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# Economic Assessment of Meteorological Information Services for Livestock Farmers: A Case Study in Taiwan

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**Abstract**

The substantial livestock production losses can be attributed to increased mortality, reduced feeding efficiency, and productivity, and those phenomenon could be affected by the extreme weather events. This research uses contingent valuation method (CVM) to evaluate the economic benefits of the meteorological information services provided by Central Weather Bureau for livestock farmers in 2016. Meteorological services has typically been perceived as public goods which should be provided by the government with free charges. However, there is no marketing mechanism designed for meteorological services. So CVM should be an appropriate methodology to adopt to evaluate their economic values.

The livestock industry in Taiwan has approximately 30 percent of total production values in agricultural sector. The top four livestock productions by values are hog, chicken, egg, and dairy. Therefore, we recruited 125 registered livestock farmers who hogs, chickens, egg chickens, and dairy cows in 2016 as our research participants and conducted face-to-face survey to collect data. Research outcomes has found that 74% and 83% of the respondents perceive that weather information will have positive effect on and can reduce risk on livestock production respectively.

Additionally, research has found that dairy farmers have higher frequency in using internet or smartphone application to access weather information than other livestock farmers. As a result, the dairy farmers have higher average willingness to pay for weather information services with better accuracy than other livestock farmers. Respondents' judgement on the accuracy of weather information, years of experiences in livestock farming, and first bid price all have a significant influence on their Willingness to Pay (WTP).

With the CVM calibration methodology, we have found that an estimate of respondents' average monthly WTP for meteorological information service is 488.63 NT dollars. The monthly WTP estimates in 95% confident interval lie between 457.72 and 519.54 NT dollars. Compared this result to our previous findings concerning the WTP estimates of crops farmers and fishermen, starting point bias has less impact on livestock farmers' WTP. That is their WTPs are anchored within certain ranges of economic values. Besides, for farmers with longer years of experiences in livestock farming, their WTP is higher. This might indicate that senior livestock farmers are more likely to pay more cost to access weather information service with better accuracy, and this has shown a big difference than our previous research which whose research participants are farmers or fishermen.

**Keywords:** Contingent Valuation Method, Willingness to Pay, Meteorological Information Service, Livestock

## 1. Introduction

The occurrence of extreme weather events is on the increase due to climate change. In addition to significant influence to lifestyles of the public, the production values, production yield, and the profits in various industries would also been influenced. According to the fifth scientific assessment report (AR5) released by the Intergovernmental Panel on Climate Change (IPCC) in 2014, the impact of the climate change for agricultural and food security can be divided into the aspect of atmospheric and climate factors (such as temperature, rainfall, carbon dioxide, ozone, etc.) and the aspect of non-climate factors (such as soil fertility, irrigation, population, economic, social policies, etc.). Factors of these two aspects then could affect agricultural production directly or indirectly. So issues such as the decrease of the food self-sufficiency ratio would be gradually formed.

The production values in agricultural sector has gradually increased in recent years. In 2016, the total value has reached 517.573 billion NT dollars and which has grown 33.01% compared to the amount of 389.129 billion NT dollars in 2007. If we categorize the production value by agricultural, livestock, forest, and fishery productions, agricultural productions has continued to be the highest, followed by livestock productions, fishery productions and forest productions. For example, agricultural productions accounted for 51.30% (265.529 billion NT dollars) of the total agricultural output value in 2016. In addition, livestock productions accounted for 31.95% (165.384 billion NT dollars), fishery productions accounted for 16.70% (86.453 billion NT dollars), and forest productions accounted for 0.04% (207 million NT dollars) of the total agricultural output value.

Although the production value of the agricultural sector is increasing, the amount of agricultural disaster losses (including agricultural disaster productions and loss of private facilities) in Taiwan has showed a trend to increase first, then to decrease, and increase again since 2007. In 2009, typhoon Morakot made a new rainfall record (a total of 3059.5 millimeters of rainfall measured at the Alishan station), resulting in an annual losses of 29.132 billion NT dollars by agricultural disasters. The losses of agricultural products was approximately 20.528 billion NT dollars (70.46% of total agricultural disaster losses), and private facilities losses were approximately 8.605 billion NT dollars (29.54 % of total agricultural disaster losses). In 2016, because of the severe cold current in January, Typhoon Nepartak, and Typhoon Megi, the amount of agricultural disaster losses has increased to reach 38.340 billion NT dollars in 2016, which has grown 138.37% compared to 16.050 billion NT dollars in 2015. The product loss was 35.510 billion NT dollars (92.62% of the total agricultural disaster losses), and the private equipment losses were approximately 2.830 billion NT dollars (7.38% of the total agricultural disaster losses). The loss of agricultural disasters in

Taiwan is mainly attributed to crop losses. If we look at agricultural productions, forest productions, fishery productions, and livestock productions, the annual loss of agricultural disasters is mainly attributed to agricultural productions. Only in 2009 and 2016, fishery productions, livestock productions, and forest productions can be observed to have a more severe disaster losses.

