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Structural Changes in the Philippine Pig Industry and Their Environmental Implications

Maria Angeles O. Catelo, University of the Philippines, Los Baños
Clare A. Narrod, International Food Policy Research Institute
and
Marites M. Tiongco, International Food Policy Research Institute

Markets, Trade, and Institutions Division

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INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
2033 K Street, NW
Washington, DC 20006-1002 USA
Tel.: +1-202-862-5600
Fax: +1-202-467-4439
Email: ifpri@cgiar.org

www.ifpri.org

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ABSTRACT

Pig production in the Philippines has intensified in the urban and peri-urban areas in response to a radical structural change in the pig industry and a growing demand for pork products. Alongside this rapid growth is the emergence of societal concern about the increasing negative environmental externalities that the industry produces, particularly those related to the disposal of waste and dead animals. Pig producers are said to benefit from negative externalities when they do not bear the full social costs of their business enterprise. Non-internalization of such externalities occurs when pig producers receive payment for their output while not investing in pollution abatement or not making compensatory payments to surrounding communities affected by their production processes. In some cases, producers are able to recycle all nutrients from swine production on-farm through various cropping mechanisms. In other cases, pig production is so large that there is no land to properly dispose of such by-products without some environmental mitigation effort. Failure to implement any sort of measure will most likely lead to an environmental externality. To determine whether a farmer has the ability to utilize all manure produced on-farm, we use a mass balance calculation approach in this paper. Results for the mass balance calculations suggest that, in general, smaller farms generate less excess nutrients per hectare than larger farms. This is because most small-scale pig farms are mixed systems where some croplands are available for nutrient assimilation. Large commercial farms tend to be "pure land-intensive" systems.

We used a Tobit regression analysis to determine the factors affecting environmental mitigation expenditures of pig farms. Results of the regression showed that smaller farms tend to respond to opportunities to make use of manure as fertilizer on their own farms and crops. For large farms, no single factor significantly influenced mitigation costs. An interpretation of why this is so or what this result implies apparently cannot be achieved without ambiguity. Thus, we do not attempt to do so and we leave the matter for further investigation. With respect to the effects of production arrangement on environmental capture, the factors that significantly influenced mitigation costs varied between independent and contract farms. Only the operation of croplands mattered for independent producers. For contract farms, lands that are classified as agricultural carried the expected positive coefficient sign. Further, farmers in the industrial pig sector, which is concentrated in peri-urban areas favored by market access or feed availability, may consider being located as close as possible to cropland that they can use to dispose of the wastes in pig production. Policy options include zoning, mandatory nutrient management plans, licensing or limiting the number of animals raised per production unit, and contractual agreements between livestock producers and crop farmers. The effectiveness of such regulations will depend largely on the degree to which they are enforced and whether they are accompanied by a well-developed system of education and extension with focus on proper manure management systems and dead animal disposal.

Key words: environmental mitigation, mass balance, structural changes, pig production, Philippines

1. INTRODUCTION

Significant structural changes have occurred in the Philippine livestock sector, particularly in the pig industry, over the past 10 years. One important structural transformation that has evolved is the intensification of pig production in urban and peri-urban areas in response to a growing demand for livestock products in general and pork in particular (Figure 1). In a span of just 10 years, total national pig production was estimated to have grown at an annual rate of 3.6% from 9 million heads in 1996 to 13 million heads in 2006 (Bureau of Agricultural Statistics 2006). In the top two pig-producing regions of Central and Southern Luzon, the growth in pig population in the past decade was 3.6% and 5%, respectively. However, alongside this rapid growth is the emergence of societal concern about the increasing negative environmental externalities that the industry produces, particularly the disposal of waste and dead animals. Pig producers are said to capture the benefit of negative externalities when they do not bear the full social costs of their business enterprise. Non-internalization of such externalities occurs when they receive payment for their output while neither investing in pollution abatement nor making compensatory payments to surrounding communities affected by their production processes in terms of such things as odor, poor water quality, and deteriorating soil quality (Costales et al. 2003). There are serious and well-documented environmental effects such as water and air pollution associated with scaling-up and concentration of pig production. With robust growth in pork output predicted along trend matching the rapidly increasing domestic demand, fuller attention must be accorded to assessing the extent to which farms capture the environmental externalities they create through their production activities. This discussion paper aims to make that assessment and to identify the factors affecting the environmental mitigation behavior of pig producers.[1]

The research questions we address are the following:

i. What are the current pathways of disposal of pig waste and dead animals?
ii. To what extent are farms internalizing the environmental pollution arising from their production activities?
iii. Do farms differ in their expenditures on reducing or preventing the environmental damage they create? If they do, are differences in the value of captured environmental externalities related to (a) farm and production characteristics such as scale, location, and production arrangement; and to (b) social/institutional, environmental, and market opportunities?

The hypotheses that motivated this study are the following:

i. The nature and extent to which pig producers abate pollution varies across farm characteristics such as size of operation and production arrangement.
ii. Contract growers spend more on mitigating pollution than do independent growers. This is due to the presumed pressure from the integrator for contract growers to employ clean production technology.
iii. Large-scale farms have higher mitigation expenditures per unit of output than small-scale farms. This is because large farms have a relatively greater financial capacity to invest in pollution abatement facilities and are more likely to possess sufficient agricultural lands on which to spread pig manure.
iv. Farms that are within the jurisdiction of environmental regulatory agencies will spend more on pollution abatement.
v. Farms that are located near residential communities will have higher expenditures on environmental mitigation because of social pressure for clean farms.

