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Hog industry and hog production related water pollution problem in Taiwan: an application to valuing the willingness to pay for improving water quality

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Hog industry and hog production related water pollution problem in Taiwan: an application to valuing the willingness to pay for improving water quality

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TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

A contingent valuation method (CVM) was employed to measure the general public willingness to pay (WTP) for improving water quality. A telephone survey was conducted on the Kaoping area in southern Taiwan. This study used two different questionnaires which had two distinctive levels of WTP categories while other questions remained the same. This approach tried to examine whether the different stated WTP amounts would lead the different expected WTP values. Gender, income, number of children, and concerns with water pollution were determinants of the hog production related willingness to pay (WTPHOG). Results indicated that the household's WTPHOG was between NT$1,240 to NT$4,590 annually, depending on the questionnaire was employed. It was found that the higher suggested WTP amount would lead higher expected WTP value to respondents while the socioeconomic characteristics of two population samples were statistically equal. As a result, the environmental cost of the water pollution per pig based on aggregate WTPHOG was from NT$182.94 to NT$677.16 in the Kaoping area of Taiwan

PREFACE

While the Taiwan government attempted to reduce hog production and hog related pollution, it now has an opportunity to act. Taiwan's government announced that Taiwan has become a Foot and Mouth Disease (FMD) affected area and placed a ban on pork exports on the March 21st 1997, the day following the learning of the outbreak of deadly FMD at local hog ranches.

Taiwan's hog industry feared facing imminent collapse after FMD had been broken out among some 14 million hogs in Taiwan. So far 16 cities and counties, including Kaohsiung and Pingtung, have been declared FMD-affected areas. Some officials of the Council of Agriculture in Taiwan said there was a great chance that over 3 million hogs or 25 percent of the total hogs across this island might be infected by this outbreak of FMD.

The pork export ban will remain valid at least three years and may last even longer. This export ban will certainly cost Taiwan's hog industry. As a result, the domestic wholesale pork market nearly collapsed. In the southern Taiwan area, wholesale pork plunged from NT$4,385 per 100 kilograms to NT$1,848 in late March 1997. Not only are the hog farmers impacted by this FMD case, but food, meat, and hog feed industries are jeopardized. Taiwan's officials also predicted that Taiwan's hog, food-processing, and hog-related industries will suffer losses exceeding NT$100 billion after Taiwan has been listed as an FMD-affected area.

Taiwan's government now is trying to control the FMD by killing all pigs among 16 affected cities and counties and importing a large quantity of vaccines to help control the

FMD for other non-affected cities and counties. On March 24th, Taiwan's government announced an agricultural policy to offer 3 percent low-interest loans, total NT$20 billion, to hog farmers and to subsidize 3/5 of the wholesale hog price. After all, Taiwan's Economics Minister Wang said the outbreak of FMD has offered Taiwan a great chance to review whether to keep this hog industry going. Wang described the hog industry as a highly polluting one, because the daily waste created by a hog is six times that of a person. Wang also said the costs of maintaining the industry are running far too high.

This study had been finished before the FMD case was announced on March 20th 1997 in Taiwan. The FMD incident did not have any influence on the result of this survey research.

CHAPTER 1. INTRODUCTION

Problem Statement

Pork is the traditional and dominant meat product in Taiwan. Since the mid-1960s, Taiwan has gone beyond self-sufficiency and has become a major exporter of pork and pork products. Pork production increased from 200,000 tons (live weight) in 1965 to over 1.3 million tons in 1996. Also, pork exports increased from 1,000 tons in early 1960s to 266,000 tons in 1996; and the foreign exchanges earned from the exports, consequently, contributed to buy industrial capital goods in Taiwan.

However, a study shows that hog waste has become the most important source of agricultural production-related pollution in Taiwan after three decades of rapid growth accompanied by environmental neglect (Weng, 1992). The ensuing hog waste-related environmental pollution problems have become a major concern of the public and policy makers in Taiwan. The increasing awareness of the environmental problems associated with hog production is a serious threat to the growth of Taiwan's hog industry in the long run.

The purpose of this study is to examine the impact of hog waste pollution in Taiwan. It seeks to find out whether there is any significant implication of reducing Taiwan's hog production and opening its pork market to foreign importers due to concerns about hog production related pollution problems. The issue of the hog production related to water pollution is chosen because this issue represents a serious challenge to the public and the policy makers in Taiwan. This study used a telephone survey to deal with people's willingness to pay (WTP) for improving water quality. The contingent valuation method (CVM) was employed to estimate the scarcity rent of water.

A Historical Overview of Hog Production in Taiwan

Increased per capita income, fueled by rapid economic growth since the 1960s, has led to a basic and significant overall change in dietary patterns in Taiwan. Meat consumption has increased at the expense of cereal products, with per capita meat consumption estimated at 73.39 kilograms in 1994 (DAF, TAY). Pork is the most common meat product in the Taiwanese diet, per capita pork consumption jumped from 16.77 kilograms in 1965 to 37.4 kilograms in 1992 (see Figure 1). As a consequence, the pork share of total per capita meat consumption was more than 50 percent in 1992. Moreover, as shown in Figure 2, the domestic pork supply has also been increasing since the 1960s. Taiwan provided over 1 million tons of pork products for domestic consumption in 1992.

Hog production has been Taiwan's predominant livestock industry. In 1993, there were over 9.8 million pigs produced by 29,771 pig farms. Table 1 revealed that hog production has dominated the agricultural production industry since 1986. The value of livestock production (NT$141.01 billion) and the value of hog production (NT$88.99 billion) accounted for 34.3 percent and 21.2 percent, respectively, of the total value of agricultural production (DAF, TAY).

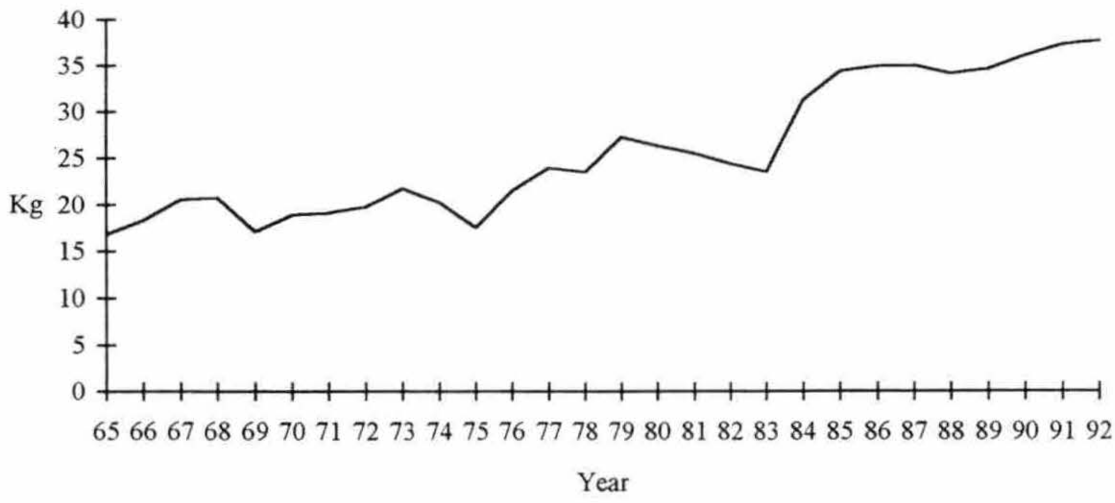

Figure 1. Taiwan Per Capita Pork Consumption, 1965-1992
Source: Taiwan Agricultural Yearbook, various issues

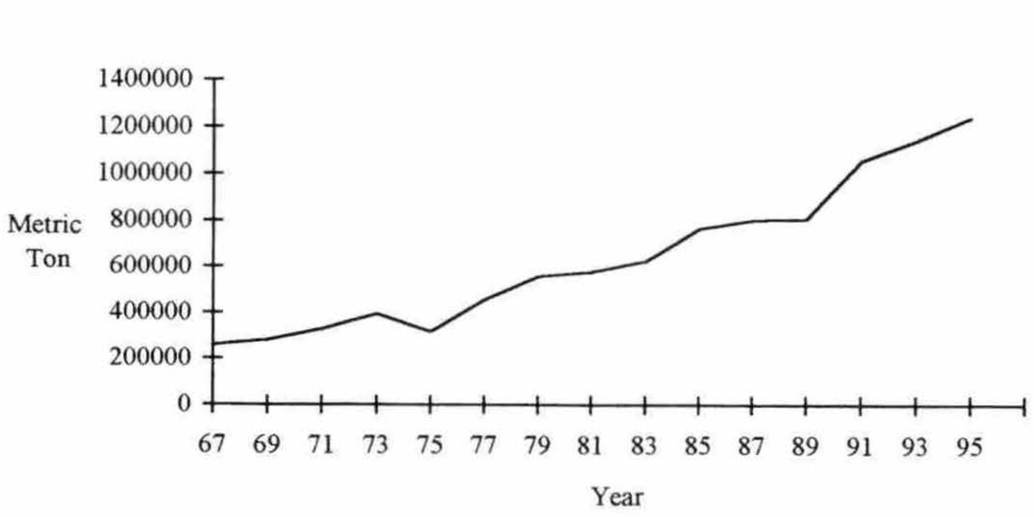

Figure 2. Taiwan Domestic Pork Supply, 1967-1995
Source: Taiwan Agricultural Yearbook, various issues

Table 1. Value of Agriculture, Livestock, Hog, and Rice Production, 1981-1995

Year	Agriculture Production Value	Livestock Production Value	Hog Production Value	Rice Production Value
1981	238.47	73.24	42.68	46.41
1982	267.45	80.40	48.83	49.53
1983	280.87	83.60	46.16	48.57
1984	281.38	83.33	43.86	45.23
1985	270.07	73.58	40.00	41.33
1986	286.72	88.33	52.82	36.45
1987	304.66	88.97	55.46	33.81
1988	313.50	86.92	52.50	36.63
1989	329.08	99.83	58.21	38.66
1990	313.54	84.50	48.22	37.91
1991	323.34	90.77	53.23	38.85
1992	333.67	106.30	63.38	35.15
1993	368.62	116.84	68.45	40.48
1994	375.08	124.53	75.28	39.26
1995	411.13	141.01	88.99	39.76

Unit: Production value is in Billion NT$
Source: Taiwan Agricultural Yearbook, various issues

Taiwan began its heavy agricultural protection in the early 1970s when the policy about hog production was reoriented from agricultural taxation to subsidization. Benefiting from the Taiwan government's guidance and trade protection, pork production, the most valuable agricultural product, has surpassed rice as the leading agricultural export in Taiwan since the late 1980s. Furthermore, Taiwan was a major exporter of pork and pork products to Japan. The pork and pork product exports in 1968 amounted to 1,002 tons, valued at US$1.4 million (Green et al., 1989). In 1996, Taiwanese pork and pork product exports were estimated at about 266,000 tons, valued over US$1.5 billion. The quantity and value of hog production and exports during the period of 1965 to 1993 are listed in Table 2.