Wu (2013) conducted research to evaluate meteorological information services for agricultural crops, and has found that the economic value interval ranges from 883 million to 1.432 billion NT dollars, of which rice producers is the highest (from 286 million to 463 million NT dollars). From the economic value of meteorological information services for aquaculture and coastal fisheries in 2016, we found that the annual economic value of meteorological information for aquaculture was about 240 million to 266 million NT dollars, and 484 million to 539 million NT dollars for coastal fisheries. Therefore, this research will recruit livestock farmers as research participants, and applying contingent valuation method to evaluate the economic value of meteorological information services for livestock farmers. The purpose of this research is to provide more information for various government departments and public sectors in agriculture, especially in the process of formulating policy related to applying meteorological services in agricultural industry.

## 2. Methodology: Contingent Valuation Method

Generally, it is the most straightforward way that we evaluate the value of a product or service by the theoretical method of economics. In other words, we can calculate consumer’s willingness to pay, the price of the goods, and the profits earned by the producers by observing the demand and supply equilibrium in the market. Besides, we can obtain the social value of the goods by the market size. Currently, most weather information in Taiwan is provided by Central Weather Bureau, which makes the weather forecast information to have the characteristics of public goods. That is, the weather forecast information is "non-exclusiveness" and "non-rivalry". When some people get access to weather information, that would not influence how other people use and access the information. Therefore, it is difficult to reflect the value of Taiwan's weather information. Besides, when decision-makers use the weather information to make decisions and bring values to the market, it cannot be reflected in the market as well. Although Taiwan's weather information is not a market transaction commodity, it can be classified as a common non-market commodity category in the field of environmental economics. Its value comes from use value and non-use value of the information by people. According to the environmental economics, sum of values that people are willingness to pay for the information is used as a measurement of the value of meteorological information when we evaluate

the value of the goods. At present, we can only use Contingent Valuation Method (CVM) to conduct the two methods of value connotation at the same time. This study also adopted this method and conducted a nationwide survey to measure the willingness to pay (WTP) of meteorological information for livestock producers in Taiwan and evaluate economic value of meteorological information services for livestock productions.

The basic concept of CVM was proposed by Ciriacy-Wantrup (1947). He believes that if we want to know the value of specific "goods," we should ask people directly. How can we obtain the amount of "goods" and WTP or willingness to accept (WTP) that we are concerned about, so as to reflect the value and benefits that people possess these "goods" or willingness to accept when people provide the "goods". Therefore, one important task of using this research method is to understand how to use the survey design to have respondents reflect their WTP as a real market in the virtual market. This study follows the guidelines recommended by Arrow et al. (1993) to complete the survey design and the planning of the assessment of meteorological forecast information value. The questionnaire consists of three parts: “Respondent’s Personal Data”, “Meteorological Forecast Information” cognition and experience, and “Meteorological Forecast Information” value assessment, in which “Meteorological Forecast Information” value assessment is the source of the economic value assessment information. The following is the instructions for the establishment of hypothetical market and the induced payment model.

### *2.1 Setting up a hypothetical market*

Generally in a hypothetical scenario, we ask the respondents their value or WTP for a non-market good by utilizing CVM. In real life, the respondents do not have the experience to buy or trade this type of good in the market. Investigators need to construct a hypothetical market for the good and ask the valuation question of respondents’ willingness to pay. The good in this study was identified as meteorological information services provided by the CWB in Taiwan. We used survey questions to construct a hypothetical market for those services, so the livestock farmers selected for this study could perceive the hypothetical market when they were being interviewed. This was the most challenging part of this study.

To achieve the purpose of having respondents successfully develop a perception of the hypothetical market, we used three surveying steps. First, we focused on the “forecast accuracy” of the meteorological information services accessed in their everyday life, and asked the respondents their rating scores on the subjective accuracy of weather forecasts. Secondly, we asked respondents how they apply weather information in their agricultural activities. Finally, we asked them what their yearly

WTPs are for the meteorological information services provided by the CWB.

### *2.2 Induced payment model*

To increase the response rate, we adopted the dichotomous choice model with an open-ended question for WTP valuation. Respondents were given the first bid as the "bid1" shown in Figure 1. They needed to consider whether his/her real value was higher than the value of the first bid, and answer Yes or No. Then, this process was repeated. Respondents who answered Yes, were given a new value (bid2) which was higher than the first bid, while those who answered No, were given a new value (bid3) which was lower than the first bid. After finishing the second stage, the investigator asked the respondent what value was the maximum WTP for him or her.

The advantage of using this method is to offer a bargaining process, as we usually buy a normal commodity in a traditional market. For those who may not have a certain amount of value in mind, they would be able to figure out what their perceived economic value of meteorological information services was at the end. In other words, this valuation question design makes the bidding process easier, and it is more convenient for both respondents and investigators to understand the valuation question.

