources. Notably, the

sense of the word control in the theory refers to volition as compared to something less than full volition, or less than full control. Contrast this notion with that of personal construct theory (Earl, 1990, p. 732), wherein control refers more to gaining control over one's environment, e.g., possibly buying a drip irrigation system in order to better control yield by regulating the delivery of fertilizer through the drip system. The Ajzen concern appears somewhat different with its focus on whether the individual really has control or not over the decision to buy the drip system, and not addressing control over the farming environment.

Ajzen (1991, p. 189) also speculates that only the attitude measure will be an important explanatory variable in some cases. In others, only attitudes and perceived behavior control may be explaining variables. In still others, the social norm and the attitude may be explaining, which would instead support the Theory of Reasoned Action. Whether control in the volitional sense needs to be considered becomes a testable, empirical issue in the Theory.

Economic reasoning suggests the need to add actual financial control, i.e., that self-reports will be inadequate to the task of explaining behavior. Specifically in the Theory of Derived Demand (see, e.g., Beattie and Taylor, 1985), the capital constrained derived demand function is

$$B = f(\text{product prices, technology prices, other input prices, capital}), \tag{3}$$

where behavior (B) in this model represents the amount of technology installed on the farm. For the case where all farmers receive approximately the same prices and all buy similar types of technologies,

$$B = f(\text{capital, or financial ability generally}). \tag{4}$$

We have previously found financial variables to be important supplements to attitude measures in technology adoption modelling (Lynne and Rola, 1988; Lynne et al., 1988). This suggests that actual wealth and income may not be completely mediated through attitudes toward taking some action.

We have some concern, then, about not explicitly including a measure of the actual financial capability of the farmer. First, this capability is probably embedded as a significant component of actual control (Beck and Ajzen, 1991, p. 286). Second, we are suggesting that farmers may not accurately translate real financial capability into perceptions of control.

3. Expectations and hypotheses

A model with interaction of all the scaled components becomes

$$B = \beta_0 + \beta_1(A) + \beta_2(\mathrm{SN}), + \beta_3(A \times \mathrm{SN}) + \beta_4(\mathrm{PBC}) + \beta_5(A \times \mathrm{PBC}) + \beta_6(\mathrm{SN} \times \mathrm{PBC}), + \beta_7(A \times \mathrm{SN} \times \mathrm{PBC}) + \beta_8(\mathrm{AC}) + \epsilon. \quad (5)$$

Behavior (B) is still the action described as "to adopt" and then "to invest" at varying degrees of intensity. The β are estimated with regression procedures (ϵ is the error). We expected β_7 to be significantly greater than 0, i.e., a higher probability of being an adopter and that more capital investing effort would be associated with simultaneous conditions of (1) stronger attitudes favoring the action to adopt the technology, (2) more intense importance attached to what the community (subjective, or social norm) deems appropriate behavior, and (3) more perceived control. We also expected that $\beta_8 > 0$,, i.e., that actual control over spending would be an important force.

It is our hypothesis that a lack of perceived control could lead to the ironic situation that government attempts at control give it less actual control. If borne out, this would not necessarily suggest there should not be controls, but instead that there may need to be a balancing of control against moral suasion and incentives.

4. The setting: strawberry production, water law, and water technology policy in florida

Florida is a leading US producer of many high value crops such as citrus and other fruits, ornamentals and vegetables. A favorable climate gives Florida producers unique market windows in most domestic and some international markets. This same climate advantage gives high temperatures and extensive numbers of sunlit days leading to crops being critically dependent upon irrigation water. Florida has the most irrigated acreage of all states in the eastern US, and ranks eighth overall in the US with over 2 million acres. Most of this acreage is suitable for micro-drip irrigation technology (Smajstrla et al., 1991).

Micro-drip irrigation is a technology using low volume emitters to release water slowly from irrigation piping. It uses less water to irrigate

crops, because of lower evaporation and potentially less deep percolation (water entering groundwater below the root zone of the plant) and water runoff. Micro-drip technology allows more precise water application. Such extra precision, however, always costs more in farmer effort and capital.

