Environmental Regulation and Productivity: The Impact of Emission Standards on the Productivity of the Hog-raising Industry in Taiwan

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Abstract

This research is to investigate whether changes in effluent standards can affect the productivity of the hog-raising industry in Taiwan. Our empirical results show that the strictness of the BOD, COD and SS standards can have an impact on the productivity of the hog-raising industry. Effluent standards changed in 1993 cause the Taiwanese hog-raising industry to shift its cost curve. Effluent standards change in 1998 did not cause a shift in the cost equation. Effluent standards changed in 2004 caused the costs of the Taiwanese hog-raising industry to increase by 52% in comparison to those under the 1993 standard. The vertical shift of cost curve implies that the productivity has been changed.

Key words: Environmental regulation, Emission standard, Hog, Productivity

Introduction

The hog raising industry is one of the major income sources for the agricultural sector in Taiwan. Before 1997, the revenue share of the hog raising industry in the Taiwanese agricultural sector was around 40% (60% in the Taiwanese livestock industry). When the sales revenue of this industry reached its peak in 1996, the value of shipments was around 3 billion dollars with the production of hogs reaching 14,310,000 head per year. Following the outbreak of foot and mouth disease, the revenue share the Taiwanese hog-raising industry was reduced to 15%. However, it is currently still around 40%, even though exports of uncooked pork products to its major foreign market, Japan, have been prohibited. The industry has thus been transformed into a domestically-oriented industry. However, according to data during these last 5 years, the value of shipments has averaged around 2 billion

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dollars.   Pork is still the major meat product consumed in Taiwan.

The hog-raising industry in Taiwan has undergone a structural change.   The percentage of hog farms with less than 200 pigs declined from 90.5% in 1985 to 55.5% in 2001.   The percentage of farms with more than 5,000 pigs by contrast increased from 0.1% in 1985 to 0.9% in 2001. The environmental damage to water bodies, such as rivers and lakes, by this industry was exacerbated as the scale of hog-raising farms expanded.   This phenomenon gave rise to much public concern.

Although the hog raising industry is important for the Taiwanese agricultural sector, this industry is one of the major sources of water pollution.   According to Taiwan's Environmental Protection Agency, in 2008 319,000 tons of BOD, 822,000 tons of COD and 705,000 tons of SS were released.   The agricultural sector accounted for 12% of BOD released, 11% of COD released, and 6% of SS released.   Within the agricultural sector, the hog-raising industry accounted for more than 90% of the pollutants released.

In an attempt to keep water bodies from being

polluted, Taiwan's Environmental Protection Agency has since 1987 promulgated the Water Pollution Control Act.   Initially, for the livestock-raising industry, only large scale hog-raising farms in water reservoir areas were subjected to this environmental regulation.

There used to be no specific emission standards for general hog farms.   Since 1990, however, water pollution controls have become stricter.   A set of emission standards for BOD, COD and SS were subsequently promulgated for all hog farms.   The new standards were enacted in 1993.   From Table 1 it can be seen that the emission standard at that time for BOD was 100 g/ml, the standard for COD was 400 g/ml, and the standard for SS was 200g/ml.   In order to improve the environmental quality needed to protect the ecological system, the EPA modified its emission standards for BOD, COD, and SS in 1998.   The standards were became much more strict than they had been previously.   The BOD standard was changed to 80g/ml, the COD standard to 250g/ml, and the SS standard to 150g/ml.   The change in the COD standard was hotly debated.   Many specialists argued that no

Table 1. Emission standards for the hog-raising industry

items g/ml \ year	1993	1998	2004
BOD	100	80	80
COD	400	250	600
SS	200	150	150

Taiwanese hog farms were able to comply with the new COD standards. Hence, the Environmental Protecting Agency in Taiwan postponed the enactment of this new COD standard, and continued to use the old COD standard: 400g/ml. Two years after this stricter standard was promulgated, Taiwan joined the World Trade Organization. The hog-raising industry in Taiwan had to face an unprecedented competitive environment. Many hog-raising farmers petitioned the government to relax the emission standards for their industry. They asserted that if the government keeps the current emission standards, they will not be able to remain in business. Many people in this industry believed that this was true especially for older farmers who were not able to comply with the emission standards. The government in Taiwan adjusted the emission standards for the hog-raising industry again in 2004.