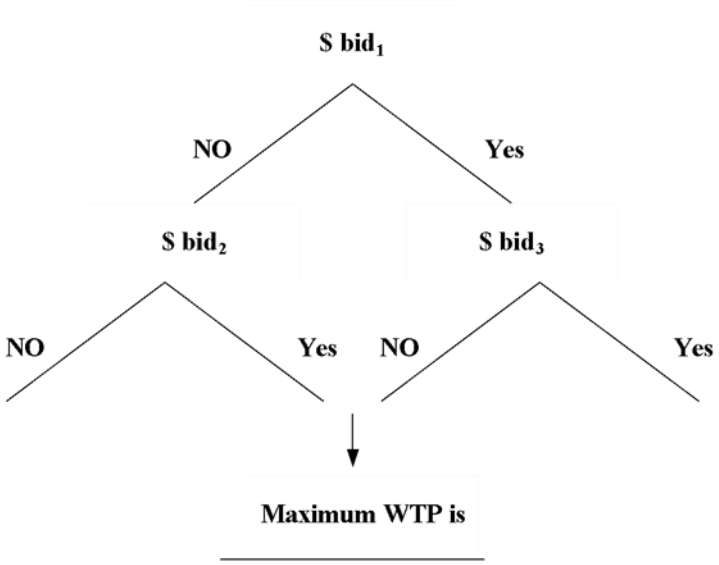



**Figure 1. Dichotomous Choice Model with an Open-ended Elicitation Method**

After we modified our questionnaire, we visited the farmers personally. The main target of this survey was the dairy industry (dairy farmer), chicken industry (chicken farmer), broiler industry (chicken farmer) and hog industry (pig farmer) who are the top four biggest livestock industry in Taiwan. Changhua county and Pingtung County

were our main survey sites. A total of 125 questionnaires were recovered. Table 1 shows the distribution of the questionnaires.

**Table 1: Distribution of Questionnaires**

| | Counties/Townships | Sample Size | Percentage |
|---|---|---|---|
| Dairy Farmer | Changhua County, Lukang Township | 31 | 25% |
| Chicken Farmer | Changhua County, Fangyuan Township | 41 | 33% |
| | Changhua County, Zhutang Township | 25 | 20% |
| Pig Farmer | Changhua County, Zhutang Township | 8 | 6% |
| | Pingtung County, Neipu Township | 20 | 16% |
| Total | | 125 | 100% |

## 3. Data Source

### *3.1 Empirical Data*

**Table 2** shows the ways for respondents to obtain meteorological information were "Television" (96%), followed by "Internet" (54%) and "Experiences from Others" (45%). In addition, 43% of respondents used "Mobile Phone App" to receive meteorological information. The proportion of dairy farmers using "Internet" or "Mobile Phone APP" is higher than chicken farmers and pig farmers. Besides, livestock farmers were more concerned with "Typhoon" (99%), "Rainfall" (90%) and "Temperature" (85%). Regardless of dairy farmers, chicken farmers or pig farmers, their main concern is the trend of typhoon, rainfall and temperatures in order to adjust production management immediately.

**Table 2: The Ways to Obtain Meteorological Information, Usage Status and Demand Ratio (Total sample)**

| | Total | Dairy Cattle | Chicken | Pig |
|---|---|---|---|---|
| Sample Size | 125 | 31 | 66 | 28 |
| **Source of Meteorological Information（%）** | | | | |
| Television | 96% | 90% | 100% | 93% |
| Broadcast | 27% | 23% | 35% | 14% |
| Newspaper | 29% | 13% | 35% | 32% |
| Chinese Lunar Calendar | 22% | 16% | 26% | 18% |
| Internet | 54% | 65% | 53% | 46% |
| Agricultural Weather Advisory System | 4% | 0% | 6% | 4% |
| Field Helper | 1% | 0% | 2% | 0% |
| Experiences from Others | 45% | 61% | 39% | 39% |
| Mobile Phone APP | 43% | 52% | 42% | 36% |
| Past Experiences | 40% | 35% | 39% | 46% |

| | | | | |
|---|---|---|---|---|
| Others | 1% | 0% | 2% | 0% |
| **Usage of Meteorological Information（%）** | | | | |
| Temperature | 85% | 71% | 91% | 86% |
| Rainfall | 90% | 94% | 89% | 86% |
| Typhoon | 99% | 97% | 100% | 100% |
| wind Direction | 34% | 13% | 47% | 29% |
| Wind Speed | 42% | 23% | 55% | 36% |
| Humidity | 30% | 16% | 35% | 32% |
| Comfort | 26% | 10% | 38% | 18% |
| Others | 1% | 3% | 0% | 0% |

On average, livestock producers need to obtain weather forecasts four days ago. Dairy farmers need weather forecasts four days ago, chicken farmers and pig farmers need weather forecasts three days ago. **Table 3** shows 56% of respondents need "One Day Ago" to obtain weather information, followed by 46% of respondents who need "One Week Ago" to obtain weather information. In particular, the majority of dairy farmers needed "One Week Ago" (52%) to obtain weather information, followed by "One Day Ago" (39%). It shows that the dairy farmers need longer response than others. According to the responses from respondents, the demand of the livestock industry for forecasting days mainly falls on "One Day Ago" and "One Week Ago".