The warm winter climate of Florida also attracts large numbers of new residents and millions of tourists annually. This puts ever increasing pressure on the same water supplies with the result being a move by state agencies to "encourage" adoption of water saving technologies like micro-drip. Currently, agriculture withdraws the most water from the state's lakes, rivers and aquifers.

There are potential benefits beyond water savings for the farmer using micro-irrigation technologies. Such technologies may improve strawberry yield and quality. Costs for fertilizer and chemicals may not be reduced, however, if more expensive soluble forms are used. Improved strawberry quality may result from avoiding frequent wetting of the plants' foliage and thus removing conditions favorable for growth of plant pathogens. Fertilizer and chemical use may be reduced due to less water moving through the soil and fields. If labor effort is not increased, however, water could be lost beyond the root zone from operating the system too many hours per day. Water use could also increase due to higher yield from more plant transpiration.

Importantly, initial costs of a new micro-irrigation system may range from $500 to $40,000 per acre, and may be as much as 20 times higher than a conventional irrigation system (Smajstrla et al., 1991). Therefore, the farmer's financial situation will be an important explanatory variable in microdrip adoption.

Florida's agricultural industry generally has not adopted water saving technology to the degree technically feasible. Smajstrla et al. (1991) report that approximately 40 percent of the suitable crop acreage in Florida is under micro-irrigation. It is used extensively in the citrus industry with over 50 percent of the acreage. Micro-irrigation is used on only 11 percent of Florida's large commercial vegetable acreage. The reason for these differences in rate and intensity of water saving technology adoption is poorly understood, and, thus, is an important impetus for this study. There may be implications for Florida technology policy in addition to providing for a further testing of the Theory of Planned Behavior.

Current water technology policy reflects the 1972 Florida Water Resources Act (Florida Statutes, Chp. 373). Its extensive set of rules has led to considerable on-farm influence by government regulators. The designers

envisioned a central-government-run water allocation system (see Maloney et al., 1979). Control was accomplished by creating five regional water management districts all responsible to the Florida Department of Environmental Protection. Technology control is a key feature of these districts, ostensibly to reduce waste. Control is exercised by holding the spectre of permit denial unless the technology standards are met.

The stage was set by unusually cold winter temperatures in the late 1970s and early 1980s. Heavy water use to protect crops from frost and freezing lowered water levels in nearby domestic wells. Local water users requested that farmers reduce pumping, and the Southwest Florida Water Management District became involved. By 1992, 86 percent of the growers had switched to drip irrigation.

5. Questionnaire and sampling

Virtually all the 110 commercial strawberry farmers in Florida are near Plant City (east of Tampa), Florida. A stratified random sample of 51 growers and an additional 33 alternates was drawn. A questionnaire was field tested with six growers, and revisions were made to include what they expressed as more salient behavioral and normative beliefs. The 51 sample members plus alternates, were contacted by telephone to arrange interviews. Those who declined to participate were replaced by an alternate respondent. The questionnaire was administered to 44 farmers representing 44% of the population. The survey was conducted by two graduate students in personal interviews requiring 1 to 2 hours per respondent. The interviewing was conducted during the summer of 1993. Each respondent was informed they were free to refuse to participate, and that they need not answer a sensitive question. No payments were made for participation.

Respondents were asked for data pertaining to the early 1980s through 1992. Usable data were obtained from 40 farmers representing 36 percent of the population. The results are illustrative of what strawberry growers actually do, within a 90 percent confidence interval ± 25 percent of the mean of each variable.