The new emission standards set in 2004 were not as strict as those promulgated in 1998. While the BOD and SS standards remained the same, the COD standard was relaxed to 600g/ml. The relaxing of the BOD standard in 2004 gave rise to huge public concern. The environmental protection groups argued that it was unprecedented to relax the environmental standards, and blamed the Environmental Protection Agency in Taiwan for failing to protect the natural environment for its citizens. However, some political groups supported the

relaxation of the COD standard to help the hog-raising industry. A question that needs to be asked is whether relaxing such standards can really can help producers. If a relaxed emission standard does not help producers, there results a deterioration in environmental quality without any offsetting benefit. According to the conventional wisdom, a relaxed emission standard can improve the producer's productivity. However, recent researches regarding the environmental regulation and productivity assert that a stricter environmental standard can help producers to enhance their productivity or profitability. Beyond the conventional perception that an environmental regulation increases the producers' costs, Porter et al. [13] have drawn attention to the perception that environmental regulations could sustain productivity improvement at the firm level. Subsequently, many studies have investigated such a viewpoint [6, 12]. A growing body of empirical research on specific industries suggests that regulations can induce efficiency improvements [1, 2, 4, 5, 8, 9, 16]. There are a few studies that look at the relationship between environmental regulation and total factor productivity. Yang et al. [17] used the DEA method with undesired output to investigate the relationship between environmental performance and production efficiency. Their results showed that producers' environmental protection efforts could cause costs to increase by 10%. Piot-Lepetit et al. [11] investigated the impact of

environmental regulations on the producers' total factor productivity.   Their results seem to verify Porter's hypothesis in the case of the French hog-raising industry.

Our research goal is to investigate whether changes in BOD, COD, and SS standards can affect the productivity of the hog-raising industry in Taiwan.   The results of this research might serve as valuable reference to the Environmental Protection Agency.

Data and Empirical Model

This research uses a trans-log specification of the cost function to analyze factors that affect neutral technological progress.   Ray [14] utilized a trans-log cost function to analyze the neutral technological progress in the US agricultural sector.   Baltagi *et al*. [3] used a trans-log cost function to derive the total factor productivity (TFP) index.   Lee [10] used this function to investigate environmental performance and total factor productivity.   In this study, a trans-log cost function for the hog-raising industry is established as follows:

$$(1) \quad ln \frac{C_t}{kp} = \alpha + \mu_1 \, ln \frac{fp_t}{kp_{t_t}} + \mu_2 \, ln \frac{wp_t}{kp_t} +$$

$$\mu_3 \, ln \, output_t + \frac{1}{2}\left\{\delta_{11}\left(ln \frac{fp_t}{kp_{t_t}}\right)^2 +\right.$$

$$\left.\delta_{22}\left(ln \frac{wp_t}{kp_t}\right)^2 + \delta_{33}(ln \, output_t)^2\right\} +$$

$$\lambda_{12}ln \frac{fp_t}{kp_{t_t}} ln \frac{wp_t}{kp_t} + \lambda_{13}ln \frac{fp_t}{kp_{t_t}} ln \, output_t +$$

$$\lambda_{13}ln \frac{wp_t}{kp_t} ln \, output_t + \sigma_1(ENV_{82}) +$$

$$\sigma_3(ENV_{87}) + \sigma_4(ENV_{94})\sigma_5(TIME)$$

where C_t is the total hog production cost.   The data source for the hog production cost is the database of the Council of Agriculture in Taiwan [7], and the period of the data extends from 1982 to 2007.   However, for 1990, 1994 and 1995, the data are missing.   The major parts of the hog production cost include: expenditure for feed and labor.   On an annual basis, approximately 60% of production is for paying for feed.