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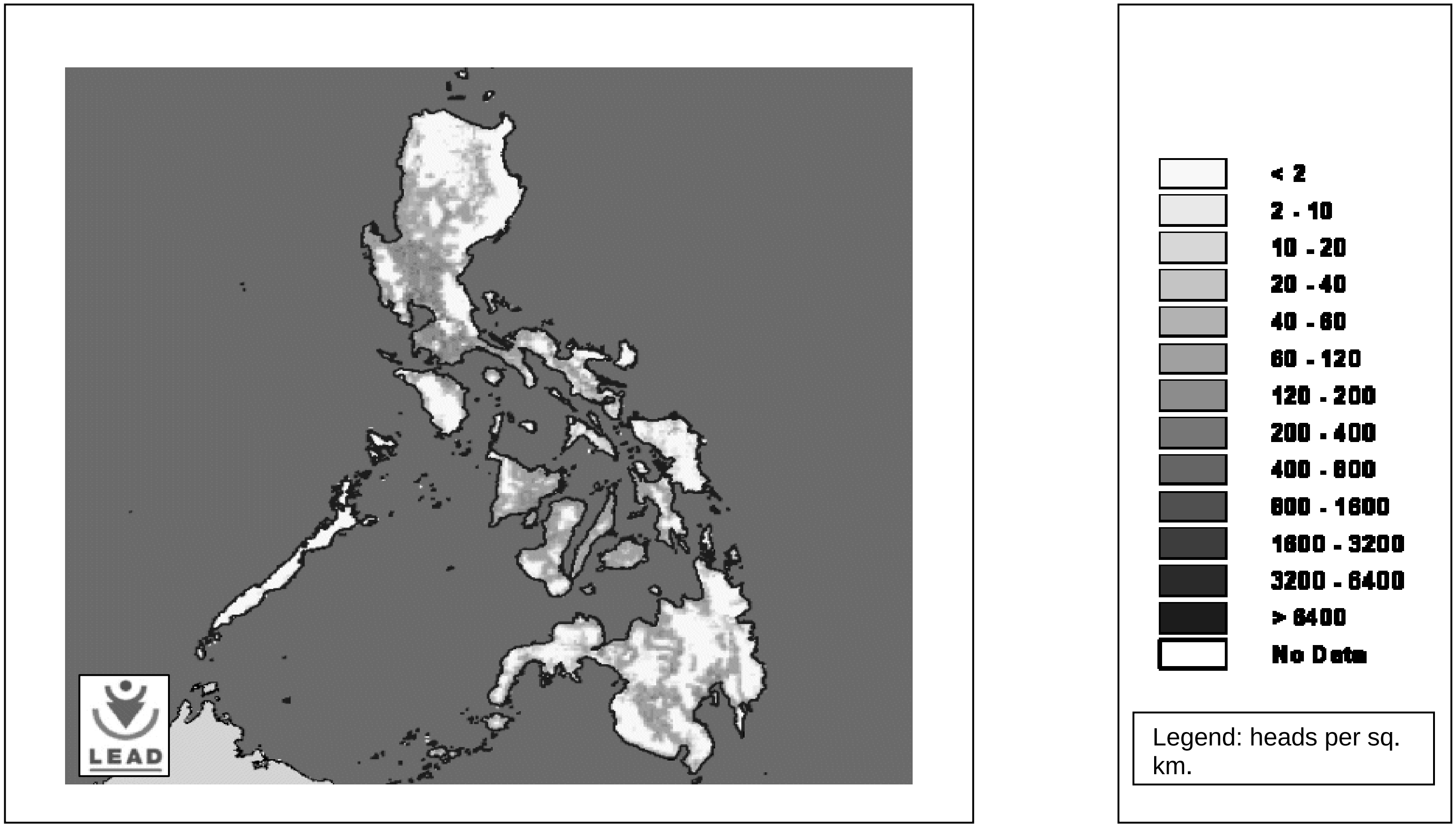
[1] Further, this paper draws heavily on the section on environmental impacts of scaling-up in the pig sector of the Philippine report for the IFPRI-FAO-LEAD project titled “Livestock Industrialization Trade and Social-Heath-Environment Impacts in Developing Countries” that was conducted 2002–2003.

The paper is organized as follows: Section 2 identifies the salient structural transformations that have unfolded in the Philippine pig industry over the past decade. Section 3 presents a brief review of the international and local literature on the environmental impacts associated with intensified pig production. This section also includes a review on environmental mitigation expenditures as well as factors affecting mitigation costs. Section 4 introduces the sources of data and methods of analysis used in this study. Section 5 presents the analysis of investigation, and Section 6 gives the concluding observations and implications for policy that have bearing on more efficient allocation and use of increasingly scarce public funds for correcting negative externalities in light of improving social welfare.

Figure 1. Geographical concentration of hogs: Philippines, 2002



Source: P. Gerber, Livestock, Environment, and Development (LEAD) Secretariat, Food and Agriculture Organization (FAO).

2. STRUCTURAL CHANGES IN THE PHILIPPINE PIG INDUSTRY

The livestock sector has had the strongest and most consistent growth performance of all economic activities in Philippine agriculture over the past decade. Its average real annual growth between 1990 and 2006 was 3.7%, and its share of gross value added in agriculture steadily increased from 18 percent in 1990 to 25 percent by 2005 (FAO 2006). The main livestock industry is pig production, which comprises about 58 percent of total meat output and is growing at 5.5 percent per year (Costales et al. 2007).

The main drivers of growth in the livestock sector are the steadily increasing domestic demand fuelled by rising population (2.4% per year between 1995 and 2000), increased urbanization, and modest improvements in per capita incomes (Asian Development Bank (ADB) 2006; NSCB 2006; NSO 2005a). Estimated per capita consumption of meat[2] rose from 18 kilograms in 1990 to 31 kilograms by 2002 (FAO 2006). In the past decade, meat imports supplemented the growth in domestic demand, but since imports had started with a very low base value, its share in total supply continued to remain below 5 percent in 2003 (Costales et al. 2007; FAO 2006).

Demand for pork is concentrated in the national capital—metropolitan Manila—which is also a major urban and commercial center. In 2003, their populations accounted for 13 percent of the national total, and households earned incomes that were, on average, twice the incomes of households outside the national capital. Central Luzon and Southern Luzon are two peripheral regions of metropolitan Manila that are likewise considered secondary growth centers of consumer demand due to progressive urbanization, rising incomes, and growing population (Costales et al. 2007; NSO 2005b).

Just as the domestic market for pork has been expanding in the past decade, pig production has been changing structurally. Close to 80 percent of total pig inventories are still held in “backyard” farms or farms that hold no more than 20 head of in adult-equivalent animals BAS 2005). The major pig-producing regions are Central Luzon and Southern Luzon, where total hog inventories are growing at a significant rate of 4.5 percent annually. However, over time, the share of backyard pig inventories has been declining. The substantial decrease in backyard pig production, which now accounts for less than half of regional production, evidences this trend in “commercialization” of pig farms, particularly in Central Luzon and Southern Luzon. The total number of farms raising pigs in these regions also declined between 1991 and 2002; but between 1997 and 2004, the number of registered commercial pig farms in these two regions increased by 60 percent (BAS 2005; NSO 2005b. Moreover, the average swine herd size at any one time on these commercial farms was 430 head in Southern Luzon and 1,100 head in Central Luzon (BAS 2004 as cited in Costales et al. 2007).

This rapid intensification and scaling-up of pig production in the Philippines in response to the growing demand for pork has also stirred societal concern over environmental issues associated with this phenomenon. The traditional way of disposing hog waste involves using water to flush waste out of the pens and letting it flow to the nearest creek, which carries the waste downstream. With concentration of production, this method can no longer be continued without adverse consequences (such as pollution and massive nutrient surpluses of surface and ground water) for neighboring and downstream residential communities. As Delgado et al. (2008) put it, pig production is probably the least environmentally friendly livestock production.

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[2] Derived from FAO food balance sheets (where per capita food supply includes net imports).

3. REVIEW OF RELATED LITERATURE

Environmental Issues Associated with Intensification of Pig Production

The environmental effects[3] associated with pig waste, especially those generated from confinement or factory pig farms, include the following: (a) air pollution and greenhouse gas emissions, (b) surface water eutrophication and groundwater contamination, (c) fish kills, (d) land degradation and long-run soil toxicity to plants and animals, and (e) habitat destruction and loss of biodiversity.