Table 2. Quantity and Value of Hog Production and Exports, 1965-1993

Year	Production Quantity	Production Value	Exports Quantity	Exports Value
1965	198,923	-	0	0
1968	265,826	-	1,002	1,402
1970	323,630	-	4,814	5,389
1975	325,744	-	7,760	21,176
1980	597,875	-	16,996	56,000
1985	830,709	1,600,000	67,006	234,459
1986	868,332	2,112,800	85,816	391,116
1987	937,644	2,218,400	137,730	649,224
1988	911,124	2,100,000	106,705	520,866
1989	916,775	2,328,428	111,909	507,043
1990	1,008,729	1,928,831	157,318	662,090
1991	1,126,132	2,129,265	226,982	986,621
1992	1,126,406	2,535,289	212,709	1,013,035
1993	1,135,361	2,632,764	196,829	1,061,280

Unit: Production and export quantities are in metric tons
Production and export values are in US $1,000
Source: Taiwan Agricultural Yearbook, various issues

Pork exports to Japan have been a major source of foreign exchanges in Taiwanese agricultural sector. However, with its geographic advantage, Taiwan's fresh, chilled, and frozen pork exports are almost exclusively destined for Japan. During 1990-1992, Japan imported an average of nearly 200,000 tons of pork products from Taiwan annually and made Taiwan Japan's leading supplier, with a 45 percent share. Figure 3 indicates Japan's pork imports from Taiwan (46 percent), Denmark (32 percent), the United States (13 percent), and Canada (6 percent).

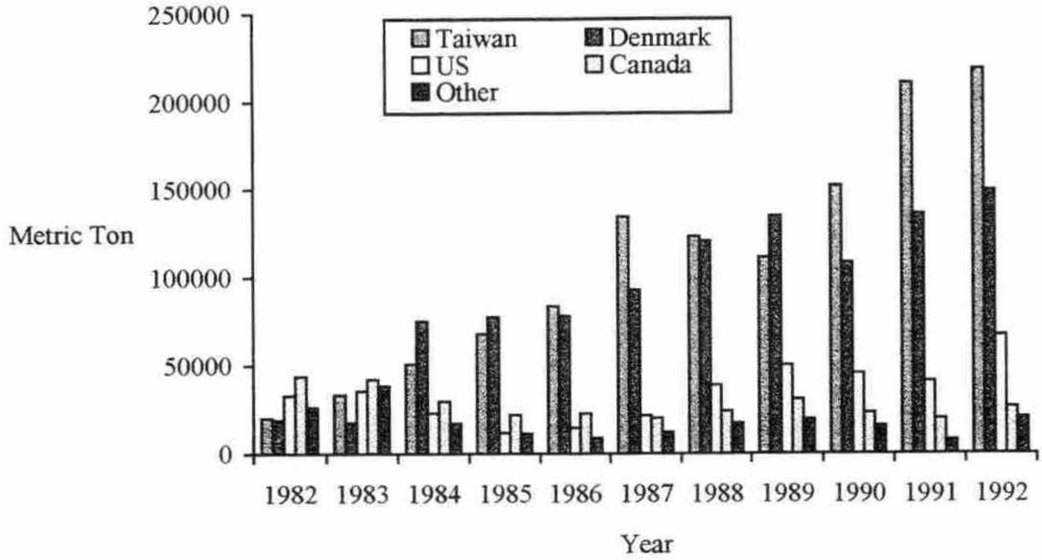

Figure 3. Japanese Pork Imports by Source, 1982-1992
Source: Agricultural Trade Statistics of Republic of China, various issues

Traditionally, as a sideline, Taiwanese hog production used surplus farm labor and residual agricultural materials for feeding hogs. The sideline hog producers obtained incidental profit from selling hogs and used the manure for enriching the soil; hence, increasing crop production. The production cost of raising hogs was not much of a concern since hog-raising was mainly used as a store of value. Hog farms were generally small scale and inefficient.

In the early 1960s, Taiwanese government introduced an integrated hog production and marketing program to encourage technical innovations such as use of balanced rations, disease control, and improved management. Taiwan's policy makers supported the development of the mixed feed industry and promoted improvements in marketing. They relaxed import controls for coarse grains and soybeans beginning in 1967 and ending in 1988 as imports of these feedstuffs were fully liberalized. As a result, plentiful supplies of low-cost feedstuffs have been available to develop the hog industry. In 1960, about 94 percent of Taiwanese farm households raised hogs, and the average number of hogs per farm household was four head. In the early 1970s, less than 15 percent of hogs were from farms with herds larger than 1,000 head (Chen, C., 1993).

During the 1970s, Taiwan's farmers were encouraged to raise hogs by a series of actions of the government. As a result, by 1979, the domestic hog price had dropped significantly due to a large surplus in hog production. The government tried to balance the domestic pork supply and demand to stabilize the domestic hog price. To achieve this goal, Taiwan's government made a special hog stabilization fund of NT$1 billion to purchase hogs from the livestock market and to forbid large-scale hog farms with more than 5,000 hogs, like Taiwan Sugar Corporation, to sell pork into the domestic market.

In 1980, an adjustment program of hog production and marketing was established by the Executive Yuan in Taiwan. This hog program was to stabilize hog prices, modernize hog-raising operations, and expand the breeding-pig supply (ROC Yearbook, 1991).

Under this program, hog farms were divided into four categories:(1) sideline hog farms (fewer than 50 head), (2) medium-scale hog farms (50-1,000 head), (3) large-scale hog farms (1,000-5,000 head), and (4) enterprise hog farms (over 5,000 head). To stabilize hog prices, the first two categories of hog farms were given priority in the sale of their hogs to domestic markets, and the last two categories of hog farms were basically required to sell their hogs only in external markets (Green et al., 1989). After the implementation of this program, modernized hog farms in Taiwan are typically large scale with efficient production and management techniques.

Further, due to escalating production costs in recent years, small-scale hog operations have become non-competitive in the market place and have steadily decreased in numbers. The hog industry has been transformed from traditional sideline backyard operations into large business enterprises. Hog farms with over 1,000 pigs are common today. Table 3 lists the changes in number of hog farms and hogs for the period of 1971-93. As listed, the production scale of pig farms was dramatically changed by the 1980 adjustment program; while the number of hogs increased threefold from 1971 to 1996, the number of hog farms declined from 540,583 to 29,771. Table 4 shows that 99.54 percent of the total hog farms raised fewer than 100 pigs in 1973, accounting for 78.53 percent of the total pig production. In contrast, only 3.38 percent of the production in 1993 was accounted for by hog farms raising fewer than 100 pigs.

Table 3. Changes in Number of Hog Farms and Hogs, 1971-1993

Year	Number of Hog Farms	Number of Hogs	Number of Hogs (per Hog Farm)	Slaughter
1971	540,583	3,078,546	5.69	4,374,787
1981	140,452	4,825,862	34.35	7,738,018
1986	72,451	7,056,918	97.40	10,529,549
1987	63,229	7,129,034	112.75	11,300,000
1988	55,574	6,954,322	125.14	11,020,942
1989	53,022	7,783,276	146.79	11,080,000
1990	47,221	8,565,250	181.38	12,120,000
1991	39,662	10,089,250	254.38	13,525,987
1992	33,247	9,754,460	293.39	13,250,000
1993	29,771	9,844,920	330.69	13,225,000

Source: Taiwan Agricultural Yearbook, various issues

Table 4. Production Scale in Hog Industry, 1973-1993

Number of Scale	Year	Number of Hog Farms	Share of Total Hog Farms(%)	Number of Head	Share of Total Hogs(%)
5,000 Head and	1973	-	-	-	-
over	1993	123	0.41	1,950,010	19.81
4,900-2,000	1973	-	-	-	-
Head	1993	480	1.61	1,442,096	14.64
1,999-1,000	1973	77	0.02	364,000	10.03
Head	1993	1,204	4.04	1,616,107	16.42
999-500	1973	98	0.02	67,000	1.86
Head	1993	3,738	12.56	2,845,911	28.91
499-300	1973	239	0.05	90,000	2.48
Head	1993	2,000	6.72	790,001	8.02
299-200	1973	339	0.08	81,000	2.25
Head	1993	1,357	4.56	331,870	3.37
100-199	1973	1,302	0.29	176,000	4.85
Head	1993	3,747	12.59	536,111	5.45
1-99	1973	441,965	99.54	2,857,000	78.53
Head	1993	17,122	57.51	332,814	3.38
Total	1973	444,020	100.00	3,635,000	100.00
	1993	29,771	100.00	9,844,920	100.00

Source: Taiwan Agricultural Yearbook, various issues

With large-scale operations, Taiwanese hog producers are able to adopt more efficient production and management techniques to improve feed-hog conversion, lower production costs, adopt proper breeding systems, improve disease controls, and reduce retail prices (Chow and Tai, 1991).