**Table 3: How Long to Acquire Weather Forecasts in Advance**

| | Total | Dairy Cattle | Chicken | Pig |
|---|---|---|---|---|
| Sample Size | 125 | 31 | 66 | 28 |
| **How Long to Acquire Weather Forecasts in Advance（%）** | | | | |
| One Day Ago | 56% | 39% | 61% | 64% |
| Two Days Ago | 27% | 19% | 30% | 29% |
| Three Days Ago | 35% | 35% | 41% | 21% |
| Four Days Ago | 11% | 10% | 12% | 11% |
| Five Days Ago | 10% | 10% | 9% | 11% |
| Six Days Ago | 8% | 3% | 9% | 11% |
| One Week Ago | 46% | 52% | 41% | 50% |
| One Month Ago | 2% | 0% | 0% | 7% |
| One Quarter Ago | 1% | 0% | 0% | 4% |
| Two Quarter Ago | 0% | 0% | 0% | 0% |
| Others | 6% | 6% | 6% | 4% |
| **Average Days** | 4 | 4 | 3 | 3 |

**Table 4** shows the overall score was 74 points, and the score of accuracy of weather forecasts for dairy farmers (76 points) was the highest, followed by chicken farmers (75 points), and pig farmers (72 points) was the lowest. In addition, 74% of respondents believe that the weather forecasts can increase the positive impact for

livestock industry. 83% of respondents believe that it can reduce negative impact. We have two ways to increase positive impacts. First, we can adjust cooling devices accurately (fans, sprinkler systems) to reduce electricity costs and increase operating profits. Second, we adjust environmental temperatures to increase animal production. Conversely, we have three ways to reduce negative impacts. First, we can prepare for disaster preparedness in advance to reduce the loss of livestock and animal deaths. Second, we should adjust the animal nutrition formula timely to reduce the physiological discomfort of the animal. For example, when the weather is hot, vitamin C can be added to the animal feed to prevent the animals from suffering heat stroke. Third, when the weather is wet, we can reduce feed storage to avoid feed loss and waste.

**Table 4: The Score of Accuracy of Weather Forecasts for Livestock Industry**

| | Total | Dairy Cattle | Chicken | Pig |
|---|---|---|---|---|
| Sample Size | 125 | 31 | 66 | 28 |
| The Score of Accuracy of Weather Forecasts (Score 0 to 100) | 74 | 76 | 75 | 72 |
| Impacts of Weather Forecasts for Livestock Industry（%） | | | | |
| Increase Positive Impacts | 2% | 0% | 2% | 4% |
| Reduce Negative Impacts | 6% | 0% | 8% | 7% |

**Table 5** shows the socio-economic background of respondents. Most of the respondents were male (89%), the others were female (11%). The average age of respondents was 50. Dairy farmers (average 43 years old) were younger than others. Therefore, the proportion that dairy farmers used "Internet" or "Mobile Phone APP" was higher than chicken farmers and pig farmers. After further analysis of the respondents, they were engaged in livestock industry for an average of 21 years, of which pig farmers had an average of 25 years. This outcome showed that the proportion of pig farmers use "Past Experience" to acquire the meteorological information was higher than others. Furthermore, the respondents whose education above the senior high school was 72%, among which the proportion of pig farmers (93%) was the highest, followed by dairy farmers (80%), chicken farmers (59%). In addition, the respondents' annual income which between 0.5 million to 2.5 million NT dollars accounted for 22%, the annual operating income which above 10 million NT dollars accounted for 24%, and some respondents are reluctant to answer their annual income (22%). Because livestock farmers need to spend more time to take care of livestock and poultry such as cows, chickens, and pigs, most of livestock farmers are engaged in livestock industry as their main work, and up to 98% of respondents' income are mainly came from livestock industry.

**Table 5: Social Economic Background of Respondents（Total Samples）**

| | Sample | Dairy Cattle | Chicken | Pig |
|---|---|---|---|---|
| Sample Size | 125 | 31 | 66 | 28 |
| **Variable** | | | | |
| **Gender** | | | | |
| Male | 89% | 90% | 88% | 89% |
| Female | 11% | 10% | 12% | 11% |
| Average Age | 50 | 43 | 52 | 51 |
| Average Working years in livestock industry | 21 | 20 | 20 | 25 |
| **Education** | | | | |
| Illiteracy | 2% | 0% | 3% | 0% |
| Elementary | 13% | 0% | 21% | 7% |
| Junior High Vocational | 14% | 19% | 17% | 0% |
| Senior High | 42% | 48% | 30% | 61% |
| Two-year Technical | 14% | 16% | 15% | 11% |
| College | 13% | 13% | 12% | 14% |
| Graduate | 3% | 3% | 2% | 7% |
| **Annual Income** | | | | |
| < 500,000 | 10% | 0% | 14% | 11% |
| 500,000-2,500,000 | 22% | 13% | 27% | 21% |
| 2,500,000-5,000,000 | 14% | 6% | 12% | 25% |
| 5,000,000-7,500,000 | 3% | 0% | 3% | 7% |
| 7,500,000-10,000,000 | 5% | 10% | 5% | 0% |
| 10,000,000-15,000,000 | 9% | 10% | 5% | 18% |
| 15,000,000-20,000,000 | 6% | 13% | 3% | 4% |
| > 20,000,000 | 9% | 23% | 5% | 4% |
| Refuse to Answer or Don’t Know | 22% | 19% | 27% | 11% |
| Average Annual Livestock Income | 36,310,000 | 76,360,000 | 25,040,000 | 18,510,000 |
| Livestock as The Main Source of Income | 98% | 97% | 97% | 100% |

Although the total sample was 125, there were 5 samples (4%) which called "protest zero sample". Protest zero sample means that people’s willingness to pay was 0, but it did not mean that it was worthless to the resources, it was unwilling to pay. There were 8 unknown samples (6.4%) which WTP cannot be determined. Therefore, there were six "Other Sample" (4.8%) were included. After deducting "Protested Sample", "Unknown Sample" and "Other Sample", we have only 106 effective samples, accounting for 84.8% of the total sample.