Significant amounts of nitrogen (N) from pig waste evaporate into the air as ammonia, which is one of the "main carriers of bad odor" (World Bank 2005). About two-thirds of anthropogenic ammonia emissions that significantly contribute to acid rain are attributed to livestock (Steinfeld et al. 2006). Furthermore, some amounts of N from livestock waste are lost as nitrous oxide (N_2O), which is the "most damaging" greenhouse gas that depletes the ozone layer—296 times more damaging than the global warming potential of carbon dioxide (CO_2). There is an estimated global N excretion of 135 million tons per year from livestock (Steinfeld et al. 2006). Methane is another potent greenhouse gas that causes global climate change since it traps the sun's energy. Its global warming potential is 23 times that of CO_2. Livestock and manure management account for 37 percent of anthropogenic methane (Steinfeld et al. 2006). An earlier study by Delgado et al. (1999) placed livestock's contribution to annual global methane production at 16 percent.

Groundwater and surface water contamination arise from waste spills and leakages from lagoons as well as nutrient surpluses from saturated soils, particularly in areas of high animal concentrations. There are also poorly managed hog farms that indiscriminately discharge their wastes directly into rivers and streams without any treatment. Phosphorus (P) and N in hog wastes can cause eutrophication, the process of overenriching water bodies, leading to the production of excess algae. This situation can then damage aquatic and wetland ecosystems and reduces overall biodiversity (Catelo et al. 2001; FAO-LEAD 2007).

Animal wastes are carriers of parasites, bacteria, and viruses (Delgado et al. 1999; Steinfeld et al. 2006; World Bank 2005), including salmonella, campylobacter, E. coli, cryptosporidium, giardia, cholera, streptococcus, and chlamydia. Cryptosporidium and giardia are resistant to conventional chlorination, and therefore there is a greater probability of drinking water contamination when lagoons containing high concentrations of hog manure leak (Carpenter et al. 1998).

Long-term soil toxicity to plants and animals is due to accumulation of heavy metals included in medicine and feed supplements for disease prevention and improvement in digestion. This may ultimately pose risks to animal and human health (Bos and de Wit 1996; Delgado et al. 1999).

In the Philippines, indiscriminate dumping of massive hog waste and untreated wastewater directly into creeks, rivers, and other receiving water bodies has resulted in the pollution of these surface waters. The underlying cause of this pollution is the lack of waste treatment facilities in most backyard and commercial hog farms in the country. Over time, such pollution has decreased the quality and productivity of affected water bodies because their assimilative capacities have likewise deteriorated. Thus, receiving waters are rendered unfit even for noncontact activities and irrigation. In extreme instances, surface waters have become biologically dead. Evidence of such cases in Central Luzon, Southern Luzon, and Northern Mindanao has been documented in the local literature (Catelo et al. 2001; Deustch et al. 2000 cited in Rola et al. 2003).

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[3] For an extensive review of the international literature on the environmental effects of pig waste, see Steinfeld et al. (2006), "Livestock's Long Shadow: Environmental Issues and Options" at http://www.virtualcentre.org/en/library/key_pub/longshad/A0701E00.htm; World Bank (2005), "Managing the Livestock Revolution: Policy and Technology to Address the Negative Impacts of a Fast Growing Sector" at http://siteresources.worldbank.org/INTARD/Resources/Livestock_final+no+maps.pdf; and the following websites: http://www.epa.gov/owmitnet; proinfo@nrdc.org;] http://www.farmweb.org/b/icrppoints; http://www.starnews.com/news/metrostate98/apr/0422sn_facts.html; http://www.igc.apc.org/nrdc/nrdc/nrdcpro/factor/cons.html; http://www.checc.sph.unc.edu/rooms/library/docs/Hogs/hogcase.html; and http://www.inmotionmagazine.com/hwenv/html.

Furthermore, empirical evidence of soil toxicity has been documented in Lipa City, Batangas, a top-ranking hog-producing province of Southern Luzon. N loading attributed to the application of hog waste as fertilizer onto agricultural lands was found to be 10 times the allowable limit of 100 kilograms of N per hectare (Lipa Environmental Profile 2000; IMO-MADECOR 1997). Gerber et al. (2005) have also shown evidence of phosphate overloads around urban centers in metropolitan Manila. They estimated an average 15.4% of high (more than 20 kilograms of phosphate per hectare of agricultural land) and 4% of very high (more than 40 kilograms of phosphate per hectare of agricultural land) phosphate overloads. Thus, although it is recognized that hog manure application on agricultural land as a substitute for inorganic fertilizer can be an environment-friendly contribution of pig production, excessive application can also be detrimental.

Environmental Mitigation in Pig Production

To correct for negative environmental externalities arising from pig production, flexible, site-specific, well-targeted policies and programs must be designed to address the underlying causes of environmental degradation. It is recognized, however, that there is no single solution for addressing and arresting the "deep and wide-ranging" environmental impacts of the livestock sector in general and pig production in particular (Steinfeld et al. 2006; World Bank 2005).

The more common technological solutions include (a) improved animal diet composition and feeding management practices that reduce the volume of manure as well as N and P concentration in waste; and (b) wastewater conservation, manure handling strategies, and storage systems (World Bank 2005).

In general, public policy instruments to promote farm owner internalization of environmental damages include incentive-based policies, such as taxes, subsidies, and tradable discharge permits; command and control policies, such as ambient and emission standards; decentralized techniques, such as liability laws, property rights, moral suasion, and green goods; zoning; limitation of manure production by legislation; and environmental cooperatives (Bremmers 2000; Field and Olewiler 2005). Unlike the case of poultry manure, which can be efficiently transformed into good quality organic fertilizer for widespread domestic and export use, developing markets for hog manure has proven to be quite restricted. This is due mainly to transport problems and the potential risk of exporting classical swine fever (Bremmers 2000).

Economic instruments, such as emission and effluent charges, are the most commonly used in developing and transition countries. But more often than not, these charges have been set at quite low levels; and because of the unsystematic enforcement of such instruments, they have not had much impact on the behavior of polluting farms (World Bank Group 1998). Furthermore, environmental regulations may not work best when the polluter is difficult to identify (i.e., nonpoint source pollution), as is the case with many small and diffused pig farms, or when regulatory institutions are too weak to enforce the regulations and/or lack the financial resources to monitor compliance since "environmental regulations are not self-enforcing" (Field and Olewiler 2005). Thus, self-reporting and waste auditing mechanisms as well as public disclosure programs and community pressure have also been resorted to (Catelo et al. 2007; Markandya et al. 2002).

Notwithstanding enforcement and compliance monitoring issues, environmental policies and regulations can be more effective if the environmental damages or deterioration of environmental quality arising from production activities such as hog raising can be quantified and monetized. Various valuation techniques and methods have evolved in the realm of environmental economics. These include estimation of marginal pollution abatement costs, annualized investment cost for waste treatment facilities or compliance costs, contingent valuation methods, and preventive expenditures approaches (Boardman et al. 1996; Field and Olewiler 2005; Markandya et al. 2002). The nutrient mass balance approach is another method for directly assessing the interaction of animal density with the environment (Costales et al. 2003).