Water Pollution Related to Hog Waste in Taiwan

Taiwan is a subtropical island extending nearly 240 miles north and south across the Tropic of Cancer, with a maximum width of less than 90 miles. This island covers an area of about 35,960 square kilometers, which is about one-fourth of Iowa's area. This island's hog inventory was 9.8 million head in 1993, while Taiwan's human population was about 21 million, giving Taiwan the world's highest ratio of hogs to people. A study by the Taiwanese government shows that each hog produces 5 gallons of waste a day (DAF, PTOHW, 1993). Therefore, Taiwan must deal with the great amount of 190,000 tons of hog waste excreted in solid and liquid, as well as gaseous forms, per day. As the number of hogs per farm expands, it has become more difficult to utilize all hog waste for land application, especially for those hog producers who do not hold sufficient crop land. Even some large-scale hog farmers are not concerned about the environmental consequences of irresponsibly discharging hog waste and directly send huge quantities of hog pollutants into rivers (Chen, C., 1993). If not treated properly, the hog waste seriously pollutes rivers, creating enormous cleanup costs. For instance, in 1991 the Taiwan government estimated that it would cost over US$500 million to clean up southern Taiwan's Kaoping River, which suffers serious pollution from about 3.4 million hogs along the river banks (DEP, 1991).

According to a 1991 report from the Department of Environmental Protection about one-third of Taiwan's major rivers were seriously polluted. Livestock waste water, mainly from hogs, accounted for about 25 percent of the river water pollution throughout this island, while industrial waste and residential waste, respectively, accounted for 55 and 20 percent (ROC Yearbook, 1996).

Water pollution has not only precariously affected the habitability of the island of Taiwan, but also has caused direct economic hardships for the people there. For example, the reduced oxygen concentration in water caused by hog waste is primarily responsible for fish kills. In Pingtung county where more than 3.4 million pigs were raised, tensions between hog and aquaculture producers have escalated in recent years, as hog pollutants have rendered the rivers unusable for fish husbandry. Out of desperation, the aquaculture producers have subsequently resorted to massive exploitation of the groundwater, which has resulted in large-scale collapsing of the land level in some parts of Pingtung county. Floods and other disasters have ensued.

In addition, the waste water from slaughtering, which contains high concentrations of grease and suspended solids, can cause water pollution. The pig slaughtering and processing operation is also considered a major source of river and land pollution in Taiwan (Li et al., 1987).

Current Hog Production Policy in Taiwan

In light of the potential hazard of pollution caused by hog waste, many methods to treat and utilize hog pollutants have been introduced by the Taiwanese government since the 1970s. To further improve hog waste disposal systems, the government has spent over NT$245 million on promoting these treatments of hog waste since 1988 (DAF, PTOHW, 1993). In addition, in 1987 the Taiwanese government proposed a project called "Short-term Improvement Measures for Water Pollution Control" to regulate hog waste water on large-scale hog farms (DEC, 1987). Due to these efforts, 83 percent of hog farms which raise over 200 hogs have set up equipment to treat their hog waste. However, this does not mean that all of those hog farms with hog waste treatment equipment have met the official hog pollutant requirements. In fact, more than 50 percent of those hog farms fail to meet the official effluent standards. A study by the Department of Agriculture and Forestry indicated that

4,664 of all 9,051 hog farms with over 200 hogs had not met the official effluent requirements in June 1993 (DAF, PTOHW, 1993).

To tighten up pollution controls, the Taiwanese government placed into effect a new hog policy adjustment plan in January 1991. This plan is to switch the hog sector in Taiwan from export-oriented production to domestic market supply only. In addition, this plan is also to improve hog waste disposal systems on the island. The plan aims at achieving four major goals (DAF, PTOHW, 1993):

1. As a first step, to cease hog-farming operations along major rivers.
2. To establish minimum self-sufficiency in hog production.
3. To reduce hog production in the long run.
4. To help hog producers meet official waste effluent standards.

Under the 1991 Hog Policy Adjustment Plan, the Taiwanese government will compensate hog farmers along major rivers NT$600 (about 13% of wholesale hog price), per head if they cease hog-farming operations (DAF, PTOHW, 1993). The government plan will cut hog slaughter 26 percent by 1997 (Huang, 1993). A new biological oxygen demand and a new chemical oxygen demand requirement in waste water went into effect on January 1, 1993. Further, these biological and chemical oxygen demand requirements will be more tightly enforced by 1998.

Table 5 shows the schedule of regulations concerning animal waste effluent by the Department of Environmental Protection of the Executive Yuan, Taiwan.

Table 5. Waste Effluent Standards of Animal Husbandry

Item	1987-1993 Animal Husbandry (1)	1987-1993 Animal Husbandry (2)	1993-1998 Animal Husbandry (3)	After 1998 Animal Husbandry (3)
pH	5.0-9.0	5.0-9.0	6.0-9.0	6.0-9.0
Biochemical Oxygen Demand (mg/l)	200	400	100	80
Suspended solid (mg/l)	300	400	200	150
Chemical Oxygen Demand (mg/l)	-	-	400	250
NH^3-N (mg/l)	-	-	20	10
Phosphate (mg/l)	-	-	10	4

Footnotes: (1) Pig farms raising over 1,000 head
(2) Pig farms raising 200-900 head
(3) Non-herbivorous animals, such as pigs, chickens, ducks, geese, etc.

Source: The Environmental Protection Department of the Executive Yuan, Taiwan, 1993

However, this plan does not seem to be successful as long as hog farming is still profitable to attract new entrants, because Taiwan's hog farmers had 9 profitable years during 1981-1992 (see Table 6).

Rationale

The rationale of this study is based on the fact that little research has been conducted to examine the impact of the hog waste pollution in Taiwan. Although studies on the issue about the hog production in Taiwan help us to understand that the hog industry has significantly changed since the 1960s, there has been no research focusing on the impact of the hog waste pollution on the general public.

Table 6. Price and Cost of Hogs, 1981-1992

Year	Price of Hogs	Cost of Hogs	Profit/Head
1981	5,804	5,464	340
1982	6,250	5,550	700
1983	5,951	5,489	462
1984	4,884	5,421	-537
1985	3,927	4,665	-738
1986	4,913	4,784	129
1987	4,880	4,163	717
1988	4,791	4,359	432
1989	5,394	4,756	638
1990	3,994	4,229	-235
1991	3,949	3,518	431
1992	4,698	3,618	1,080

Unit: NT$ per 100kg
Source: Taiwan Agricultural Yearbook, various issues

CHAPTER 2. LITERATURE REVIEW

Livestock Waste System

Early history has recorded the use of animal waste for soil enrichment. Primary components in soil enrichment were nutrients and organic matter. Organic matter from waste enhances soil physical properties such as structure, water holding capacity and soil microbial activity (Smith and Kemper, 1992). Furthermore, the basic nutrients in manure, nitrogen (N), phosphorus (P), and potassium (K), are the same as N, P, and K in commercial fertilizer, and are equally effective in promoting plant growth (Fulhage, 1992). As a result, manure could be viewed as a fertilizer resource, and managed in the fertility program in a manner similar to commercial fertilizer. Such a philosophy guarantees that maximum benefit from the manure will be realized, water quality will be protected, and regulatory requirements will be met.

Although manure can be viewed as a fertilizer resource, it requires a much different management approach than a commercial fertilizer does. Commercial fertilizers can be obtained in very precise formulations which lend themselves to standard practices and procedures. Manure is highly variable substance, even within a given animal species and diets. Significant nutrient losses generally occur in the various components and operations of a waste management systems (Fulhage, 1992). For instance, the temperature and rainfall strongly influence the losses of nutrient, and bacterial activity/degradation and the degree of exposure of waste to the atmosphere are also primary factors influencing the nutrient losses during manure storage. Therefore, in managing manure as a fertilizer, it is highly desirable to have a laboratory analysis of the manure and to have soil test data to provide nutrient information for the crop being grown.

On the other hand, the livestock manure nutrients could be viewed as potential contaminants. Nitrogen is of concern as a potential contaminant because of the possibility of creating high nitrate levels in groundwater. In addition, livestock waste runoff which typically contains relatively high levels of ammonia nitrogen, can cause ammonia toxicity in fish and other aquatic life if allowed to enter streams and surface water. Phosphorus is of concern as a potential contaminant because of its eutrophication potential in surface water. Eutrophication is the stimulation of aquatic plant growth and accumulate in soils to the extent that plant productivity is degraded (Fulhage, 1992).

Furthermore, over the last two decades swine production has changed dramatically. Animal waste has been not considered a tremendous asset in providing fertility to soils. Stewart (1992) pointed out that the change in attitude toward livestock waste had mainly been due to two factors. One was livestock and poultry production has been become concentrated in large scale, confinement-type enterprises. A large majority of the hog industry uses total confinement facilities. The number of producers has decreased while the size of individual operations is considerably larger than in the past. The other factor was marked improvements in the techniques for making farm fertilizers from atmospheric nitrogen were made in the period before World War II.

Anaerobic lagoons are widely used throughout the swine industry. They are highly efficient in the stabilization of organic material and are reasonably cost-efficient to construct and manage. However, several potential drawbacks have been found. One concern is the potential in some soils for lagoon liquid to leach through the bottom of the lagoon and contaminate the groundwater below (Safley, 1992). Odor is another concern associated with anaerobic lagoons. Although, anaerobic digestion reduces odors, the treated waste is not completely inoffensive. In cold regions, where wastes in lagoons go inactive, odors will be more offensive when the temperatures increase in the spring and in the fall (Bundy, 1992). These temperature changes cause the lagoon water to turn over.

Aerobic treatment is the most effective method for controlling the odors form the livestock production. Because of the high amounts of energy required to operate aerators, they are seldom used (Bundy, 1992).