In this research, the total production cost is deflated by the producer price index paid by the farmer. fp_t is the feed price for hogs, with the data source for feed prices being the database of the Council of Agriculture in Taiwan.   Similar to the total production cost, feed prices are deflated by the producer price index paid by the farmer. kp_t is the capital price, and the data source for the capital price is Taiwan's Central Bank. wp_t is the wage rate.   The data source for the wage rate is Agricultural Statistics, compiled by the Council of Agriculture, Taiwan [15]. $output_t$ is total hog output, for which the data source for the hog-raising industry is the Council of Agriculture's database.   In addition, a time trend is included to represent the growth of technological progress.

To analyze how emission standards affect the total factor productivity of the hog-raising industry, this research includes three dummy variables for changes in environmental policy. The dummy variables for environmental policies

are set as follows: For the emission standard enacted in 1993, $ENV_{82}=1$ if $1996 \leq T$, $ENV_{82}=0$ otherwise.   The coefficient of ENV_{82} refers to the cost incurred by the change in the standard in 1993.   If the coefficient of ENV_{82} is positive, this implies that the enactment of 1993 standards caused the cost curve to shift upwards and the total factor productivity of the hog-raising industry was harmed because of the change in standards.   If the sign of the coefficient of ENV_{82} is negative, this implies that the enactment of the 1993 standards caused the cost curve to shift upwards. The total factor productivity of the hog raising industry was damaged because of the change in standards.   The traditional wisdom implies that the coefficient of ENV_{82} is positive.   For the emission standard enacted in 2000, $ENV_{89}=1$ if $2000 \leq T$, $ENV_{89}=0$ otherwise.   The coefficient of ENV_{89} refers to the cost incurred by the change in the standard in 1993.   Because the standards for BOD and SS are stricter, we expect the coefficient of ENV_{89} to be positive.   For the emission standard enacted in 2004, $ENV_{93}=1$ if $2004 \leq T$, $ENV_{89}=0$ otherwise.   The coefficient of ENV_{89} refers to the cost incurred by the change in the standard in 2004.

If the productivity of input is not changed, a change in intercept term in cost function could be deemed as the changed in the total factor productivity.   This implies a horizontal shift in cost function since output, input prices are given and total cost is changed.

By taking a total derivation of (1) with the log of the feed price, we have the following equation for the feed expenditure share:

(2) $ln\,fs_t = \alpha_1 + \delta_{11} ln \frac{fp_t}{kp_t} + \lambda_{13} ln \frac{wp_t}{kp_t} +$

$\rho_1\,ln\,output_t$

where fs_t is the share of the feed cost.

Taking a total derivation of (1) with the log of the wage, we have the following equation for the labor cost share:

(3) $ln\,ws_t = \alpha_2 + \lambda_{13} ln \frac{fp_t}{kp_t} + \delta_{33} ln \frac{wp_t}{kp_t} +$

$\rho_3\,ln\,output_t$

where ws_t is the labor cost share.   Equations (1), (2) and (3) are estimated simultaneously by the Seemingly Uncorrelated Regression (SUR) econometrics technique.

Empirical Results

The estimation results are listed in Table 2. In Table 2, only the coefficient of $ln \frac{fp_t}{kp_t} \times ln \frac{wp_t}{kp_t}$ is significant.   This may be due to the high degree of correlation between all of the independent variables.   The time trend is significant and positive.   This means that the Taiwanese hog-raising industry does not experience technological progress during the research period.   This phenomenon could be caused by the aging of producers in the hog-raising industry.

The coefficient of the dummy variable for environmental policy change in 1993 is significant.