Policies and Institutional Mechanisms to Mitigate Environmental Externalities in the Philippines

The Ecological Solid Waste Management Act, the Clean Air Act, and the Clean Water Act may very well be the Philippines' overarching policies governing environmental issues behooving pig industry compliance. Command and control policies such as zoning, discharge ordinances, and permits and effluent standards are the common regulatory prescriptions for mitigating negative environmental impacts of pig production. Existing ordinances across some municipalities mandate that commercial pig farms be established at least one kilometer away from public roads. In addition, raising pigs in heavily populated areas is prohibited. Pig farms are required to dispose of their waste properly, and dumping by-products into bodies of water is not allowed. Environmental compliance certificates are required particularly of commercial pig farms before they are issued permits to operate. There are effluent standards for major pollutants such as the biological oxygen demand (at 50 mg per liter) and total suspended solids (at 70 mg per liter). The color of the wastewater from pig farms is also regulated. The Department of Environment and Natural Resources monitors compliance with these standards across the country through its regional, provincial, and municipal offices (Catelo et al. 2001; Costales et al. 2003).

On the other hand, the regulating agency for industries including livestock farms whose wastewater drain into the Laguna de Bay in Southern Luzon is the Laguna Lake Development Authority (LLDA). In 1997, the LLDA embarked on a market-based instrument, the environmental user fee system, to curb pollution in the lake. The LLDA has also issued a board resolution mandating smallholder pig farms to adopt wastewater minimization and reduction technologies.

Although the above-mentioned environmental regulations are already in place, the problem of inadequate financial and human resources, particularly for implementing regulations and monitoring compliance, still remains (Catelo 2002; Catelo et al. 2001).

In addition to policy mechanisms for mitigating environmental hazards, the use of impounding structures such as biogas digesters for both commercial- and backyard-scale pig production are encouraged. Technological improvements in animal genetics, feed ration, and feed digestibility to minimize wastes are likewise being explored.

The literature, however, is not replete with empirical studies on either quantification or valuation of environmental damages specifically caused by pig production because of the difficulty of measuring the externalities associated with livestock production processes. This discussion paper contributes to the literature by addressing negative externalities through a measurement index composed of investment and operating costs for pollution prevention and abatement facilities as well as user fees paid.

From the household survey data, we attempt to estimate the potential externality in terms of the ability of a farm to utilize all nutrients on-farm that it produces. If the manure produced exceeds the potential for on-farm use, then the farm should either, (1) sell the manure, (2) transport the manure to an area where there is enough land for application, or (3) utilize a processing technology to transform the manure to a product amenable to profitable long-distance sale or a product that eliminates the need for transportation. Estimating the potential externality may help us to understand why some farms are spending more money on manure mitigation technologies than on others and to understand differences across size of operations, particularly if large farms have limited land to dispose of manure.

Given the lack of indicators for environmental mitigation in pig production, we hope to enrich the existing literature using this paper's methodology.

4. METHODOLOGY

Data Sources and Sampling Procedure

We drew the data for this paper from the College of Economics and Management at the University of the Philippines, Los Baños (UPLB)-The International Food Policy Research Institute (IFPRI)-Food and Agriculture Organization (FAO)-LEAD Livestock Industrialization (LI) Project survey of 207 pig farm households that was conducted from November 2002 to January 2003. The survey areas included the top pig-producing regions of Central Luzon and Southern Luzon and the emerging pig breeding and production center of Bukidnon in Northern Mindanao. Moreover, the sample pig farms were chosen from the top pig-producing provinces in each of these regions.

To enable us to capture the effect of scale and institutional environment on the differences in behavior to mitigate negative externalities created by monogastric production activities, we performed a stratified random sampling by scale of operation and production arrangement. Thus, we drew the sample pig farms from areas where there is sufficient representation for different sizes of operation and types of production arrangement.

For scale of operation, we classified farms with fewer than 100 sows as small scale and those operating with more than 100 sows as commercial scale. Furthermore, commercial farms were further disaggregated into medium scale, or those operating with between 100 and 1,000 sows, and large scale, or those with more than 1,000 sows. Production arrangement refers to whether farms were independently growing pigs or engaged in contracts to grow them.

We surveyed 207 hog farms, of which 110 farms were small scale and 97 were commercial scale. Of the 110 smallholders, 87 were independent growers and 23 were contract growers; of the 97 commercial farms, 67 were independently growing pigs and 30 were engaged in contracts. Inasmuch as we wanted to have an equal distribution of samples across regions, scale of operation, and production arrangement, there was immense difficulty in obtaining the planned sample sizes during the survey. In particular, one production arrangement dominated the other in certain areas, such as Central Luzon and Northern Mindanao, where independent smallholders were prevalent and smallholder pig contract growers were not found. Nevertheless, despite the challenges in performing the survey, the research team was able to come up with a good quality data set.

Methodological Approaches

Mass Balance Calculations

To determine whether a farmer had the ability to utilize all the manure on-farm, we used household survey data to calculate the farm's balance of manure nutrients relative to the farm's potential to utilize the nutrients through crop production.[4] We also included the amount of chemical fertilizer applied per land unit to compute the mass balance of nutrients. We estimated land assimilation capacity to determine whether it could assimilate all the nutrients produced on the farm and then subtracted the amount of manure sold off-farm, if any.

We estimated the total nutrient deposited by household *h* as the sum of the nutrient produced by animal units of livestock type l in household *h*. We added data on chemical fertilizer use to the calculations to derive total nutrients used on the farm using the following formula:

$$T_h^n = \sum \alpha^n AU_h + CF_h^n + Mpurch_h^n - Msold_h^n \, , \tag{1}$$

where n is nutrient type; h is household; T_h^n is total nutrient n (N and P in this case) deposited by household; AU_h is animal unit in household h, where swine is estimated to produce 63 pounds (29 kilograms) of manure per day per animal unit[5]; CF_h^n is form of nutrient n applied as commercial fertilizer by household h; $Mpurch_h^n$ is manure purchased by household; $Msold_h^n$ is manure sold off-farm by household; and α^n is amount of nutrient n produced per animal.

We estimated the capacity of the land to absorb nutrients based on the existing cropping pattern of the sample households and the nutrient uptake rates of different crops. We computed the capacity of each household to use the nutrients produced by the animals as the area planted to crop *i* by the household multiplied by the nutrient uptake by the crops planted on the land. Since there were no data from the sample households on crops planted, we assumed that all available cropland was planted with rice. We assumed the N uptake for rice production to be 100 kilograms per hectare and the P uptake to be 32 kilograms per hectare (Delgado et al. 2008).

$$U_h^n = \sum_i \; \beta_i A_i \, , \tag{2}$$

where A_i is area of planted to crop i by household h; β_i is absorptive capacity for nutrient n per unit of land; and U_h^n is removal of nutrient n by all crops on the farm.