Both global and component attitude variables were developed using format recommendations in Ajzen (1988) and Ajzen and Fishbein (1980). The global attitude (A) statement was "*My installing a drip irrigation system is*" was evaluated on three 7-point semantic differential scales, one cognitive scale (*harmful...beneficial*), and two affective scales (*wise...foolish, and*

good...bad). The 7-point scale descriptors used were *extremely, quite, slightly, neither, slightly, quite, extremely*. The 11 belief components (b_i) had the character, "*A drip irrigation system results in decreasing the amount of water withdrawn from groundwater for crop maintenance*" on the 7-point scale, *extremely likely, quite, slightly, neither, slightly, quite, extremely unlikely*. Each linked component attributes of micro-irrigation to outcomes from adoption (see Doll and Ajzen, 1992, p. 755). The associated subjective evaluations (e_i) were elicited with statements like, "*Less crop maintenance water withdrawn from groundwater is*" on the 7-point scale, *extremely important to me, quite, slightly, neither, slightly, quite, extremely unimportant to me.*

6. Use of the important–unimportant scale

Cohen et al. (1972, p. 457) argue for using a good–bad scale rather than an important–unimportant scale for measuring e_i by critiquing a statement in an unpublished paper by Sheth and Talarzyk, "Attributes for each of the product categories are listed below. I would like to know how important each of these attributes would be to you if you were designing an ideal brand for the category...." They point out how an attribute might in this approach be rated important whether the respondent wanted more of it or less. This is clearly a problem. Also, the concern was raised that the important rating might be used to determine the salience or relevance of some piece of information (Cohen et al., 1972, p. 458).

We avoided both of these problems by shifting the focus away from the attribute, e.g., *groundwater*, toward the action. By including the action verb, e.g., *reducing* groundwater we have eliminated ambiguity. If the respondent says "extremely important" we know that reducing groundwater use is valuable, and can presume that increasing it is not. Also, we did not ask farmers to rank the attributes on the importance scale, and did not apply any weights on attributes so weighted.

Cohen et al. (1972, p. 457), also argue that the evaluative component e_i is to be deemed affective, e.g., good–bad. In more recent papers, however, it has been shown that one may need to recognize both the affective and cognitive dimensions of attitude (see Millar and Millar, 1993, especially p. 19), and that only certain types of behavior are predicted by affective reactions (p. 3, citing Zanna and Rempel, 1988). We believed that specific action changes like "decreasing water use" would be largely cognitive in character and thus we were reluctant to use an affective scale. The

important–unimportant scale directed at cognitive action (changing fertilizer, fuel and water use) might better reflect the farmers attention to cognition rather than emotion.

Using important–unimportant to apply to action also embraces a much richer array of cognitive dimensions. It encompasses such ideas as the action "having value, being worthy, being critical, essential, vital and useful" at the important end of the scale, and offset by ideas like the action "being immaterial, non-essential, irrelevant, incidental and useless" at the unimportant end.

Additionally, Ajzen's "manual" (1988, p. 123) for guiding researchers from other disciplines in this type of research cites the important–unimportant scale applied to an action attribute (*"Using a feeding method that provides complete nourishment for my baby is..." important–unimportant, to me*). Ajzen implies by reference that it is appropriate for measuring evaluation as long as the action and not the attribute itself is the subject of evaluation.

The same approach was used for the subjective norm components, with 11 normative beliefs (n_j) about what referent groups thought to be appropriate behavior, elicited by statements like *"The water management district thinks I should install energy and water conserving technology,"* on the same 7-point *extremely likely, ..., extremely unlikely* scale, and motivation to comply (m_j) measured by such statements as *"In general, what these groups think I should do is (water management district)"* on the same *extremely important to me,..., extremely unimportant to me* scale. Again, as with the attitude components, the importance scale seems appropriate in that we included the action "what I should do is" which focuses the respondent on the action rather than the group.

The perceived behavioral control was based on two control beliefs (c_k), *"How much control do you have over whether you do or do not install a drip irrigation system?"* on the 7-point scale, *extremely complete control, quite, slightly, neither, slightly, quite, extremely little control*, and *"Organizations and agencies can require me to install a drip irrigation system"* on the 7-point scale *extremely likely, ..., extremely unlikely*. The power to comply (p_k) was presumed equal for each statement.