Pollution related to livestock production

Livestock waste can be a significant polluter of many streams, rivers, ponds, lakes, and ground water. Many U.S. federal and state government reports as well as university studies show that livestock waste poses a serious threat to many water resources across the nation. According to a study by the U.S. Environmental Protection Agency (EPA), over 1 billion metric tons of manure are produced annually by the U.S. livestock industry (Safley et al., 1991). If mishandled, this manure can impair both ground and surface water quality by leaching into and contaminating drinking water. Additionally, the offensive odors associated with livestock waste contribute to the discomfort of living and the depreciation of neighboring property value (Palmquist, Roka, and Vukina, 1997 and Abeles-Allison and Connor, 1990).

Moreover, recognition of the importance of the environment has been growing. People have been more sensitive to protection of water quality, air quality, and land sustainability. The combination of all of these changes has created major challenges for managing manure from modern production facilities (Safley, 1992).

Three common livestock related environmental pollution are discussed as following:

Gaseous pollution

Hog production results in the escape of volatile gases. Most volatiles are undesirable from environmental and/or animal health points of view. These volatiles include mainly carbon dioxide, methane, and ammonia. It is thought that carbon dioxide is a contributor to the greenhouse effect. Therefore, methane causes concerns because of its possible effect on the impairment of the ozone layer. Ammonia exposure at a certain level may be detrimental to the respiratory organs of farm animals. More importantly, it contributes to acid depositions on soil and in surface water. Other volatiles of hog waste which are not directly hazardous to the environmental and/or animal health may still cause such problems as a decrease in quality of life, because their smells are unwelcome and repulsive (Tamminga, 1992). Furthermore, odors from livestock production systems, like other non-toxic odor emissions, generally are regarded as nuisance pollutants.

Soil pollution

Traditionally, animal manure is deposited on crop land, whereby it decomposes to become a source of plant nutrients and organic humus to improve soil. The recycling of nutrients to plants in this way reduces the need for using inorganic fertilizers (Archer and Nicholson, 1992). As cultivated lands decrease year after year, it becomes more difficult for farmers to recycle all the increasing animal waste into crop land. Huge amounts of hog waste spread on a land area can cause serious soil pollution. For example, the accumulation of phosphates in surface soils can increase the risk of their runoff or erosion losses to surface water (Kao, 1993). Likewise, nitrates can enter the ground water with rain, and destroy the reservoir for drinking water (Josef and Hans, 1990). The heavy application of hog waste may also cause damage to crop plants through excess ammonium, soil reduction, and phytotoxic substances (Harada, 1990).

Water pollution

Pollution by runoff from fields on which slurry or other liquid waste has been applied occurs when hydraulic loading exceeds the surface infiltration rate. This may be due either to the quantity of liquid waste applied, in itself, or to heavy rain following waste application. Either can result in polluted water reaching a watercourse. When hog waste with a high Biology Oxygen Demand (BOD) enter a watercourse, this waste is broken down by micro-organisms and oxygen is consumed. The reduced oxygen concentration in the water is primarily responsible for fish kills. Other river flora and fauna may be affected both by low oxygen and by direct effects, such as ammonium toxicity (Archer and Nicholson, 1992). As mentioned, hog waste is also a significant factor contributing to nitrates in both surface water and, more particularly, groundwater sources abstracted for drinking water.

Regulation of swine waste management in the U.S.

During the late 1980's, public environmental concerns related to intensified livestock production became a larger issue in the U.S. Corporations which were wanting to locate large swine operations found it difficult to find a state where they were welcome. Neighbors were asking for tougher regulations that would keep hog operations from their neighborhood. In the 1990's, clean water and the control of water pollution has been isolated in the United States. This concern for controlling water pollution has resulted in many states adopting regulations that require permits and some soil testing before common earthen manure treatment system can be constructed (Muehling, 1992).

Iowa is an example where recent regulations have been adopted (Wilson, 1994). Iowa Department of Natural Resources (IDNR) requires a permit for the construction of a lagoon and earthen basin. Soil samples are also required to make sure the lagoon or basin will hold waste. With concrete storage units, they need a permit if they will have over 5,000 hogs weighing over 40 pounds. A lagoon or earthen storage structure must be located at least 1,250 feet from non-owned residences or public use areas if the operation has capacity of less than 625,000 pounds live animal weight. The distance requirement is 1,875 feet for operations with a capacity of over 625,000 pounds live weight.

The Department of Health and Environment of Kansas (DHEK) requires that any confined hog operation which provides capacity for more than 300 head must register for a permit (Wilson, 1994). Also, any operation, irrespective of size, that utilizes manure pits, ponds, or lagoons must register. New operations with a capacity of from 750 to 2,499 pigs must be located at least 1,320 feet from non-owned residences, while operations with a capacity over 2,500 pigs must be located at least 4,000 feet from non-owned residences.

In 1989, the Illinois Environmental Protection Agency (IEPA) started proposing amendments to the Illinois Livestock Waste Regulation. They felt that enforcing the regulation dealing with water pollution was not too difficult. Their difficulty was with enforcing the odor nuisance portion (Muehling, 1992). A major change with their proposed amendments was to restrict new or expanded operations from being located 1,320 feet from non-farm residences and 2,640 feet from populated areas (Wilson, 1994).

The Elements of Environmental Problem

An externality is an example of market failure which occurs when markets appear to be failing to allocate resources efficiently. Externalities also arise wherever some agent takes an action which has an impact on some other agent who has not chosen to accept (Tietenberg, 1992). For an individual, the impact will be on his or her welfare or life quality. For a firm the effect will be on its level of profit. The agent who has not chosen to accept is also not able to choose the level of the impact. According to Hodge (1995) and Tietenberg (1992), livestock waste runoff which typically contains relatively high levels of ammonia nitrogen, can cause ammonia toxicity in fish and other aquatic life if allowed to enter streams and surface water. Consequently, the livestock production could be a source of a negative externality affecting the welfare of neighboring aquaculture producers. The people who suffered odors from livestock operations can not determine the quantity of odors which pass near their house. However, externality does not refer to deliberate attempts on the part of one agent to influence other agent's welfare (Hodge, 1995). For example, if someone deliberately makes a noise outside the other people's houses in order to annoy them, that would not normally be regarded as an externality.

Externalities generated by industrial processes are typically emitted at a point source such as a smokestack. The quantity of pollution often can be determined in relation to the inputs into the process and the other outputs created. The principal problem in environmental economics is to measure the economic value of the externality. However, agricultural externalities are complicated by the fact that they are not usually associated with a point source such as a smokestack. Agricultural externalities such as air or water pollution caused by soil erosion, surface water, or ground water contamination caused by chemicals, are called non-point source pollution because they are associated with production over a large area with no one point, such as a specific farm field, to which externality can be attributed. Modeling and analysis of agricultural externalities therefore must contend with the problems of measuring both the quantity and the economic cost of the pollution (Antle and McGuckin, 1993).

Methods of Valuing Environmental Costs

Environmental problems arise particularly because there are no markets or prices for the environment. If people want to establish the significance of losing elements of the environment, they would want to have a measure of their value and to describe this value in monetary terms.

There are many ways in which economists attempt to obtain a monetary measure of the environmental costs. Thus, several methods have been applied to estimate the costs of environmental change. These methods for valuing environmental change include the travel cost method, the hedonic pricing approach, the averting behavior method, and the contingent valuation method. These studies have focused how empirical measurement of such expenditures can yield conceptually valid estimates of economic cost of environmental degradation and how this information may be used in policy decisions. These non-market valuation methods are all attempts to estimate what the market clearing price would be if a good or amenity was traded in a market.

Travel cost method

The travel cost method (TCM) of valuation of some types of environmental amenities has been used successfully in some cases (Zilberman and Marra, 1993). Particularly in the area of recreational pleasantness, such as national parks, the method attempts to attribute a value to the amenity based upon how much people paid in terms of travel and equipment costs to enjoy the amenity.

This method does not account for the value of amenity to people who have not actually traveled there. These aggregate, off-site values can be substantial. For example, some people have never been to the Yellowstone national park, but it does not mean there is no value to them if the Yellowstone national park suddenly did not exit. They may plan to travel there some day or they may even attach some value to it even if they never plan to travel there. These two components of values are option values and existence values

(Zilberman and Marra, 1993). The option values represent the value preserving an environment because of uncertainty considerations. Another component of value is that which is placed on a good or amenity's availability for the enjoyment of future generations.

Furthermore, many outdoor recreation facilities are available for use without any entry fee: walking in scenic areas, picnicking in parks, and fishing in lakes. This method can offer an approach to estimating the value of recreation where there is no direct entry charge. While there is no entry fee, people enjoying the recreation do usually have to make some expenditures in order to be able to enjoy the recreation. Most particularly, they will have to travel to the recreation site. The TCM treats these travel costs as if they were an entry value. This value is often useful in planning for the provision and management of outdoor recreation. However, the method can be used to measure environmental damage by comparing the value of recreation before and after a decrease in environmental quality. The difference may represent the costs associated with the environmental changes (Hodge,1995).

Hedonic pricing

Environmental factors possibly influence people's decisions to pay for something. For instance, based on other things being equal, people would offer less for houses located in noisy or polluted areas. These factors will influence the prices at which houses are sold. In such case, it may be possible to analyze property prices in order to obtain an estimate of the value placed on some aspects of environment. Also, it may be argued that the prices paid for property comprise a combination of all of the implicit prices of each of its individual attributes. These implicit prices are referred to as hedonic prices. In order to determine a value for the environment, it is necessary to estimate the hedonic prices which is related to the environmental attributes of property (Miranowski and Cochran, 1993).

Therefore, the hedonic pricing analysis can indicate the value of small changes in the quantity of the environmental attribute. A study by Abeles-Allison and Connor (1990) employed the hedonic pricing approach to find out the impacts of changes in environmental quality on property value. According to this study, the environmental factors, specifically odors generated by the hog operations, affected residential property values in Michigan. This study assessed econometric techniques to infer hedonic prices from observed market prices. The hedonic pricing model with property sale price as the dependent variable and property, neighborhood, and environmental characteristics as independent variables were run. By using this approach, they found out that 1,000 hogs resulted in a drop on US$430 in property value on a single property which was located up to 1.6 miles away from the hog farms in Michigan. Palmquist, Roka, and Vukina (1997) used the hedonic study to determine the effect of large-scale hog production on surrounding property value. Results of their study suggested that proximity caused a statistically significant decline in neighboring house value of up to 9 percent depending on the number of hogs and their distance from the house. Also, previous studies of the hedonic pricing generally pointed out that there was a positive relationship between enhanced environmental quality and real estate property values.