In the effective samples, the percentage of respondents who graduated from the elementary school was reduced, while the proportion of respondents who graduated above college was increase. We assumed that if the respondents received higher

education, they were more willing to bid on the value of WTP. We can see the social economic background of respondents in **Table 6**.

**Table 6: Social Economic Background of Respondents（Effective Samples）**

| | Sample | Dairy Cattle | Chicken | Pig |
|---|---|---|---|---|
| Sample Size | 106 | 26 | 58 | 22 |
| **Variable** | | | | |
| **Gender** | | | | |
| Male | 88% | 88% | 86% | 91% |
| Female | 12% | 12% | 14% | 9% |
| Average Age | 49 | 43 | 52 | 48 |
| Average Working years in livestock industry | 20 | 20 | 19 | 23 |
| **Education** | | | | |
| Illiteracy | 2% | 0% | 3% | 0% |
| Elementary | 11% | 0% | 19% | 5% |
| Junior High Vocational | 14% | 19% | 17% | 0% |
| Senior High | 42% | 42% | 31% | 68% |
| Two-year Technical | 14% | 19% | 16% | 5% |
| College | 14% | 15% | 12% | 14% |
| Graduate | 4% | 4% | 2% | 9% |
| **Annual Income** | | | | |
| < 500,000 | 9% | 0% | 14% | 9% |
| 500,000-2,500,000 | 22% | 4% | 29% | 23% |
| 2,500,000-5,000,000 | 14% | 8% | 14% | 23% |
| 5,000,000-7,500,000 | 4% | 0% | 3% | 9% |
| 7,500,000-10,000,000 | 6% | 12% | 5% | 0% |
| 10,000,000-15,000,000 | 9% | 12% | 5% | 18% |
| 15,000,000-20,000,000 | 7% | 15% | 3% | 5% |
| > 20,000,000 | 8% | 27% | 3% | 0% |
| Refuse to Answer or Don’t Know | 19% | 15% | 22% | 14% |
| Average Annual Livestock Income | 37,970,000 | 84,620,000 | 24,450,000 | 18,450,000 |
| Livestock as The Main Source of Income | 99% | 96% | 100% | 100% |

According to **Table 7**, the average monthly WTP from valid sample was 604 NT dollars. Males’ WTP were significantly higher than females’. People who graduated from college were willing to pay the highest price, followed by junior high, senior high, two-year technical, elementary, and illiteracy. However, we also found that masters’ WTP was the lowest. According to the annual income, those who refuse to answer or answer don’t know were willing to pay the highest price, followed by the annual income between 7,000,000 and 10,000,000 NT dollars, whose income below

500,000 NT dollars were willing to pay the lowest price. Dairy farmers were willing to pay the highest price, followed by chicken farmers and pig farmers. This study estimates the annual income of the main livestock products of the farm, we found that the annual income of the dairy farmers were the highest, followed by the chicken farmers, and the pig farmers were the least. From this result, we can infer the dairy farmers' WTP was the highest.

**Table 7: WTP among Social Economic Background (Efficient Samples)**

| | Sample | Dairy Cattle | Chicken | Pig |
|---|---|---|---|---|
| **Average WTP** | 604 | 623 | 598 | 598 |
| **Variable** | | | | |
| **Gender** | | | | |
| Male | 385 | 467 | 413 | 150 |
| Female | 637 | 643 | 629 | 647 |
| **Education** | | | | |
| Illiteracy | 500 | - | 500 | - |
| Elementary | 513 | - | 536 | 250 |
| Junior High Vocational | 720 | 860 | 650 | - |
| Senior High | 559 | 488 | 575 | 604 |
| Two-year Technical | 521 | 317 | 631 | 250 |
| College | 825 | 1,075 | 700 | 700 |
| Graduate | 467 | 300 | 500 | 600 |
| **Annual Income** | | | | |
| < 500,000 | 425 | - | 413 | 475 |
| 500,000-2,500,000 | 464 | 250 | 490 | 430 |
| 2,500,000-5,000,000 | 679 | 450 | 613 | 925 |
| 5,000,000-7,500,000 | 650 | - | 700 | 600 |
| 7,500,000-10,000,000 | 725 | 283 | 1,167 | - |
| 10,000,000-15,000,000 | 683 | 800 | 583 | 667 |
| 15,000,000-20,000,000 | 686 | 550 | 800 | 1,000 |
| > 20,000,000 | 533 | 586 | 350 | - |
| Refuse to Answer or Don't Know | 733 | 1,175 | 692 | 317 |

Notes：106 valid samples, removed 4 outliers, 102 samples for this analysis.