Equation (2) provides estimates of uptake of nutrient *n* on-farm *h*, and equation (1) provides estimates of nutrient *n* deposited through manure and chemical fertilizers. Thus, subtracting equation (1) from equation (2) provides an estimate of the balance of nutrient *n* on farm *h*. This result indicates a household's potential assimilative capacity of nutrients based on the current number of animals and cropping pattern. A positive mass balance implies that there is sufficient land to assimilate the nutrients produced, whereas a negative mass balance suggests that there is not enough land to absorb them.

Although manure is a potentially valuable fertilizer and soil conditioner, areas with concentrated livestock production may not have adequate cropland for nutrient utilization stemming from by-products of livestock. In these cases, exporting nutrients from concentrated areas to surrounding areas may be both environmentally and economically beneficial. The nutrients from manure if not utilized or disposed of in a safe manner, can seep into the water table and cause ground water pollution. There is a limited market

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[4] The methodologies used for mass balance calculations and regression analysis come from Delgado et al. (2008).

[5] The animal unit used is the United States Department of Agriculture (USDA) measure and is defined as 1,000 pounds of live animal weight, but requirements for specific animals differ by species, age, weight, diet, and such. For instance, whereas 250 chickens produce 298 pounds (135 kilograms) of N per year and 209 pounds (95 kilograms) of P_2O_5, it takes only about 10 pigs (at 200 pounds per head) to produce the equivalent nutrients (Sources: Penn State Cooperative Extension Service 1993; USDA Natural Resources Conservation Service. *Agricultural Waste Management Handbook*, 1995).

for liquid swine manure, perhaps because there are considerable costs to disposing of bulky liquid manure. The size of the current livestock population in this study and its expected growth portend difficulties for future adequate environmental mitigation.

To put the measurement of environmental mitigation into a logical and consistent framework using the available household and farm-specific characteristics data generated from the survey, we generated a working index of environmental damage mitigation cost.[6] This index includes all costs of waste and dead animal disposal as well as costs of compliance to environmental regulations: water treatment costs, investment in lagoons, labor spent collecting and drying manure for sale (evaluated at market rates), rental cost of machinery used for manure disposal, taxes paid for abatement, and cost of compliance in dealing with environmental problems. The index also involves the valuing of "environmental credits" from the economic use of livestock waste, for example, the value of manure sales and the value of manure used or applied on cropland. Manure spread on one's own fields is valued at what it could have been sold for at the farm gate.[7] Thus, if manure is spread on the field and has any market value (i.e., farmers are not merely dumping it), the latter is included in the internalization of the externality (also a good sign for management of mass balances). The worst that any farm can do under this approach is to have no abatement expenditure at all per unit of output, and this is in fact the case for about 25% of the sample farms.

The main concept behind the approach that Delgado et al. (2008) developed is to be able to measure how much each farm can internalize the externalities arising from the livestock production process or how much effort each farm makes to mitigate environmental externalities per unit of animal output. The internalization can be in the form of investing in pollution abatement facilities or undertaking waste and dead animal disposal activities that are environment friendly. We evaluated the value of disposing of a given amount of manure through spreading for mitigation purposes at the market prices of manure for fertilizer mainly because that is the best observable measure of the value of manure in that place and time. This assumes that spreading manure on crops is uniformly good (despite runoff into watercourses in some cases) and ignores the fact that farms close to population centers and watercourses probably produce more ecological harm per ton of manure than do those far from people and watercourses, *ceteris paribus*.. We also postulate that a farm that incurs higher mitigation expenditures per unit of output, others things being equal, will create fewer negative environmental externalities. For this to hold true, a "heroic" assumption has to be set in place—that if a given amount of manure is not put to any economic use such as spreading it on land, it is equally polluting regardless of which farm is producing it. Thus, we assumed land application of manure to be ecologically sound, holding everything else constant. The above assumptions are not perfect but may generate feasible regression results and do not disregard negative externalities altogether in econometric work.

Tobit Analysis

Now that we have a workable index that differentiates (inversely) across farms in the amount of negative environmental externalities incurred, we use it to assess why some farms are more prone to spending more for pollution abatement than others are. The factors that are hypothesized to influence the level of environmental mitigation expenditures include (i) household characteristics, such as education level of the household head (as decision maker) and his or her experience with livestock raising; (ii) farm characteristics, such as type and scale of operation, production arrangement, and locational variables; (iii)

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[6] We fully recognize that there are difficulties and complications in measuring the environmental externalities of livestock production. These may stem from the "nonpoint source" issue as well as intertemporal or intergenerational impacts of pollution from livestock farms, among other things. Although we also recognize that appropriate valuation methods have evolved within the realm of environmental economics, such as measuring the disposal of nutrients and the final uptake by some source from each household, such an approach is beyond the scope of the LI project.

[7] Although spreading manure is counted as internalizing a negative externality, it may also boost a farm's profitability. It is not practical to net out benefits obtained from "expenditure" on mitigation, however, nor is it conceptually necessary, as the effort involved presumably still prevented pollution downstream, and presumably the person downstream does not care whether the farmer benefits as long as the pollution is stopped.

production characteristics, such as animal mortality rate in the past cycle; and (iv) the social/institutional environment, which includes the active presence of a regulatory agency and community pressure as proxied by the proximity of the farm to residential communities.

We used a Tobit analysis for the environmental regression to determine the factors affecting environmental mitigation expenditures of swine farms. We fit the Tobit model because of the presence of zero values on the dependent variable (environmental mitigation expenditures). These zero values do not necessarily represent a discrete decision not to internalize the negative externalities; thus, we cannot confine our attention to the nonzero observations.

The dependent variable is the total mitigation cost in Philippine pesos. The explanatory variables include age and education of the household head or decision maker (in years), wage rate (in pesos per hour), animal mortality rate in the past cycle (in percent), distance to nearest residential community (in kilometers), and dummy variables for land classification, existence of croplands, location within LLDA jurisdiction, and scale of operation.

All the variables above except the distance to nearest residential community are hypothesized to positively influence environmental mitigation expenditures for the following reasons: (a) the age and education of the household head act as proxies for access to information on the importance of mitigating pollution from hog production as well as on the available technological processes for pollution abatement; (b) the wage rate is the cost of labor for disposing of pig waste and dead animals and since mitigation activities are presumed to be labor intensive, a higher wage rate would mean higher mitigation expenditures; (c) animal mortality rate in the farm would reflect the volume of waste to dispose of, thus, higher rates increase the cost of environmental mitigation; (d) farms that have been established on lands classified as agricultural and the availability of croplands would mean potential areas for manure application and, therefore, higher capture of environmental externalities; (e) being located within the LLDA jurisdiction means greater probability of being monitored by the regulatory agency and, therefore, farms will tend to abate more, thus increasing mitigation costs; and (f) scale of operation is a proxy variable that would reflect the volume of potential waste generated and, therefore, small scale means less waste to dispose of and lower mitigation expenditures.

The variable that negatively influences environmental mitigation cost is the proximity of pig farms to residential communities. This may mean greater social pressure to clean up, thus increasing expenditures for environmental mitigation.