Averting behavior

In some circumstance, individuals or firms will have the opportunity to take actions which either reduce or avoid completely the consequences of environmental damage. This is referred to as averting behavior. For example, people may reduce the impacts of air pollution by repainting and renovating their buildings. An increase in the level of noise from a road may encourage local residents to take some specific actions to reduce the noise level inside their houses. People even may choose to move away from the polluted location. If these actions taken in response to the environmental damage completely reduce or remove the impacts of the environmental changes, then the cost of the actions would represent a good measure of the cost of the environmental damage (Hodge, 1995).

The averting behavior method suggested households may take a variety of possible actions in order to reduce the risks faced by pollutants. Those actions can be viewed as the environmental costs associated with these pollutants. Recent research applied the averting behavior method to estimate the environmental costs caused by the pesticide contamination of drinking water in Perkasie, Pennsylvania (Abdalla et al., 1992). Abdalla and his colleagues have studied the responses of residents in Perkasie to the chemical contamination of water supplies. Researchers examined the averting behavior method for valuing environmental improvements and used to approximate the economic costs of ground water degradation to households. Results suggested that households' knowledge of pollution, perception of risk, and presence of children determined whether they undertook averting actions.

Contingent valuation method

Often the environmental impacts do not impose costs on firms or industries and are not represented in the markets for particular goods. In this situation, the most direct approach is simply to ask the affected people to give their estimate of the value of the environmental impacts. This technique is usually referred to as contingent valuation. The contingent valuation method (CVM), used over the past decade, utilizes survey questions to elicit people's preferences for public goods by finding out what they would be willing to pay for specified improvements in them (Mitchell and Carson, 1989). This method shows promise as a powerful and flexible tool for measuring the economic cost of the environmental changes. In addition, applications have included estimates of the value of landscape, recreation, beaches, water quality, natural conservation, and air quality and more.

The method is thus aimed at eliciting their willingness to pay (WTP) in dollar amounts. Due to the absence of markets for public goods, the CVM needs to establish a set of circumstances in which the respondent can make a valuation. These circumstances are necessarily hypothetical. Therefore, people could have the opportunity to buy the good in the hypothetical markets. This concept has a wide range of uses. For example, Whitehead (1992) used the CVM to measure the economic benefits of best management practices used to reduce agricultural non-point source pollution on Tar-Pamlico River in North Carolina. Edwards (1995) also utilized the CVM to estimate the willingness of the Scottish public to pay for a reduction in the amount of water pollution arising from livestock production system. Recently, the CVM was employed to estimate the WTP for water in Georgia (Elnagheeb and Jordan, 1997). Elnagheeb and Jordan indicated that the average WTP was US$15.10 above the current monthly water cost, or about 81 percent of current bills. The results also showed that the aggregate WTP for all of Georgia was estimated to be nearly US$393 billion, suggesting that water was underpriced.

However, one criticism about the CVM is that stated WTP may be a poor indicator of actual WTP. Some studies have tested the validity of the CVM responses. Neill et al. (1994) and Kealy, Dovidio, and Rockel (1988) indicated that the hypothetical WTP were typically statistically greater than actual WTP. The differences between hypothetical and actual WTP were about 9:1 (Neill, et al., 1994).

Another study (Loomis et al., 1996) showed the different results. Loomis et al. used three WTP statements to test the differences in stated and actual WTP. These three statements were:

1. WTP (h: no reminder): hypothetical WTP asked as in a standard CVM survey.
2. WTP (h: reminder): hypothetical WTP asked after subjects were reminded not give what they think a fair price is or what it sells for and to act as if they were in a real market with their real budget.
3. WTP(a): actual WTP in the form of cash, check, or promissory note.

This experiment indicated that the differences in WTP(h: no reminder) and WTP(a) were about 3:1, and the differences in WTP(h: reminder) and WTP(a) were about 1.8:1. The results rejected the equality of hypothetical and actual WTP, but the differences were smaller than Neill et al.'s study.

In the most regions of Taiwan, water is not bought or sold in competitive market, and data do not normally exist for standard demand analysis that would reveal the value of water. The CVM has successfully been used to value water (Mitchell and Carson, 1989 and Elnagheeb and Jordan, 1997). Therefore, this study used the CVM to measure the households' WTP in order to have clean and drinkable water in Taiwan. The purpose of this study is to evaluate the cost associated with hog related water pollution in the Kaoping area of Taiwan.

CHAPTER 3. METHODOLOGY

Data Collection

The contingent valuation method (CVM) requires a survey of affected people to value their willingness to pay (WTP) to bring about a change. In this study, the CVM was utilized to elicit financial WTP for having clean and drinkable water in the Kaoping area of Taiwan. The analysis in this study was based on a telephone survey on the Kaoping area residential households where water pollution is a serious problem. This area raises over 3.4 million hogs which have contributed to the water pollution. The Kaoping area includes Kaohsiung municipal city, Kaohsiung county and Pingtung county. Thus, Kaohsiung municipal city and Pingtung city of Pingtung County were selected as samples of the regions with water polluted by hog waste. The population of these two cities were 1.43 million and 220,000, respectively. The telephone survey was conducted from March 1st to March 19th 1997 following the guidelines of Fowler's Survey Research Method. Key questions used to estimate and explain WTP are displayed in Table 7. The samples were drawn from Kaohsiung city and Pingtung city phone directories using a random-digit dialing technique to contact residential households in these two cities. A random number table was used to select the specific telephone numbers. According to Kraemer and Thiemann (1987), 200-500 subjects may be required to reach statistical confidence level in a survey process. Therefore, in this study, 400 residential households, 200 in each city, were drawn from the telephone directories and be interviewed via this telephone survey. Two telephone questionnaires (Appendix A and Appendix B) were used to estimate the WTP in response to contamination in each city.

Table 7. Variable Used in Empirical Analysis

Variable	Survey question
AGE	"What is your age?"
GENDER	"What is your gender?"
EDU	"What is your highest level education you have attained?"
OCCUP	"What is your occupation?"
INCOME	"Which best describes your annual household income?"
MEMBER	"How many members are in your household?"
NCU3	"Do you have children under age 3 living at home?" Followed by: "How many are they?"
NCB3N12	"Do you have children between 3-12 living at home?" Followed by: "How many are they?"
WATESAFE	"Is your city water available in your community safe for human consumption?"
INDUSTRY	"What do you think that causes the water pollution in your community?" Followed by: "Heavy industry?"
HOGINDU	"What do you think that causes the water pollution in your community?" Followed by: "Hog production?"
HOUSEHOL	"What do you think that causes the water pollution in your community?" Followed by: "Household?"
AGRICUL	"What do you think that causes the water pollution in your community?" Followed" by: "Agriculture, except for hog production?"
WTPINDU	"How much money are you willing to pay to have non-polluted water each year?" Followed by: "For industry related pollution?"
WTPHOG	"How much money are you willing to pay to have non-polluted water each year?" Followed by: "For hog related pollution?"
WTPHOUS	"How much money are you willing to pay to have non-polluted water each year?" Followed by: "For household related pollution?"
WTPAGRI	"How much money are you willing to pay to have non-polluted water each year? Followed by: "For agricultural pollution, except for hog pollution?"

*For complete survey see Appendix A & B

Empirical Methods

In this survey, gender, age, education, income, occupation, and children in his/her household were used for sample socioeconomic characteristics. Questions about the safety of city water for consumption and specific actions used by household in order to avoid the water pollution problem were utilized. These actions included purchasing bottled water, hauling water, boiling water, and using an in home water treatment system. Also, respondents were asked their opinions about what causes the water pollution and their WTP in order to have clean and drinkable water.

Item non-response is a typical problem with open-ended CVM because the WTP question is difficult to answer. For that reason, the scaled WTP question was used in this study: how much money you would be willing to pay each year in order to have non-polluted and drinkable water? Followed by categories of amounts.

In addition, respondents would be asked what pollutant sources caused the loss of water quality. Sources were distributed into four categories which were heavy industry, hog industry, household, and non-swine agriculture. By using these four classes, it would be clearly specified what kind pollutant source the respondents were most concerned.

This study used two different questionnaires which had two distinctive levels of WTP categories while other questions remained the same. The first questionnaire (Form A) had lower suggested WTP amount than the other questionnaire (Form B). Table 8 shows the different suggested WTP amounts in the two questionnaires. The WTP amount of the second questionnaire (Form B) was three times as much as the WTP amount of the first questionnaire (Form A) in this survey. This approach tried to examine whether the different stated WTP amounts would draw the different expected WTP values. Also, the equality of WTP in these two cities also was examined where the Kaohsiung city was viewed as the urban city and the Pingtung city as the rural city. This study seeks to find out whether there is any significant difference between the WTP of these two cities.

Ordinary least-squares (OLS) regression function was used to estimate the WTP (Eq. 1).

Eq. 1: $WTP_i = \beta X_i + \varepsilon_i$

where WTP_i is a dependent variable

β is a vector of coefficients

X_i is a vector of independent variables

ε_i is a normal distribution error term

$i = 1,\ldots\ldots,n$ observations

Previous studies (Elnagheeb and Jordan, 1997, Whitehead and Groothuis, 1994, and Loomis, 1987) suggested that socioeconomic characteristics and concerns with water pollution had been significant variables in the WTP estimation. Thus, AGE, GENDER, EDU, OCCUP, INCOME, MEMBER, NCU3, NCB3N12, WATESAFE, and HOGINDU were hypothesized to be significant independent variables in Eq. 1.