All the attitude, subjective norm and perceived behavioral control components were elicited for both "then, in the early 1980's, about 10 years ago" which was the time when District activities started, and "last year, 1992". The "Then" responses were used in the regressions.

Data were also collected on other attributes of the farmer (e.g., age,

education, years in farming) and the farm (e.g., debt/asset ratio, taxable income from farming, taxable income from all sources, total operated acres including acres in strawberry production). Most were middle-aged, 40 to 60 years old (51%), and 80% had at least 12 years of formal education with 27% having at least some college. Experience in farming averaged 18 years. These variables were not included in the models because they cannot be changed, and also will probably be mediated through the various attitude, norm and control variables (see East, 1993, p. 341). Most farmers declined to answer the financial questions, so total operated acres was used as a proxy for the financial capability of the farmer.

Behavior is measured by a zero (no investment) for the nonadopter, and by the estimated total dollar investment over the period of the early 1980's until 1992. Hierarchical Tobit regression (see Ameniya, 1984) maximum likelihood analysis was applied, starting with the attitude and subjective norms, then progressively adding perceived behavioral control, and then actual control. When the dependent variable is censored or truncated in some way, the Tobit model generally performs more satisfactorily than ordinary least squares regression (Ameniya, 1984, p. 5).

The Tobit likelihood function is composed of a discrete component (not adopt, adopt) and a continuous component (money invested). The presumption in using this function is that the same variables affect both the decision whether or not to adopt, and the decision to invest more capital (Norris and Batie, 1987, p. 84). Maximum likelihood analysis is based on the idea that the sample data are more likely to come from the real world characterized by one set of parameter values than from a world characterized by another set (Kennedy, 1993). The estimates are consistent and asymptotically efficient. The model estimated is the Type I Tobit in Ameniya (1986, Chapter 10).

7. Scaling

Following typical literature, our first inclination was to use a 1:7 scale, checking correlations of components with global measures, and then using the components with high Pearson correlation coefficients in the resulting Tobit regressions. We conceptualized beliefs on a probability scale, so 1:7 seemed appropriate. We conceptualized evaluation as utility in standard economics: it also is not negative so again the unipolar 1:7 scale seemed appropriate.

The question of scales led us to the work by Bagozzi (1984), who demonstrates that one can arrive at any level of the Pearson correlation coefficient between components $b_i e_i$ and the global attitude (A) measure that one wants by simply changing the scale, i.e., the correlation between A and $b_i e_i$ (or the sum of such component parts) is a function of the means of the b_i and e_i (or mean of the sum) components. This fact puts a large share of the literature in social psychology in question as a criterion like "select the belief as salient when the correlation coefficient is greater than some threshold," is now shown to be spurious.

As Bagozzi (1984) demonstrates, the superior approach is multiple regression analyses for the model

$$A = \beta_0 + \beta_1 b_i + \beta_2 e_i + \beta_3 b_i e_i + \xi. \tag{6}$$

The focus is on β_3. If it is significantly different from zero, then this particular $b_i e_i$ represents a salient component of the global A. The advantage of the Bagozzi (1984, p. 300) approach is that the size and sign of β_3 and the R^2 is invariant to the selection of scale.

We did not take a global SN measure. It seemed inappropriate to ask farmers to indicate the global importance of such disparate groups as the family, neighbors, and the water management district. As a result, we simply added the component parts to create the SN index. We did the same for PBC.

The problem of scale was then addressed in the Tobit regressions. We tried bipolar (−3:3) and unipolar (1:7, 0:6), and combinations thereof, e.g., for the subjective norm n_j on 1:7 and m_j on −3:3. The −3:3 scaling has sometimes been shown to give an improvement (see, e.g., Ajzen, 1991, p. 194). The Tobits were checked one against the other using the full model described in Eq. 2. The t-statistics were used as indicative: t-statistics were substantially higher when unipolar scaling was used, which is also consistent with theoretical arguments. That is, beliefs can be thought of as probability scales and evaluation or utility is also best measured as a positive variable. For the latter we found no difference between 0:6 and 1:7 scales.