5. RESULTS AND ANALYSIS

Profile of Sample Pig Farms

Table 1 shows the detailed size and composition of our survey sample. As much as possible, we took an even distribution of smallholder and commercial hog raisers. Such is the case for all areas except Southern Luzon, where the sample of smallholder hog producers was significantly larger than that of commercial producers (62% vs. 38%).

Table 1. Sampling distribution of 207 hog farms by area and scale of operation, with and without contracts: Philippines, 2002

Item	Area						All Areas	
	Central Luzon	Percent	Southern Luzon	Percent	Northern Mindanao	Percent	Number	Percent
Smallholders	24	40.7	47	61.8	39	54.2	110	53.1
Independent	24	40.7	24	31.6	39	54.2	87	42
Contract			23	30.2			23	11.1
Commercial (100+)	35	59.3	29	38.2	33	45.8	97	46.9
Independent (100+)	13	22	18	23.7	19	26.4	50	24.2
Independent (1000+)	7	11.9	4	5.3	6	8.3	17	8.2
Total Independent Commercial	20	33.9	22	28.9	25	34.7	67	32.4
Contract Commercial	15	25.4	7	9.2	8	11.1	30	14.5
Total	59	100	76	100	72	100	207	100

Source of basic data: UPLB-IFPRI-LI Field Survey, 2002–2003.

To reiterate, we stratified the samples according to the scale of operation (i.e., smallholder vs. commercial). For hog producers, we categorized those operating with fewer than 100 heads as smallholders; otherwise, we categorized them as commercial raisers. Commercial raisers were subclassified as medium commercial (100–1,000 heads) and large commercial (>1,000 heads).

Stratifying the sample further by production arrangement, however, reveals some level of skewness: Three-fourths of the respondents are independent growers, and only one-fourth are engaged in contract growing. Independent growers bear all the costs and risks that go with the production activity and take all the profits as well. Those who enter into contracts with contractors or integrators normally supply the facilities, labor, and skills to undertake the pig growing activity; whereas the integrators provide the piglets, feeds, and veterinary medicines and services. Integrators typically engage in vertically coordinated activities that may involve feedmilling and/or breeding and meat processing. They may be large multinational or national corporations or even local feedmillers who establish contract growing schemes with livestock raisers (Costales et al. 2003). Swine contracts have been found to be either (a) profit sharing, where the integrator and contract grower share 50–50 in the profit earned; or (b) fee contract, where the integrator guarantees the contract grower a base fee, but there are also fines and incentives involved depending on the contractor's performance.

Hog raisers in the sample engaged in four types of production activity (Catelo et al. 2001):

i. Farrow-to-Wean (F-W) involves breeding and farrowing sows and raising the piglets or weanlings until they are ready for sale at a market weight of about 10–20 kilograms.

ii. Farrow-to-Finish (F-F) involves breeding and farrowing sows and raising the litter or offspring until they reach a market weight of about 75–100 kilograms.

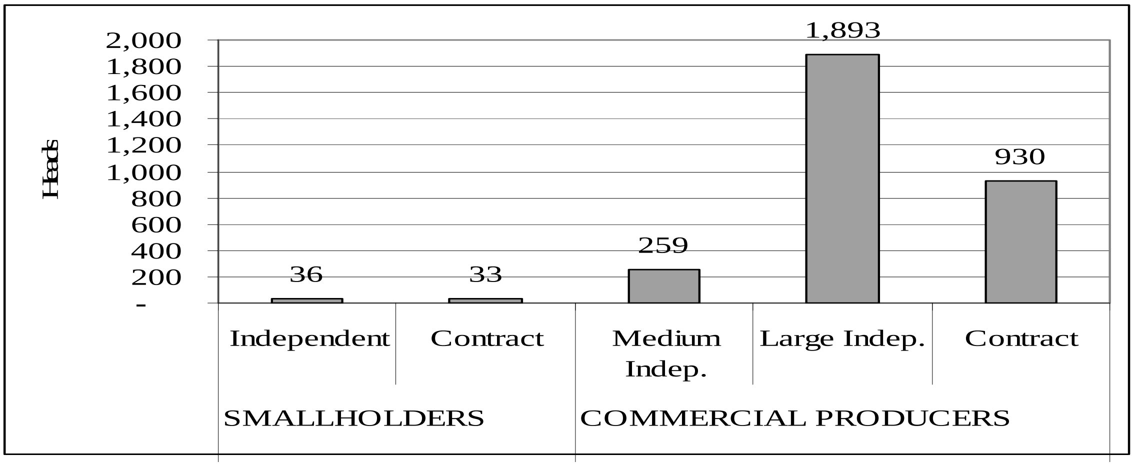
iii. Grow-to-Finish (Grow-Fin) involves purchasing weanlings or piglets and raising them until they are ready for sale at a market weight of about 75–100 kilograms.

iv. Combination (F-W + F-F) involves both farrow-to-wean and farrow-to-finish operations.

The predominant type of production was farrow-to-finish (40%) followed by grow-to-finish (29%). The more serious business of hog raising is in these types of operations. Farrow-to-wean is the least common type of production activity. But the farrow-to-wean operation is the domain of smallholders perhaps because a relatively low level of capital investment is required to start the business and there is a faster payback period. The medium- and large-scale producers are in the higher investment operations of farrow-to-finish and combination (F-W + F-F) activities. Needless to say, practically all contract growers, regardless of scale, are engaged in the grow-to-finish operations.

The average animal inventory in adult equivalent (in heads) to reflect scale across production arrangement indicates that smallholder independents have an average holding of 36 heads and smallholder contract growers have an even lower average holding of 33 heads, reflecting the output of backyard producers (Figure 2). Large-scale independents, on the other hand, have an average holding of 1,893 heads, which is double that of the large-scale contract growers.

Figure 2. Average animal holdings of 207 hog farms by scale of operation, with and without contracts: Philippines, 2002



Source of basic data: UPLB-IFPRI-LI Field Survey, 2002–2003.

Table 2 presents the descriptive information on certain characteristics of the household head and the farms that we hypothesized to influence environmental mitigation expenditures. We used these as determinants in the Tobit regression in Section 5.4.