Table 8. Two Levels of Annual Willingness to Pay

WTP(Scale)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Form A WTP	None	1-500	500-1,000	1,000-1,500	1,500-2,000	2,000-2,500	2,500 and more
Form B WTP	None	1-1,500	1,500-3,000	3,000-4,500	4,500-6,000	6,000-7,500	7,500 and more

Unit: WTP is in NT$

CHAPTER 4. EMPIRICAL RESULTS

Sample Characteristics

Out of 400 eligible residential households, 379 respondents in the Kaoping area participated in this study, giving a response rate of 94.8 percent. The other 21 residents chose not to answer the questions. The 379 responses were acceptable to represent a statistically valid sample of the population of two cities (Kraemer and Thiemann, 1987). In 379 respondents, 52 percent of the sample was male, and 48 percent was female. Sample average age of the respondents was 39.74. The average education scale was 3.16, which was about 10 years of education (12 years of education are required to graduate high school in Taiwan). The sample average income scale was 3.08, which was about NT$516,000. The average household size was 4.31 and the total number of children who were under 12 in the household was fewer than one.

Data Analysis

In this sample, 358 of valid respondents did not believe that city water was safe for human consumption. Fifteen residential households felt that city water was drinkable and 6 residents answered they didn't know if the city water was drinkable or not. For those 358 households, Table 9 shows actions taken to avoid the water pollution.

Table 9. Action Taken to Avoid Water Pollution

Action	Number of Households
Purchasing Water	136
Hauling Water	47
Boiling Water	259
Having Water Treatment System	311
Other	17
None	4

Table 10 indicates what the 379 respondents thought caused the water pollution in their community. The scale ranged from 1 (strongly agree) to 5 (strongly disagree). In this question, residents reported heavy industry most caused the water pollution problem in their community with scale mean 1.77. The household pollution was on second place, and hog industry on third place, with 1.95 and 1.99 respectively. The non-swine agriculture, with scale mean 2.31, was on last place. For the results of the WTP, as expected, respondents would like to pay more to reduce heavy industry pollution, and pay less to reduce the non-swine agricultural pollution. The WTPHOG mean was slightly larger than WTPHOUS although people had more concerns with household pollution rather than hog pollution (Table 11).

Table 10. Source Causing the Water Pollution

Source	Mean Scale	Strongly Agree (1)	Agree (2)	Neither Agree or Disagree (3)	Disagree (4)	Strongly Disagree (5)	Don't Know (Missing Value)
Heavy Industry	1.77	164	141	55	11	1	7
Household	1.95	116	175	57	19	1	11
Hog Industry	1.99	138	128	75	25	4	9
Non-Swine Agriculture	2.31	73	137	100	31	6	32

Table 11. Comparison of Four Willingness to Pay Categories

Category	Mean Scale		Annual WTP per Residential Household (*)		Aggregate Annual WTP in the Kaoping Area (**)(***)	
	Form A	Form B	Form A	Form B	From A	Form B
WTPINDU	4.08	4.21	1,540	4,815	772,464	2,415,204
WTPHOG	3.48	4.06	1,240	4,590	621,984	2,302,344
WTPHOUS	3.52	3.90	1,260	4,350	632,016	2,181,960
WTPAGRI	2.87	3.44	943	3,660	473,008	1,835,865

(*) Unit: WTP is in NT$

(**) Aggregated by 501,600 households in Kaoping area

(***) Unit: WTP is in NT$1,000

In term of correlations, the four WTP categories have strongly correlated to each other at significant 0.01 level (Table 12). This shows that if respondents were willing to pay for one pollutant source, they would like to pay the other pollutant sources.

In this survey, 84.2 percent (319 of 379 respondents) indicated that they would be willing to pay in order to have the non-polluted drinkable water. Missing values on other explanatory variables reduced the sample size to 309. Summary statistics by explanatory variables are listed on Table 13.

Table 12. Correlations of Four Willingness to Pay Categories

	WTPINDU	WTPHOG	WTPHOUS	WTPAGRI
WTPINDU	1.000	0.904(*)	0.821(*)	0.771(*)
WTPHOG	0.904(*)	1.000	0.866(*)	0.839(*)
WTPHOUS	0.821(*)	0.866(*)	1.000	0.818(*)
WTPAGRI	0.771(*)	0.839(*)	0.818(*)	1.000

(*) Correlation is significant at the 0.01 level (2-tailed)

Table 13. Definitions and Descriptive Statistics of Explanatory Variables

Variable	Definition	Valid Sample Size	Mean	Std. Deviation
AGE	Age in years	319	39.74	13.30
GENDER	1 if male, 2 otherwise	319	1.48	0.50
OCCUP	Occupation	319	3.36	1.77
INCOME	Household annual income	315	3.17	1.18
MEMBER	Members in household	319	4.31	2.17
NCU3	Number of children under 3	319	0.43	0.65
NCB3N12	Number of children between 3 and 12	319	0.53	0.79
WATESAFE	City water drinkable? 1 if yes, 2 if no	315	1.97	0.18
HOGINDU	Hog industry causing water pollution	318	1.92	0.93

As mentioned, this study distributed the water pollutant sources into four categories which were heavy industry, hog production, household, and non-swine agriculture. Thus, there were four WTP variables which were WTPINDU, WTPHOG, WTPHOUS, and WTPAGRI (see Table 7) in this study. Since this study had focused on the hog production related water pollution, the following WTP discussion will emphasize the WTP for clean water by reducing the swine waste pollution.

Options of hog related willingness to pay

In this study, residential households were asked by what form they would be willing to pay for clean water. Four options were explained as follow:

1. WTP a higher water fee: it suggested residential households would pay for having a better city water treatment system.

2. WTP higher taxes: it suggested residential households would require the government to enforce more legislative regulations on the hog industry and would pay for enforcement cost in higher taxes.
3. WTP higher prices of pork and pork products: it suggested that if the improving waste treatment and restrictions increased the cost of pork production, residential households would pay more for pork and pork products.
4. Buying imported pork and pork products: it suggested residential households required that the government would open the hog markets in Taiwan.

Table 14 indicates that 35 percent (111 of 319 respondents) would rather pay for having a better city water treatment system than other options. The residents would like to pay higher price of pork and pork products as the second option while buying imported pork products as the third option and paying for higher tax as the last option. In addition, 5 percent (16 of 319 residents) responded that they did not know how they would like to pay for better water quality.

Table 14. Option for Hog Industry Related Willingness to Pay

Option	Number of Household
WTP for Higher Water Fee	111
WTP for Higher Tax	54
WTP for Higher Price of Pork and Pork Products	76
Buying Imported Pork and Pork Products	62
Don't Know	16

Willingness to pay regression function

The OLS regression function shown in Eq. 1 was used to estimate the WTP in this study. This regression generated the WTPHOG model (Eq. 2). Independent variable coefficients and statistical measures are shown in Table 15.

Eq. 2: WTPHOG = $F(X_i)$

where X_i is AGE, GENDER, EDU, OCCUP, INCOME, MEMBER, NCU3, NCB3N12, WATESAFE, and HOGINDU

Because AGE, EDU, OCCUP, and MEMBER were not statistically significant, a modified OLS regression model (Eq. 3) was introduced after removing these four variables

Table 15. Independent Variable Coefficients and Statistical Measures

Variable	Unstandardized Coefficient	Std. Error	Standardized Coefficient	t-value	2-Tail Sig. p-value
CONSTANT	2.638	0.980	-	2.692	0.008
AGE	-0.003	0.005	-0.027	-0.673	0.501
GENDER	-0.313	0.139	-0.086	-2.250	0.025
EDU	0.074	0.077	0.040	0.974	0.331
OCCUP	0.000	0.040	0.000	-0.006	0.995
INCOME	0.541	0.068	0.352	7.908	0.000
MEMBER	-0.010	0.040	-0.013	-0.263	0.792
NCU3	0.260	0.115	0.093	2.267	0.024
NCB3N12	0.168	0.102	0.073	1.644	0.101
WATESAFE	0.706	0.433	0.062	1.631	0.104
HOGINDU	-0.927	0.086	-0.459	-10.820	0.000

Dependent variable: WTPHOG
R Square: 0.587
Adjusted R Square: 0.573
F-Statistics: 42.125

from the original model (see Table 15). The R Square changed very little and the F statistics improved in the second model. The independent variable coefficients and statistical measures are shown in Table 16.

Eq. 3: WTPHOG = F(X_i)

where X_i is GENDER, INCOME, NCU3, NCB3N12, WATESAFE, and HOGINDU

Table 16. Independent Variable Coefficients and Statistical Measures

Variable	Unstandardized Coefficient	Std. Error	Standardized Coefficient	t-value	2-Tail Sig. p-value
CONSTANT	2.621	0.980	-	2.886	0.004
GENDER	-0.329	0.139	-0.090	-2.424	0.016
INCOME	0.552	0.065	0.358	8.462	0.000
NCU3	0.257	0.109	0.092	2.358	0.019
NCB3N12	0.152	0.088	0.067	1.736	0.084
WATESAFE	0.760	0.438	0.066	1.776	0.077
HOGINDU	-0.946	0.084	-0.468	-11.216	0.000

Dependent variable: WTPHOG
R Square: 0.585
Adjusted R Square: 0.577
F-Statistics: 70.890

The hog industry related willingness to pay (WTPHOG) for non-polluted and drinkable water increased with the level of income showing that water was a normal good. Table 16 implies that respondents with higher income were willing to pay more than those who had lower level of income. The positive coefficient on INCOME meant, with all other variables held constant, the higher income residents had, the more they wanted to pay for clean water. The regression model also suggested that male respondents were willing to pay more than female respondents since a negative coefficient of GENDER was found. According to previous studies, the older respondents had less supportive of environmental problems than younger respondents (Elnagheeb and Jordan, 1997, Loomis, 1987, and Hamilton, 1985). This study indicated WTPHOG declined as age increased, as shown by the negative coefficient on the variable AGE (see Table 15). But the statistic test shows that AGE was not significant due to its p-value was greater than its critical value, 0.10.