The fact that the unipolar 1:7 scale seemed to describe these data better also lends support to the expected utility concept in economics and is consistent with our use of the importance scale. There is considerable parallelism between the two concepts, although as Vodopivec (1992, p. 35) has noted, this parallelism needs more theoretical scrutiny, and, we might add, more empirical testing. Warshaw and Dröge (1986) also demonstrate

Table 1
Global attitude as a function of belief X evaluation components, all scales

Belief and evaluation component	β_3	R^3
Reducing fuel and electricity for pumping	0.11[a]	0.10
Increasing labor and management	0.12 [a]	0.10
Reducing yield	0.16 [a]	0.08
Increasing machinery and equipment investment	0.12 [c]	0.17
Reducing farm profit	0.13 [c]	0.15
All components	2.53 [b]	0.28

Notes: From the regressions of global attitude as a function of the belief, evaluation, and belief X evaluative components (see Eq. 6 in text).
[a] $p < 0.05$, [b] $p < 0.02$, [c] $p < 0.01$.

that merging utility and attitude models gives an improvement under conditions of non-volitionality.

Fishbein and Ajzen (1981, p. 345) note that when motivation to comply is treated in a unipolar concept the definition of subjective norm as "what important others think I should do" is "consistent with the cognitive underpinnings of this construct". The 11 normative belief based statements addressed relationships with the immediate family, water management district, state energy office, university extension service, growers association, county environmental protection commission, farmers and growers in the area, local environmental groups, irrigation equipment dealers, homeowners (others) in the community, and, farmers and growers with whom the farmer associated frequently.

8. Results

Results in Table 1 focus on β_3 from Eq. 6 as suggested by Bagozzi. The significant β_3 suggests that the following beliefs are salient: reducing the amount of fuel and electricity used for pumping water, increasing the amount of labor and management effort, reducing yield, increasing machinery and equipment investment, and reducing overall farm profit. Unfortunately, the R^2 is quite low, ranging from 0.08 to 0.17 for each part, and is only 0.28 for the summative index. This suggests that we do not have all of the salient components. Because of the low R^2, we used the global attitude (A) measure instead of the summative parts.

The Pearson correlation coefficients between the variables of Eq. 2 are shown in Table 2. Notice no coefficient is greater than $r = 0.50$ and only a

Table 2
Pearson correlation coefficients and descriptive statistics for behavior variables

A	SN	PBC	AC	DND	$	M	SD	
A	1.00						14	5
SN	0.38 [b]	1.00					314	124
PBC	−0.39 [c]	−0.0	1.00				90	18
AC	0.26	0.15	0.10	1.00			76	180
DND	0.01	0.34 [a]	−0.08	0.02	1.00		0.86	–
$	0.28	0.10	0.04	0.50 [c]	0.34 [a]	1.00	23271	28094

Notes: Attitude (A); Subjective Norm (SN); Perceived Behavioral Control (PBC); Actual Control (AC); DND represents part of the dependent variable specifically the Adopt (D), Not Adopt (ND) part, a 0,1 variable; Dollars invested on the farm ($) is the other part of the dependent variable; Mean (M) and Standard Deviation (SD).
[a] $p < 0.05$, [b] $p < 0.02$, [c] $p < 0.01$.

few are statistically significant. This suggests simple multi-correlation is not a problem.