According to **Table 8**, the average WTP which the respondents believe that meteorological forecasts can increase the positive impact on livestock production was higher than those who did not believe it. The average WTP for those who believe that meteorological forecasts can reduce the negative influence was higher than those who did not believe it. The average WTP was highest for those who had suffered "Heavy Rain", followed by "Large Temperature Gap between Day and Night", "Pests and

Diseases." Dairy farmers had the highest average WTP for those who experience "High Temperatures during the Day." Chicken farmers who suffered "Pests and Diseases" had the highest average WTP, and pig farmers who suffered from “Drought” had the highest average WTP. If analyzed by settings for livestock, dairy farmers who manage livestock productions settings have higher WTP than those who manage livestock breeding settings. Chicken and pig farmers who manage livestock breeding have higher WTP. Besides, dairy farmers and pig farmers who are semi-open managers have higher WTP. However, chicken farmers who are operating close settings have higher WTP. Generally, farmers who use wet pad cooling system for livestock farming have higher WTP. But, if we analyze by types of livestock, there is no consistent patterns observed.

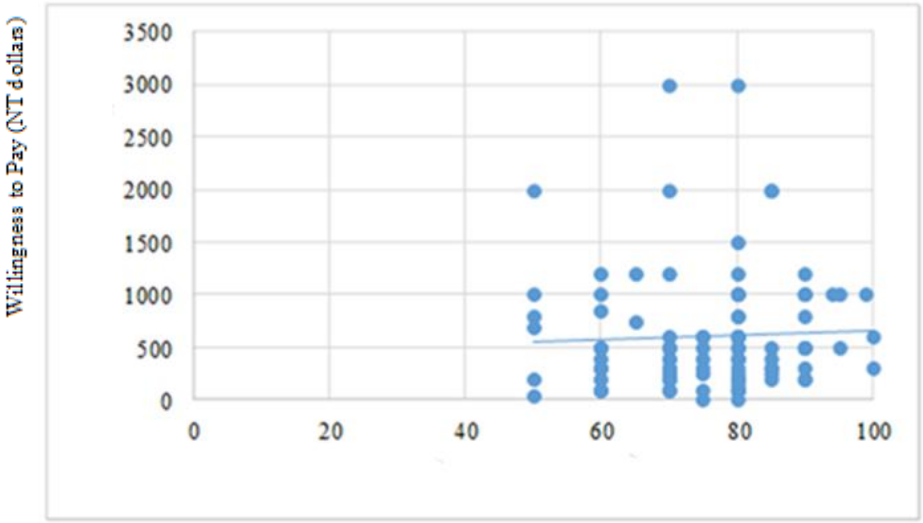
**Table 8. WTP among Production Management (Efficient Samples)**

| | Sample | Dairy Cattle | Chicken | Pig |
|---|---|---|---|---|
| **Average WTP** | 604 | 623 | 598 | 598 |
| **Variable** | | | | |
| Impacts of Weather Forecasts for Livestock Industry | | | | |
| **Increase Positive Impacts** | | | | |
| NO | 364 | 563 | 300 | 350 |
| YES | 671 | 634 | 671 | 731 |
| **Reduce Negative Impacts** | | | | |
| NO | 520 | 1,500 | 385 | 613 |
| YES | 619 | 588 | 645 | 594 |
| **Disasters** | | | | |
| Typhoon | 609 | 623 | 598 | 619 |
| Cold Weather | 615 | 389 | 659 | 640 |
| Heavy Rain | 672 | 660 | 658 | 721 |
| Drought | 607 | 340 | 550 | 1,000 |
| Pests and Diseases | 631 | 682 | 685 | 450 |
| Large Temperature Gap between Day and Night | 635 | 713 | 592 | 641 |
| High Temperatures during the Day | 607 | 742 | 526 | 632 |
| **Livestock Farms among Different Categories** | | | | |
| Production settings | 589 | 628 | 565 | 597 |
| Animal Breeding Settings | 606 | 600 | - | 613 |
| Livestock Breeding Settings | 750 | - | 750 | - |
| **Livestock Houses among Different Categories** | | | | |
| Close | 703 | - | 746 | 575 |
| Semi-Open | 756 | 757 | 440 | 979 |

| | | | | |
|---|---|---|---|---|
| Open | 513 | 467 | 578 | 350 |
| **Environmental control equipment** | | | | |
| Wet Pad Cooling System | 781 | 300 | 704 | 1,060 |
| Fan | 606 | 623 | 598 | 608 |
| Water Spray System | 594 | 623 | 588 | 555 |
| Canvas/Shade Network | 576 | 570 | 571 | 598 |

Notes：106 valid samples, removed 4 outliers, 102 samples for this analysis.

When assessing the value of meteorological forecast information for livestock farmers on the questionnaire, the five first-phase amounts and the subsequent ten second-phase amounts are: 200 (100, 400), 500 (250, 1000), 600 (300, 1200), 800 (400, 1600), 1000 (500, 2000). **Figure 2** shows the potential interaction between livestock industry's final bid and the first bid price for meteorology. This study shows that the first bid price is in a positive relationship with the livestock industry's willingness to pay, that is, the higher the first bid price, the higher the willingness to pay of the respondents is. This trend shows that the sample may have a tendency to be biased from the starting point, and subsequent analysis needs to use advanced measurement methods to clarify whether it exist a starting point bias. If there is a starting point bias in the empirical results, corrections need to be made for the estimation results.