Like Whitehead and Groothuis (1992) suggested, residents with children in their households would likely pay more than those who did not have children in houses. Positive coefficients on both NCU3 and NCB3N12 could interpreted that respondents having children would be more concerned on water pollution than others.

The hog industry related WTP for clean water increased as the individual more strong agreed that water pollution was caused by hog industry pollution. The coefficient on the variable HOGINDU had a negative number since the scale of this variable was coded from 1 (strongly agree) to 5 (strongly disagree). If the residential households thought the city water was not safe for human consumption, they would be willing to pay more in order to have clean water to drink. That was a reason that the positive coefficient on WATESAFE was presented.

Independent sample t-test

As mentioned, this study used questionnaires with two levels of WTP variables, AWTPHOG and BWTPHOG, which had two distinctive levels of WTP amounts while other questions remained the same. A null hypothesis (Hp. 1) was made that AWTPHOG and

BWTPHOG would have the same mean in spite of two levels of WTP categories shown in Table 8.

Hp. 1: H0: AWTPHOG = BWTPHOG

An independent sample t-test was performed and the p-value was less than 0.05. This result showed the null hypothesis was rejected indicating that AWTPHOG and BWTPHOG would have different average numbers, and BWTPHOG, 4.06, had higher mean than AWTPHOG, 3.48. This test suggested that the higher suggested WTP amount would draw higher expected WTP value to respondents. The result of the independent sample t-test is listed on Table 17.

This study tested that whether significant differences of respondents' socioeconomic characteristics between Form A and Form B caused the different hog production related WTP. T-test was used to compare two questionnaire (Form A and B) means of four

Table 17. Independent Sample t Test Result for Hog Industry Related Willingness to Pay

	t-test	df	2-Tail Sig. p-value	Mean Difference	Std. Error Difference
Hog Industry Related WTP: Form A vs Form B	-2.875	317	0.004	-0.58	0.20
Hog Industry Related WTP: Kaohsiung vs Pingtung	2.234	317	0.026	0.45	0.20

independent variables, GENDER, INCOME, NCU3, and NCB3N12. This study made four null hypotheses that two population means are equal for these four variables (Hp. 2-5).

Hp. 2: H0: GENDER(A) = GENDER(B)

Hp. 3: H0: INCOME(A) = INCOME (B)

Hp. 4: H0: NCU3(A) = NCU3(B)

Hp. 5: H0: NCB3N12(A) = NCB3N12(B)

Table 18 shows that there was no statistical significant differences in these characteristics between these two questionnaires. At the 5 percent significant level, the t-test strongly suggested that all of four hypotheses were accepted based on the results observed in two population samples. The results of the independent sample t-test in this study supported that the difference between AWTPHOG and BWTPHOG was not caused by the differences of socioeconomic characteristics in two samples. Furthermore, it could be argued that the higher stated WTP would generate higher predicted WTP while two population samples had statistically equal means of socioeconomic characteristics.

What can make the different WTPHOG mean between these two questionnaires (Form A and Form B)? One reason can be argued that higher stated WTP amounts in Form B may raise more respondent's awareness and concerns with the environmental quality, and they will consequently respond with their higher WTP. Nevertheless, they may actually pay the less real WTP regardless of what they said or what form they had. Like Loomis et al.'s (1996), Neill et al.'s (1994) and Kealy, Dovidio, and Rockel's (1988) suggestions, the hypothetical

Table 18. Independent Sample t Test Results for Socioeconomic Characteristics in Form A and Form B

Variable	t-test.	df	2-Tail Sig. p-value	Mean Difference	Std. Error Difference
GENDER	1.094	317	0.275	0.061	0.056
INCOME	-0.118	313	0.906	-0.016	0.130
NCU3	0.027	317	0.979	0.003	0.073
NCB3N12	0.020	317	0.984	0.002	0.089

WTP are statistically greater than real cash WTP. Therefore, the hypothetical WTP of residential households may be greater than their actual WTP.

This GROUP variable differentiated between those respondents who lived in Kaohsiung city (urban) and Pingtung city (rural.) This study also would like to examine that if there is a different WTPHOG mean between respondents in these two cities. By using independent samples t test, a null hypothesis (Hp. 6) of equality of WTPHOG between the two cities was made.

Hp. 6: H0: WTPHOG(G1) = WTPHOG(G2)

The result of the hypothesis was not accepted. The significant p-value, 0.026, was less than 0.05. The former group (Kaohsiung city) with mean 4.01 was willing to pay more than the latter group (Pingtung city) with 3.55. Table 16 also shows the result of this test.

This study tested that whether significant differences of respondents' socioeconomic characteristics between Kaohsiung city and Pingtung city caused the different hog production related WTP. T-test was used to compare two city means of four independent variables, GENDER, INCOME, NCU3, and NCB3N12. This study made four null hypotheses that two population means are equal for these four variables (Hp. 7-10).

Hp. 7: H0: GENDER(G1) = GENDER(G2)

Hp. 8: H0: INCOME(G1) = INCOME (G2)

Hp. 9: H0: NCU3(G1) = NCU3(G2)

Hp. 10: H0: NCB3N12(G1) = NCB3N12(G2)

Table 19 shows that there was no statistical significant differences in these characteristics between these two cities. At the 5 percent significant level, all of four hypotheses were not rejected based on the results observed in two population samples. The results of the independent sample t-test in this study found that the residents in Kaohsiung city (urban) would pay more for better water quality than people in Pingtung city (rural) while two population samples had statistically equal means of socioeconomic characteristics.

Table 19. Independent Sample t Test Results for Socioeconomic Characteristics in Two Cities

Variable	t-test.	df	2-Tail Sig. p-value	Mean Difference	Std. Error Difference
GENDER	-0.218	317	0.827	-0.012	0.056
INCOME	1.599	313	0.111	0.210	0.130
NCU3	-0.586	317	0.558	0.043	0.073
NCB3N12	0.702	317	0.483	0.062	0.089

Hypothetical willingness to pay versus actual willingness to pay

The OLS regression model that expressed WTPHOG as a linear function of the explanatory variables (GENDER, INCOME, NCU3, NCB3N12, WATESAFE, and HOGINDU) was found to fit the data well. Results (Table 11) from this model showed that the two population means of WTPHOG were 3.48 for Form A and 4.06 for Form B, which could be annually willing to pay NT$1,240 (Form A) and NT$4,590 (Form B). These WTP could cost from one day salary to three day salary of average household annual income in Taiwan.

Furthermore, there were about 501,600 households in two cities. Aggregating the WTPHOG across households suggests the expected hog production related WTP in these two cities could add up to NT$621.984 million or NT$2.302 billion each year overall. The two different WTPHOG values would depended on which questionnaire would be employed. The WTPHOG values in these cities could be treated as the estimated costs of environmental pollution related by the hog industry. Since there were about 3.4 million pigs in this area, the social cost of hog related water pollution could be NT$182.94 or NT$677.16 for each pig. These estimated environmental cost could be approximately from 4 percent to 15 percent of the 1995 wholesale hog price in Taiwan.

According to previous studies that indicated the hypothetical WTP greater than actual WTP, 9:1 (Neill, et al., 1994) and 3:1 (Loomis et al., 1996), the predicted WTP of this study could be greater than the resident's actual WTP. Table 20 shows various predicted WTP (hypothetical) and cash WTP (actual) in Form A and Form B questionnaires.

Table 20. Hypothetical Willingness to Pay Versus Actual Willingness to Pay

	Hypothetical WTP vs. Actual WTP (Neill, et al.'s Study, 9:1)		Hypothetical WTP vs. Actual WTP (Loomis, et al.'s Study, 3:1)	
	Hypothetical WTP	Actual WTP	Hypothetical WTP	Actual WTP
Form A				
WTPHOG	NT$1,240	NT$137.78	NT$1,240	NT$413.34
Form B				
WTPHOG	NT$4,590	NT$510.00	NT$4,590	NT$1,530.00

This study suggests that, for the Form A questionnaire, the actual WTP is approximately from NT$137.78 to NT$413.34, and the actual WTP is about from NT$510 to NT$1,530 for the Form B questionnaire. The maximum actual WTP is about eleven times as much as the minimum actual WTP in this study. This gap between these WTP can cause dilemma about which actual WTP would be chosen for estimating the environmental cost of hog related water pollution. For example, the hog producers may choose the minimum actual WTP for social cost of hog operation while the environmentalists choose the maximum actual WTP. Therefore, the further study is needed to test if greater suggested WTP would consistently generate higher expected WTP value by using smaller or larger different levels of WTP categories. The additional study would include improving the gap between people's intended behavior (hypothetical WTP) and actual behavior (real cash WTP).

CHAPTER 5. CONCLUSION

With the change in human population, incomes, and dietary patterns, the domestic demand for pork and pork products in Taiwan has increased since the mid-1960s. Unlike beef production, in which the government allowed imports to cover most of the domestic demand, the Taiwanese government projected meeting the domestic hog demand through increased local production. As a result, the Taiwanese hog industry has been transformed from traditional sideline farms into large-scale business enterprises. Hog production also has been expanded over the years and Taiwan has become a major exporter of pork products to Japan. This expansion has resulted in increased water pollution from hog production.

In this study, data from a 1997 telephone survey of the Kaoping residents was used to study hog production related willingness to pay (WTPHOG) for improving water quality. An ordinary least square (OLS) regression model that expressed WTPHOG as a linear function of the explanatory variables was found to fit the data well. This study found that WTPHOG for water increased with level of income and that male respondents were willing to pay more than females. Respondents who had children in their household and were more concerned on water pollution would be willing to pay more than others.

This study found that the higher suggested WTPHOG amount would draw higher expected WTPHOG value to respondents while the socioeconomic characteristics of two population samples were statistically equal. Further, this study showed the residents in Kaohsiung city would pay more than residents in Pingtung city.