Table 2. Household head and farm characteristics in 207 hog farms by scale of operation, with and without contracts: Philippines, 2002

Characteristics	SMALLHOLDER (<100 heads) Independent	SMALLHOLDER (<100 heads) Contract	COMMERCIAL (≥100 heads) Medium Independent	COMMERCIAL (≥100 heads) Large Independent	COMMERCIAL (≥100 heads) Contract
Education of HH head (yrs)	10.7	9.9	13.3	12.3	13.8
Age of HH head (yrs)	48	46	40	52	46
Sold manure in past 2 months (%)	1	0	1	3	5
Land class is agricultural (%)	30	65	72	94	93
Has cropland within farm (%)	40	22	58	76	73
Has cropland outside farm (%)	30	13	30	59	33
Within LLDA jurisdiction (%)	28	100	36	23	23
Distance to nearest residential community (km)	0.21	0.27	0.81	0.75	0.82
Connected to piped-in water supply (%)	44	61	38	6	10
Wage rate (PhP/hr)	8.78	9.81	12.43	16.13	10.95
Number of mortalities in the past cycle	2.2	3.9	16.0	55.1	56.6
Mortality rate (%)	11.9	9.73	11.8	16.1	11.13

Source of basic data: UPLB-IFPRI-LI Field Survey, 2002–2003.Note: HH = household head; PhP = Philippine pesos; LLDA = Laguna Lake Development Authority

We hypothesized the age and education of the household head as decision maker to proxy experience in livestock raising and accessing information on the importance of environmental mitigation and available technologies for pollution abatement. Across all farms, the mean age of the household head was 46 years. On average, the medium independents were a relatively younger group whereas the large independents were relatively older. Household heads in the commercial sample were relatively more educated, with an average of 12–14 years of schooling.

In terms of land classification of farm sites, 70 percent of independent smallholder farms were located on predominantly residential lands (nonagricultural). In contrast, the majority of the rest of the farms was situated on agricultural lands. The relative distance of the farms to the nearest residential community reinforces the previous observation: The smallholder farms are about four times closer (0.2–0.3 kilometers) to settlement areas than are commercial producers (0.8 kilometers), on average. For smallholders, being situated in predominantly residential areas brings greater challenges and more social pressure for environmental mitigation.

Markets for hog manure are apparently undeveloped or virtually nonexistent, as reflected by the quite small proportion (5% at best) of farms that were able to sell manure in the two months prior to the survey. This has important implications for how pig producers are able to dispose of the waste from the farms. The availability of cropland to which producers can potentially apply the manure, therefore, becomes crucial especially if farms, particularly the small-scale ones, do not have alternative methods of disposal such as biogas digesters, lagoons, and septic tanks.

At least one-fourth of commercial farms and about one-third to all of smallholder farms are located within the jurisdiction of an environmental regulatory agency—the LLDA in Southern Luzon. It is hypothesized that pressure from the presence of a regulatory agency, especially from a very vigilant one like the LLDA, will have an important bearing on the pollution abatement behavior of sample farms.

A piped-in water supply provides a regular supply of water that can be used for feeding and cleaning the pigs and the pens, which will in turn increase the volume of wastewater generated, thus increasing the mitigation cost. Smallholders have a higher incidence (at 44%–60%) of being connected to a municipal piped-in water supply than do commercial producers. However, this finding may be a function of the relative proximity of smallholder farms to the nearest settlement centers.

The wage rate is the cost of labor for disposing of pig waste and dead animals. Since mitigation activities are presumed to be labor intensive, a higher wage rate would generate higher mitigation expenditures. Higher animal mortality rates in the farm would mean a larger volume of waste to dispose, thus increasing the cost of environmental mitigation. The wage rates independent and contract commercial pig producers paid were higher than those smallholders paid. The average mortality rate was highest for large independent commercial farms, due in large part to the relatively higher animal holdings on these farms.

Pathways of Dead Pigs and Pig Waste Disposal

Ninety percent of the small independent hog producers buried the dead piglets. A small percentage of the households (1%) dumped the dead piglets into the river. The majority of large-scale producers, on the other hand, got rid of their dead animals by burying them or through incineration or some other method (Table 3). Despite the common practice of burying mortalities on farm premises, there appears to be no serious environmental problem occurring in these farms. Swine raisers apparently are aware of the environmental damage that can result from improper disposal of dead animals. On the other hand, they also may deal properly with dead pigs to prevent their own inventories from contracting diseases. Moreover, dead animals are easy to spot, particularly if the mortality rate is high, and this attracts complaints from affected parties.

Table 3. Manner of disposal of dead animals in 207 hog farms by scale of operation, with and without contracts: Philippines, 2002

Entry	Smallholder (<100 heads)		Commercial (≥100 heads)		
	Independent	Contract	Medium Independent	Large Independent	Contract
On-farm					
Buried	92	100	80	77	71
Incinerated	1		6	6	7
Open pit			9	2	23
Closed (cess) pit	4			13	
Consumed as dog feed	2		1	1	
Consumed as fish feed			1		
Off-farm					
Dumped in river	1				
Sold as feed			2	1	
Total	100%	100%	99%	100%	101%

Source of basic data: UPLB-IFPRI-LI Field Survey, 2002–2003.

Note: Total percentages may not add up to 100 percent due to rounding errors.

Manure is also considered livestock waste and may pose grave environmental damage if not properly treated or disposed of. The most common complaints from communities near swine farms are air and water pollution coming from pig manure. Table 4 summarizes how households in the study chose to dispose of the manure generated from their swine operations. It should be noted that these methods do not represent all possible management options available to farmers. Rather, they are those used by many of the households surveyed.

About 78 percent of the sample farms take some measures to clean up the waste. The rest simply flush out the manure directly into rivers and creeks or leave manure on the ground to dry, not mindful of whether somebody will pick it up for some economic use. Among those that mitigate externality coming from pig manure, a common way to dispose of the manure is to place it in an impounding structure such as a biogas digester, lagoon, or septic tank (55% of the sample). Some 22 percent of the sample hog raisers use the manure as fertilizer. Unlike that for poultry manure, the market for swine manure has not been established yet, thus the very low percentage of farms (1%) able to sell pig manure. For smallholders in particular, when markets for manure are virtually nonexistent and technological options to treat manure are costly and lumpy, a large proportion of the by-products stay within the farm to decompose or are thrown into the nearest river or canal systems.

Smallholders seem to have relative difficulty in cleaning up the manure. This may be because (a) they do not have the financial capacity to put up impounding structures; (b) they do not face the same regulatory environment as the large farms and therefore are not responding well to the call for cleaner swine production technology; or (c) they do not have sufficient information on how to properly contain the waste.

Table 4. Disposal of hog manure in 207 hog farms by scale of operation, with and without contracts: Philippines, 2002

Entry	Smallholder (<100 heads)		Commercial (≥100 heads)		
	Independent (n=87)	Contract (n=23)	Medium Independent (n=50)	Large Independent (n=17)	Contract (n=30)
On-farm					
Crops	21	4	23	23	23
Biogas	7	4	9	7	5
Off-farm					
Sold	1		1	3	5
Used both on- and off-farm	1		4	3	2
Noneconomic use					
Thrown in canal/river	3	9			
Laid on ground	15	13			
Open pit	20	30			
Lagoon	20	30	62	63	65
Septic tank	13	9	1	1	
No response					
Total	101%	99%	100%	100%	100%

Source of basic data: UPLB-IFPRI-LI Field Survey, 2002–2003.

Note: Total percentages may not add up to 100 percent due to rounding errors.