Table 2. SUR Empirical results

VARIABLE NAME	ESTIMATED COEFFICIENT	T-RATIO	P-VALUE
constant	-148.23	-0.8764	0.381
$ln \dfrac{fp_t}{kp_{t_t}}$	0.20276	0.3041	0.761
$ln \dfrac{wp_t}{kp_t}$	-0.30094	-0.9707	0.332
$ln\,outpit$	22.903	0.9454	0.344
$\left(ln \dfrac{fp_t}{kp_{t_t}}\right)^2$	0.057832	1.541	0.123
$ln \dfrac{fp_t}{kp_{t_t}} \times ln \dfrac{wp_t}{kp_t}$	-0.084117	-1.951	0.051*
$\left(ln \dfrac{wp_t}{kp_t}\right)^2$	0.080804	1.471	0.141
$ln \dfrac{fp_t}{kp_t} \times ln\,outoup$	0.041642	0.854	0.393
$ln \dfrac{wp_t}{kp_t} \times ln\,outoup$	0.015874	0.6474	0.517
$(ln\,outoup)^2$	-1.603	-0.9249	0.355
Time trend	-0.19683	-1.99	0.047**
Environmental Regulation 1993	0.27565	1.771	0.077*
Environmental Regulation 1998	0.057312	0.6308	0.528
Environmental Regulation 2004	0.52515	5.916	0*

** significant al 5% confident level
* significant al 10% confident level

This result implies that the change in emission standards did cause the Taiwanese hog-raising industry to shift its cost curve.   From Table 2, we see that there is a 27% increase in cost in comparison to where there is no regulation for a given set of input prices and output.   The results may be due to the farmers having to prepare the required environmental protection equipment. Furthermore, they have to expend more effort to operate such equipment with precision. Therefore, they have to expend less effort and resources to improve their production technology.

The coefficient of the dummy variable for policy change in 1998 is not significant.   This implies that the total factor productivity of the Taiwanese hog raising industry has not changed. This result may be due to the government in Taiwan having assisted hog-raising farmers in purchasing the necessary environmental protection equipment by providing low interest rate loans.   Furthermore, the government in Taiwan has also provided technicians to help farmers properly operate the environmental protection equipment.   These may be the reasons why the change in emission standards in 1998 did not cause a shift in the cost equation which implies a shift in total factor productivity.   Due to the design of regulation dummy, the missing of data in 94 and 95 will not affect the significance of parameter estimation of the effect of regulation in 98.   However, it will affect the magnitude of the estimation of the effect of regulation in 93.

The co-efficiency of the dummy variables for the policy change in 2004 is significantly positive. The empirical results show that the change in emission standards in 2004 caused the costs of the Taiwanese hog-raising industry to increase by 52% in comparison to those under the 1993 standard.

One thing we have to notice is that the standard promulgated in 2004 is less strict in comparison to that introduced in 1998.   From Table one, we can see that the difference between the 1998 standard and the 2004 standard is that the COD limit was relaxed from 400ml to 600ml.

This implies that a relaxation of the standard caused the industry to lose its productivity.   This phenomena in some sense means that the Porter hypothesis could find support in the Taiwanese hog-raising industry.   A stricter emission standard may cause farmers to expend more effort and resources to comply with the standard. However, under a stricter standard, the level of hygiene on a farm where hogs are raised is higher. This could provide a better living environment for animals and improve their health condition. Eventually, this could increase the post-weaning rate.   In the hog-raising industry, an improvement in the post-weaning rate implies that producers can use the same amount of inputs to produce more hogs.   This means that total factor productivity is improved.   Besides, under a stricter regulatory environment, producers are forced to create less wastewater, the producers can

benefit from using less labor to clean the wastewater, and the environment can be improved by the reduction in wastewater.

Conclusion

Our empirical results show that the strictness of the BOD, COD and SS standards can have an impact on the productivity of the hog-raising industry. The results show that the hog-raising industry in Taiwan faces an escalation in cost from no regulation to the promulgation of emission standards. This result is consistent with the traditional wisdom. However, an increase in the strictness of emission standards in 1998 has not increased producers' costs. This result does not seem consistent with the traditional wisdom that a stricter environmental regulation could reduce the producer's productivity. The relaxation in emission standards in 2004 has been a cause for concern among the public. The environmental protection agency in Taiwan has relaxed its emission standards in order to help hog producers enhance their competitiveness. However, the relaxation in the emission standards has even endangered the competitiveness of the hog-raising industry. This result seems to support the Porter hypothesis that a stricter environmental regulation can improve the competitiveness of producers. From the empirical results, we see that a stricter environmental standard may increase producers' investment for environmental protection. However, they can really bring an advantage to a

polluting industry such as hog-raising industry.

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