Results show that the average hog industry related WTP was between NT$1,240 to NT$4,590 annually, depending on the questionnaire was employed. Finally, the environmental cost of the water pollution per pig based on aggregate WTPHOG was from NT$182.94 to NT$677.16 in the Kaoping area of Taiwan. This amount is approximately from 4 percent to 15 percent of the 1995 wholesale pig price.

However, given the increasing concern over hog waste-related environmental problems, it is very likely that Taiwan will reduce hog production significantly in the near future. Thus, the pork market on the island will likely be opened further. As the largest supplier of Taiwan's agricultural imports, the United States is in a good position to increase its pork exports, including high-value pork products. To prepare for this new trade regime, it is advantageous for U.S. industry participants to investigate in great detail the potential impact of Taiwanese hog production reductions on the export of U.S. pork and pork products to Japan and Taiwan.

APPENDIX A. FORM A QUESTIONNAIRE

My name is Kuo-Chang Ro. I am a graduate student working toward a Master's degree in Economics Department at Iowa State University. I am conducting a study concerning the social cost which is associated with hog production related water pollution problem in Taiwan. In this study, you will be asked to fill out the questionnaire through this telephone interview.

Your participation in this study is greatly valued. Thank you very much for your time in making our study a success.

1. What is your gender?
   ___1. Male
   ___2. Female

2. What is your age?

   ____

3. How many members are in your household?

   ____

4. Do you have children under age 3 living at home?
   ___1. Yes
   ___2. No

5. If yes, how many are they?

   ____

6. Do you have children between 3-12 living at home?
   ___1. Yes
   ___2. No

7. If yes, how many are they ?

   ____

8. What is your highest level education you have attained?
   ___1. Grade school
   ___2. Junior high school
   ___3. High school graduate
   ___4. College graduate
   ___5. Graduate degree

9. What is your Occupation?
___1. Manufacture Industry
___2. Agriculture
___3. Service Industry
___4. Government Employee
___5. Education
___6. Student
___7. Other

10. Which best describes your annual household income?
___1. Under NT$300,000
___2. NT$300,000-NT$500,000
___3. NT$500,000-NT$700,000
___4. NT$700,000-NT$900,000
___5. NT$900,000 and More

11. Is your city water available in your community safe for human consumption ?
___1. Yes ___2. No

12. If no, what actions you take to avoid water pollution problem? (Check all that apply.)
___1. Purchasing bottled water
How many bottles do you purchase a week? __________
___2. Hauling water
How many trips do you take in order to haul water a week? __________
How much time and how far does a single trip take? ______ hr. ______ km
___3. Boiling water
___4. Having water treatment system
___5. Other (Please describe.) __________
___6. None

13. What do you think that causes the water pollution in your community?
___a. Heavy industry
___1. Strongly agree ___2. Agree ___3. Neither agree nor disagree
___4. Disagree ___5. Strongly disagree
___b. Hog production
___1. Strongly agree ___2. Agree ___3. Neither agree nor disagree
___4. Disagree ___5. Strongly disagree
___c. Household
___1. Strongly agree ___2. Agree ___3. Neither agree nor disagree
___4. Disagree ___5. Strongly disagree
___d. Agriculture, except for hog production
___1. Strongly agree ___2. Agree ___3. Neither agree nor disagree
___4. Disagree ___5. Strongly disagree

14. Are you willing to pay in order to have non-polluted and drinkable water?
___1. Yes ___2. No

15. If yes, how much money are you willing to pay to have non-polluted water each year? And what form are you going to pay for?

15.i For industry related pollution:
How much?
___1i. None ___2i. NT$1-500 ___3i. NT$500-1000 ___4i.NT$1000-1500 ___5i. NT$1500-2000 ___6i. NT$2000-2500 ___7i. Above NT$2500
What form? (Please choose only one.)
___1i. Pay for higher water fee
___2i. Pay for higher tax
___3i. Pay for higher prices of manufacture merchandises
___4i. Buy Imported manufacture merchandises

15.p For hog related pollution:
How much?
___1p. None ___2p. NT$1-500 ___3p. NT$500-1000 ___4p.NT$1000-1500
___5p. NT$1500-2000 ___6p. NT$2000-2500 ___7p. Above NT$2500
What form? (Please check only one.)
___1p. Pay for higher water fee
___2p. Pay for higher tax
___3p. Pay for higher prices of pork and pork products
___4p. Buy Imported pork and pork products

15.h For household related pollution:
How much?
___1h. None ___2h. NT$1-500 ___3h. NT$500-1000 ___4h.NT$1000-1500
___5h. NT$1500-2000 ___6h. NT$2000-2500 ___7h. Above NT$2500
What form? (Please choose only one.)
___1h. Pay for higher water fee
___2h. Pay for higher tax
___3h. Pay for higher prices of sewage

15.a For agricultural pollution, except for hog pollution:
How much?
___1a. None ___2a. NT$1-500 ___3a. NT$500-1000 ___4a.NT$1000-1500
___5a. NT$1500-2000 ___6a NT$2000-2500 ___7a. Above NT$2500
What form? (Please choose only one.)
___1a. Pay for higher water fee
___2a. Pay for higher tax
___3a. Pay for higher prices of food
___4a. Buy Imported food

Once again, thank you very much for your time to participate this study. We are very appreciative of your help in this study. We believe this study will provide valuable information on hog production related water pollution problem in Taiwan.

Thank you very much.

APPENDIX B. FORM B QUESTIONNAIRE

My name is Kuo-Chang Ro. I am a graduate student working toward a Master's degree in Economics Department at Iowa State University. I am conducting a study concerning the social cost which is associated with hog production related water pollution problem in Taiwan. In this study, you will be asked to fill out the questionnaire through this telephone interview.
Your participation in this study is greatly valued. Thank you very much for your time in making our study a success.

1. What is your gender?
   ___1. Male
   ___2. Female

2. What is your age?

   ____

3. How many members are in your household?

   ____

4. Do you have children under age 3 living at home?
   ___1. Yes
   ___2. No

5. If yes, how many are they?

   ____

6. Do you have children between 3-12 living at home?
   ___1. Yes
   ___2. No

7. If yes, how many are they ?

   ____

8. What is your highest level education you have attained?
   ___1. Grade school
   ___2. Junior high school
   ___3. High school graduate
   ___4. College graduate
   ___5. Graduate degree

9. What is your Occupation?
   ___1. Manufacture Industry
   ___2. Agriculture
   ___3. Service Industry
   ___4. Government Employee
   ___5. Education
   ___6. Student
   ___7. Other

10. Which best describes your annual household income?
   ___1. Under NT$300,000
   ___2. NT$300,000-NT$500,000
   ___3. NT$500,000-NT$700,000
   ___4. NT$700,000-NT$900,000
   ___5. NT$900,000 and More

11. Is your city water available in your community safe for human consumption ?
   ___1. Yes ___2. No

12. If no, what actions you take to avoid water pollution problem? (Check all that apply.)
   ___1. Purchasing bottled water
   How many bottles do you purchase a week? __________
   ___2. Hauling water
   How many trips do you take in order to haul water a week? __________
   How much time and how far does a single trip take? ______ hr. ______ km
   ___3. Boiling water
   ___4. Having water treatment system
   ___5. Other (Please describe.) __________
   ___6. None

13. What do you think that causes the water pollution in your community?
   ___a. Heavy industry
   ___1. Strongly agree ___2. Agree ___3. Neither agree nor disagree
   ___4. Disagree ___5. Strongly disagree
   ___b. Hog production
   ___1. Strongly agree ___2. Agree ___3. Neither agree nor disagree
   ___4. Disagree ___5. Strongly disagree
   ___c. Household
   ___1. Strongly agree ___2. Agree ___3. Neither agree nor disagree
   ___4. Disagree ___5. Strongly disagree
   ___d. Agriculture, except for hog production
   ___1. Strongly agree ___2. Agree ___3. Neither agree nor disagree
   ___4. Disagree ___5. Strongly disagree

14. Are you willing to pay in order to have non-polluted and drinkable water?
___1. Yes ___2. No

15. If yes, how much money are you willing to pay to have non-polluted water each year? And what form are you going to pay for?

15.i For industry related pollution:
How much?
___1i. None ___2i. NT$1-1,500 ___3i. NT$1,500-3,000 ___4i.NT$3,000-4,500
___5i. NT$4,500-6,000 ___6i. NT$6,000-7,500 ___7i. Above NT$7,500
What form? (Please choose only one.)
___1i. Pay for higher water fee
___2i. Pay for higher tax
___3i. Pay for higher prices of manufacture merchandises
___4i. Buy Imported manufacture merchandises

15.p For hog related pollution:
How much?
___1p. None ___2p. NT$1-1,500 ___3p. NT$1,500-3,000 ___4p.NT$3,000-4,500
___5p. NT$4,500-6,000 ___6p. NT$6,000-7,500 ___7p. Above NT$7,500
What form? (Please check only one.)
___1p. Pay for higher water fee
___2p. Pay for higher tax
___3p. Pay for higher prices of pork and pork products
___4p. Buy Imported pork and pork products

15.h For household related pollution:
How much?
___1h. None ___2h. NT$1-1,500 ___3h. NT$1,500-3,000 ___4h.NT$3,000-4,500
___5h. NT$4,500-6,000 ___6h. NT$6,000-7,500 ___7h. Above NT$7,500
What form? (Please choose only one.)
___1h. Pay for higher water fee
___2h. Pay for higher tax
___3h. Pay for higher prices of sewage

15.a For agricultural pollution, except for hog pollution:
How much?
___1a. None ___2a. NT$1-1,500 ___3a. NT$1,500-3,000 ___4a.NT$3,000-4,500
___5a. NT$4,500-6,000 ___6a. NT$6,000-7,500 ___7a. Above NT$7,500
What form? (Please choose only one.)
___1a. Pay for higher water fee
___2a. Pay for higher tax
___3a. Pay for higher prices of food
___4a. Buy Imported food

Once again, thank you very much for your time to participate this study. We are very appreciative of your help in this study. We believe this study will provide valuable information on hog production related water pollution problem in Taiwan.

Thank you very much.

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