The first column of Table 3 represents the tobit results for the Theory of Reasoned Action (TRA), the second for the Theory of Planned Behavior (TPB), and the third for a synthesis of TPB and the Theory of Derived Demand (TPD). All variables have significant effects at least at the 0.05

Table 3
Estimated parameters and statistical significance of behavior variables

	Fitted models (Tobit regressions)		
Variables	TRA estimate	TPB estimate	TPD estimate
Constant	14989 [c]	-0.1827×10^{7} [b]	-0.1676×10^{7} [b]
Attitude (A)	−448.82 [c]	5005 [b]	4589 [b]
Subjective Norm (SN)	−449.78 [c]	5841 [b]	5342 [b]
$A\times$SN	1.50 [c]	−15.54 [b]	−14.17 [b]
Perceived Behavioral Control (PBC)	–	144852 [b]	132496 [b]
$A\times$PBC	–	−399.34 [c]	−364.97 [c]
SN×PBC	–	–	−420.61 [b]
	462.69 [c]		
$A\times$SN×PBC	–	1.25 [c]	1.13 [c]
Actual Control (AC)	–	–	45.18 [a]
Chi square χ^2		9.49 [a]	4.42 [a]
df		4	1

Notes: Dependent variable is 0 for the nonadopter, and dollars invested on the farm in micro-technology for the adopter. TRA, Theory of Reasoned Action; TPB, Theory of Planned Behavior; TPD is a synthesis of TPB and the Theory of Derived Demand.
[a] $p < 0.05$, [b] $p < 0.02$, [c] $p < 0.01$.

probability level in all models, with most significant at least at the 0.02 level. Tested as a set, adding the perceived behavior control variable leads to a significant improvement (x^2, 9.49 with 4 df, $p < 0.05$). Adding the financial capability (actual control) variable also produces significant improvement (x^2, 4.42 with 1 df, $p < 0.05$).

9. Discussion

The significant x^2 observed by moving to the Theory of Planned Behavior suggests for this case it is superior to the Theory of Reasoned Action. Perceived control is important in explaining the decision of whether or not to adopt, and the additional decision pertaining to how much to invest in conserving technology by the adopter. The result also suggests that micro-technology was familiar and not particularly novel to the farmers (see Parker et al., 1992 on this point): this is probably due to the fact that university extension had an active education and demonstration program in the area.

The significance for perceived behavioral control suggests farmers did not have complete volition in the decision to invest in micro-irrigation technology. It is the lack of control that discriminates the models (as also shown by Madden et al., 1992, p. 8). The significant x^2 in moving to the Theory of Derived Demand indicates actual control is also a factor, which is shown to be independent of the attitudinal variables because the perceived behavioral control variables also remain statistically significant.

The significance of the subjective norm variable implies that farmers are influenced by community (subjective) norms for water conserving behavior and that individual farmers who are more influenced by the community will be more likely to adopt, and will adopt more intensely. The significance for the perceived control variable, which is another type of community "influence," however, shows that coercive control (which would reduce perceived control) could be counterproductive, not only slowing the move to becoming an adopter, but also reducing the intensity of investment into conserving technology.

The significance for all the interactions AxSN, AxPBC, SNxPBC, and AxSNxPBC runs somewhat counter to findings in other tests of the Planned Behavior Theory (see Ajzen and Madden, 1986; Ajzen and Driver, 1992, p. 211). Schifter and Ajzen (1985, p. 847) found only marginally significant interactions. Most tests, however, have dealt with trying to predict inten-

tions, and thus focused on the intention xPBC interaction, while we have addressed actual behavior. As in this study, Schifter and Ajzen (1985, p. 850) did find perceived control important in predicting actual behavior. The interactions may simply be more important in predicting actual behavior. It seems far too much to expect that a human could cognitively separate these phenomenon into only main effects of the attitude (A), subjective norm (SN), and perceived behavioral control (PBC) variables in moving to actual behavior. Maybe a farmer could separate these phenomenon in hypothetical behavior, as measured in the intention phenomenon. Our findings of significant interaction do support the original formulation of the theory (see Ajzen, 1991).

The significance of the financial variable (AC) supports the Theory of Derived Demand. The fact that both perceived behavioral control (PBC) and actual control (AC) added significant explanatory power also suggests, however, that measuring only the financial influence on investment is insufficient: there are other aspects to perceived behavioral control (PBC) larger than captured by measuring financial capability. In this case, it is the control exerted by the water management districts as the representative of central government.