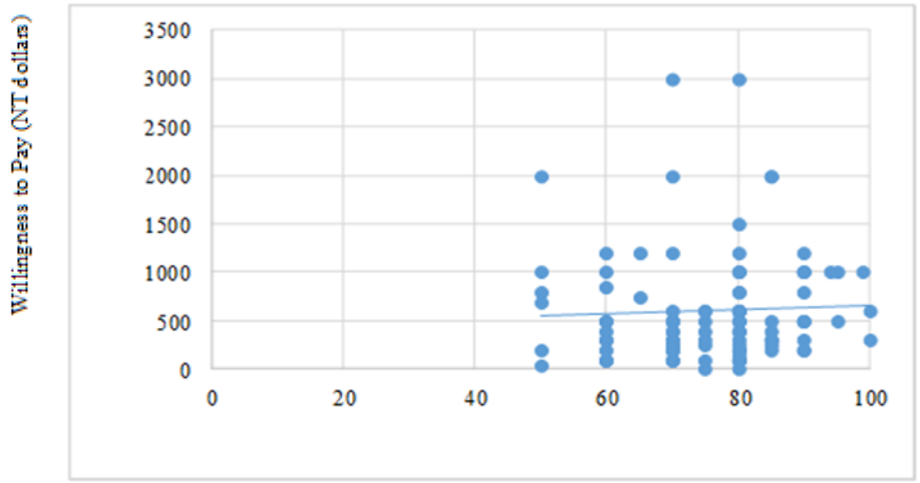



Notes：106 valid samples, removed 4 outliers, 102 samples for this analysis.

**Figure 2. The Trend between WTP and Initial Amount for Meteorological Information**

**Figure 3** shows the relationship between the weather forecast accuracy of the interviewee's subjective cognition and the willingness to pay for the meteorological

information. The accuracy and willingness to pay have a positive relationship, that is, the higher the interviewee's score on weather forecast accuracy, the higher the willingness to pay for the weather information is.




Notes：106 valid samples, removed 4 outliers, 102 samples for this analysis.

**Figure 3. The Trend between Weather Forecast Accuracy and Initial Amount for Meteorological Information**

### *3.2 Empirical Model*

This study establishes a WTP bid function of weather information services of livestock farmers and uses the questionnaire data to make empirical estimates.

**(1) Selection of Bid Function Variables**

First, we consider external social economic background variables and relevant variables of internal perception to select independent variables used by the bid function. The individual social economic background variables include: gender (sex), age, education (edu), income, experiences in livestock activities (workex), number of groups involved in livestock work (group). The variables of internal perception include: subjective score for the weather forecast accuracy (accuracy), farm management and production increase with the help of weather information (positive), and loss prevention with the help of weather information (negative). The definition of variables as shown in **Table 9**.

**Table 9. Variable Definition of WTP Bid Function for Livestock Industry**

| Variables | Definition |
|---|---|
| accuracy | Respondent’s subjective score for the weather forecast accuracy (0~100) |
| lnacc | Take logarithm of accuracy |

| | |
|---|---|
| positive | Dummy variable for farm management and production increase with the help of weather information. (yes=1; no=0) |
| negative | Dummy variable for loss prevention with the help of weather information. (yes=1; no=0) |
| sex | Dummy variable for gender. (male=1; female=0) |
| age | Respondent's age |
| edu | Education indicators. (Illiteracy=1; elementary=2; junior high=3; senior high=4; college=5) |
| workex | Experience in livestock activities (in years) |
| group | Number of groups involved in livestock work |
| lnincome | Take logarithm of income |
| p1 | First bid price |
| con | Constant |

**(2)Setting up a Bid Function**

In the specification section, this study uses multiple empirical tests, and finally selects the results of a better explanatory power to perform empirical analysis. The empirical expression of the livestock industry bid function this year is shown in formula (1).

$$\begin{aligned}\text{lnWTP} = \beta_0 &+ \beta_1 accuracy + \beta_2 positive + \beta_3 negative + \beta_4 age + \beta_5 edu \\ &+ \beta_6 workex + \beta_7 sex + \beta_8 groups + \beta_9 lnincome + \beta_9 lnacc \\ &+ \beta_{10} p1\end{aligned} \tag{1}$$

The above formula contains several key points. First, the income variables and subjective score for the weather forecast accuracy (accuracy) have been empirically tested and found a nonlinear relationship with WTP. Therefore, several important variables are taken logarithms to capture these existing nonlinear relationship. These variables include: lnWTP, lnacc, and lnincome. In addition, the inquiry process in this study adopts the open bi-binary binary selection model. In order to test whether there is a starting point bias and correct the coefficient after finding the bias, we followed a correction model for empirical estimation which was established by Liou (2015). If the respondent's real willingness to pay is WTP, when the bid price is affected by the first bid price P1, the willingness to pay is converted to WTP1. The relationship between WTP and WTP1 is shown in formula (2):

$$\text{WTP}_1 = (1 - r) * WTP + r * P_1 \tag{2}$$

Where r is the fixed anchor effect coefficient defined in the literature. This

coefficient is bounded by 0~1. When the coefficient is closer to 1, it indicates that the starting point bias is more serious and needs to be corrected, otherwise, when the coefficient is closer to 0, the smaller the influence of the starting point bias. Once a starting point bias is found, the following equation can be used for correction.

$$\text{WTP} \quad = (WTP_1 - r * P_1)/(1 - \text{r}) \tag{3}$$

## 4. Empirical Results

We use STATA for empirical estimation in this study. The results are summarized in **Table 10**.

**Table 10. Estimation Results of Bid Function**

| Variables | Definition | Coefficients | t-value |
|---|---|---|---|
| accuracy | Respondent's subjective score for the weather forecast accuracy (0~100) | 0.1380 | 1.66* |
| lnacc | Take logarithm of accuracy | -9.1926 | -1.53 |
| positive | Dummy variable for farm management and production increase with the help of weather information. (yes=1; no=0) | 0.3658 | 1.36 |
| negative | Dummy variable for loss prevention with the help of weather information. (yes=1; no=0) | 0.0771 | 0.26 |
| sex | Dummy variable for gender. (male=1; female=0) | 0.2074 | 0.69 |
| age | Respondent's age | 0.0007 | 0.06 |
| edu | Education indicators. (Illiteracy=1; elementary=2; junior high=3; senior high=4; college=5) | 0.1518 | 1.60 |
| workex | Experience in livestock activities (in years) | 0.0254 | 1.99** |
| group | Number of groups involved in livestock work | -0.0217 | -0.25 |
| lnincome | Take logarithm of income | 0.0897 | 0.84 |
| P1 | First bid price | 0.0013 | 3.48*** |
| con | Constant | 31.2712 | 1.62 |

Notes 1: *, **, and *** represent significance levels at 0.1, 0.05, and 0.01 respectively.

According to the empirical results, the factors that significantly affect the livestock industry's WTP include three variables: score for the weather forecast accuracy (accuracy), experience in livestock activities (workex), and first bid price (P1). First of all, the coefficient of first bid price is significant, indicating that there exist a starting point bias in this survey result. However, the coefficient is only

0.0013, so the degree of impact is not high, which also indicating that the WTP of the respondents already has his own core and constant economic value. Secondly, the coefficient of score for the weather forecast accuracy is 0.138. Because of its non-linear relationship with the willingness to pay, when the subjective score for the weather forecast accuracy rises by 1 point, WTP will increase by 0.138% over the average. In other words, when the subjective score for the weather forecast accuracy rises by 1 point, WTP will increase by 0.674 NT dollars over the average value (488.63 NT dollars). Experience in livestock activities also has a significant effect, with a coefficient of 0.0254, which means that for each additional year of work experience, WTP will increase by 0.0254% over the average, that is, for each additional year of work experience, WTP will increase by 0.124 NT dollars.

Based on the estimation results, the starting point bias was corrected, and the initial estimated value was obtained: the monthly average WTP of the livestock farmers was 488.63 NT dollars (95% of confidence interval: 457.72 NT dollars - 519.54 NT dollars). Furthermore, we can estimate the total economic value of the meteorological information applications in Taiwan's livestock industry from estimating the total number of livestock farmers. The total economic value of the meteorological information applications is 21,984 (households)* (95% confidence interval per year willingness to pay)*0.8 ≈ 97 million/year-110 million/year.

## 5. **Concluding Remarks**

This paper adopts contingent valuation method and completes 125 questionnaires through a nationwide sample of questionnaires and inter-visit interviews. We calculated total economic value of the application of national meteorological information to livestock production by assessing the willingness to pay on the weather information of the livestock producers. According to the estimation result, the willingness to pay per household is 457.72 NT dollars to 519.54 NT dollars in the 95% confidence interval each year. According to the nationwide bidding number, the economic value range generated by the application of meteorological information in Taiwan's livestock industry is estimated to be 97 million NT dollars to 110 million NT dollars per year. Compared with our previous WTP estimates for the application of meteorological information for agricultural farmers and fishmen (Chung-Shu Wu, 2014 and 2016), the impact of the starting point bias on the WTP of the livestock producers is lower, which led to the respondents' WTP for the weather information services falls in a specific economic value interval. In addition, the longer the years of experience in livestock industry work, the higher the willingness to pay for the weather information service. This result implies that the older the livestock producers are, the higher the amount the livestock producers are willing to pay for the more

accurate meteorological information. This result is quite different from previous research findings on farmers and fishermen.

From the perspective of policy implications, we can have two points divided by the views of public and private sector. First of all, from the perspective of the public sector, it is the most important thing that how to increase the efficiency of use of government budgets under the circumstances of limited budget and increasing public affairs. At present, the weather information in Taiwan is mainly provided by the Central Weather Bureau, and the funding resources come from official budgets. In addition to evaluating the performance measurement of the relevant services provided by the Central Weather Bureau, the research results can also be used as a reference for subsequent central decision-making department resource investment, including such items as the project to be put into, the scale of investment, and so on.

Second, from the perspective of the private sector, the research results of this paper are related to the construction of the weather information market. At present, there are markets for meteorological information that are packaged and customized to be sold as commodities. The results of this study can be regarded as a measure of the market size of meteorological information. In addition, if the relevant department intends to commercialize the weather information, the research results of this article can also serve as a reference for the pricing strategy of the relevant commodity.

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