10. Conclusions

The behavior investigated involves a situation where economic modelling, which normally presumes full volition, is problematic, i.e., state government-run water districts are exerting various indirect and some direct controls over individual water technology decisions. As Ajzen and Driver (1992, p. 208; also see Beck and Ajzen, 1991, p. 289) note, accounting for perceived behavioral control in such a situation improves prediction of actual behavior. The significance of the perceived behavioral control verifies that there was something less than full volition, and something more than constrained volition, in the case of micro-irrigation technology adoption for strawberry production in Florida. Yet, the fact that attitudes and subjective norms were also important explanatory variables implies that perceived control is not the only factor in explaining why farmers did what they did. There are also technology policy implications: as Ajzen (1991, p. 206) has noted, intention, attitude, subjective norm, and perceived behavioral control each reveal "a different aspect of the behavior, and each can serve as a point of attack in attempts to change it". The results of these

models can guide strategies for changing technology behavior (see Madden et al., 1992).

Persuasion to encourage changes in beliefs and evaluations may also be the only way to achieve full technology compliance. There appears to be a back lash effect on the part of some farmers to excessive, micro-management type controls: 14 percent have not adopted, others have put in only minimal effort. Farmers may need to perceive at least some control in order for them to move forward with technology decisions: with more (internal) control, farmers are more likely to take action, and to invest more intensely.

These findings also appear consistent with explanations for conserving behavior from the perspective of the minimal justification principle in social psychology. A weaker, more moderate justification for behavior leading to internal control by the farmer may be more effective than a highly visible, more demanding external control. Katzev and Johnson (1983, especially pp. 277–278) found that residential users of electricity were more likely to continue conserving electricity when approached with a small, moderate request as compared to more demanding requests. They demonstrated how the former lead to a longer term commitment to conservation, probably due to changing conservation attitudes, while the latter may lead to only short term responses. The highly visible, external threat from the water district that the farmer would lose the water permit unless she/he complied may well have been counterproductive (or at least unnecessary) as this principle would suggest. The minimal justification principle also seems to suggest there may even be varying thresholds in the request, with some farmers responding and some not responding to the same level of external control (afterall, 86 percent did switch technologies, although the intensity at which they responded varied). The request threshold idea needs to be examined in future research.

The robust regression result simultaneously occurring with the low correlations among A, SN, PBC and AC (Table 1) suggests each variable is reflecting a different underlying latent variable (see Fishbein and Ajzen, 1981, p. 341, on this same line of reasoning). The results suggest strong support for the construct validity of the Theory of Planned Behavior model.

For the purposes of furthering theoretical development, findings hint at the possibility of synthesis. Including perceived control from the Theory of Planned Behavior facilitates linking complete volition theories (Reasoned Action) and constrained volition theories (Derived Demand). If perceived control is found not to have a significant effect, one can surmise nearly full

volition, and Reasoned Action theory becomes descriptive. When perceived control is significant, some variant on Planned Behavior theory describes behavior more accurately. When actual control is found to be important, Derived Demand theory is descriptive. One can now test how important volition really is in the decision process, rather than having to assume it. The Theory of Planned Behavior points the way toward improving economic decision models, at least in the case of technology adoption/investment decisions. It holds the potential for enhancing the understanding of water conserving behavior by US farmers in that many experience incomplete volitional control due to most US state governments, in varying degrees, controlling use of the water resource. It represents a better fit with our experience in working with farmers and conservation issues.

East (1993) concludes that support for this theory demonstrates that investment decisions are essentially consumer decisions. We agree. More testing may be fruitful not only to improving theory but also in beneficially improving conservation technology (investment) policy. The direction for the latter would be toward introducing fewer controls while providing more incentives to participate in conservation programs than is currently the case in the US.

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