Smallholders generate more untreated and ill-disposed wastes than the other groups. This is because farrow-to-wean is this subgroup's predominant type of production activity; thus, their most common disposal method is to throw manure into waterways or lay it on the ground to decompose. In contrast, larger farms, particularly the independent farms, are able to make more economic use of the manure by applying it to cropland. In general, large farms also invest in impounding structures for waste disposal. Beyond production type or production arrangement, the overriding factor that seems to account for the differential behavior in mitigating pollution from swine manure is scale or size of farm. There is a much smaller proportion of medium to large farms, regardless of production activity and production arrangement, that are unable to make an effort to contain the waste.

Methods Used to Mitigate Negative Externalities

Air and water pollution brought about by the improper treatment and disposal of hog waste and dead pigs are the common complaints among people residing near hog farms. Noise from the piggeries is also considered a nuisance. Yet, none of the hog farms surveyed offered compensation to neighbors as a means of internalizing the costs of these negative externalities. Table 5 gives information about the other methods of environmental mitigation used by households in the sample.

Some farms hired workers or made use of family labor to dispose of manure and dead animals if they were not able to derive any economic use of these by-products. The independent growers, regardless of scale, showed consistency in cleaning their surroundings. In particular, the proportion of the medium and large independent growers (about 40%) that made use of such labor was twice that of small producers (22%).

Relatively more of the large-scale farms sampled had invested in equipment and facilities for environmental mitigation than small-scale farms. As a consequence, depreciation costs were incurred. About 9 out of 10 large-scale pig farms had impounding structures for collecting and/or treating pig waste compared to only half of the smallholders.

The incidence or proportion of farms paying license fees, taxes, and pollution fees/permits was zero among smallholder contract growers in the sample and was quite low among independent smallholders (13%). On the other hand, the proportion of commercial farms paying these fees was at least twice as high. It can be surmised that compliance or noncompliance of large pig farms to environmental regulations are relatively easier to monitor since commercial farms are easier to spot and are not as dispersed as their smaller counterparts.

Table 5. Incidence (%) of farms that incurred costs for environmental mitigation in 207 hog farms by scale of operation, with and without contracts: Philippines, 2002

Entry	Smallholder		Commercial		
	(<100 heads)		(≥100 heads)		
	Independent (n=87)	Contract (n=23)	Medium Independent (n=50)	Large Independent (n=17)	Contract (n=30)
Manure/dead animal disposal (%)	22		40	47	20
Depreciation and maintenance cost of waste treatment facilities (%)	42	57	88	88	80
License, taxes, pollution/permit fees (%)	13		26	41	33

Expenditures on Environmental Mitigation

We aggregated swine farms' expenditures on environmental mitigation and estimated them per unit of output. These costs include the value of manure sold or used on-farm evaluated at market prices and the cost of disposing of nonmarketed or unused waste and animal carcasses. Also included are the depreciation and maintenance cost of waste minimization and treatment facilities, value of labor for disposing of pig manure and dead animals, pollution fees, taxes, licenses and permits, and compensation to neighbors for being subjected to the negative impacts of the pollution from pig farms (Table 6).

Table 6. Value of captured environmental externalities in hog production by scale of operation in 207 hog farms, with and without contracts: Philippines, 2002

Entry	Smallholder (<100 heads)		Commercial (≥100 heads)		
	Independent (n=87)	Contract (n=23)	Medium Independent (n=50)	Large Independent (n=17)	Contract (n=30)
Value of manure sales					
PhP/cycle	39		4	171	143
PhP/100 kg	3.8		0.2	4.8	0.3
Value of manure used on-farm					
PhP/cycle	96	12	224	8,219	216
PhP/100 kg	43	1	6	17	1
Cost of manure/dead animal disposal					
PhP/cycle	161.5		265.2	577.6	193.6
PhP/100 kg	23.2		6.5	3.1	0.6
Depreciation and maintenance cost of waste treatment facilities					
PhP/cycle	31.7	79.0	89.0	940.1	446.6
PhP/100 kg	3.7	3.5	2.6	4.2	1.1
License, taxes, pollution/permit fees					
PhP/cycle	67.0		83.0	760.0	765.0
PhP/100 kg	5.1		2.1	3.5	1.4
Value of captured environmental externalities					
PhP/cycle	**256**	**91**	**641**	**10,281**	**1,746**
PhP/100 kg	**57**	**4**	**17**	**27**	**4**
Share of environmental mitigation costs to total variable cost (%)	**0.8**	**0.1**	**0.4**	**0.3**	**3.5**

Source: UPLB-IFPRI LI Field Survey, 2002–2003.

Note: PhP = Philippine pesos.

On a per production cycle basis, independent farms incurred higher costs on environmental mitigation than contract farms regardless of scale. Specifically, the large independent farms spent the most on environmental mitigation at an average of 10,281 pesos. It appears that independent producers tend to capture larger amounts of externalities from waste and dead animals than contract producers do. However, if standardized on a per 100 kilograms of output, the smallholder independent farms had the highest expenditure at 57 pesos. This value is 14 times the value captured by the commercial contract farms, 2 times that for medium commercial farms, and 3 times that for the large independents.

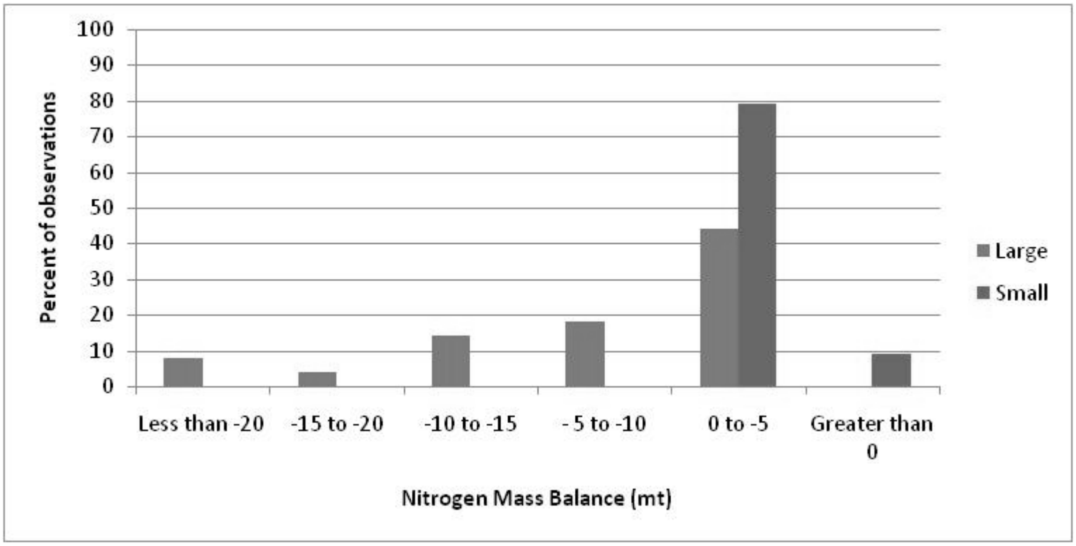
The t-tests conducted across scale and production arrangements in hog raising revealed significant differences in the mean values of captured environmental externalities. Thus, we accept hypothesis (i) and affirm that the nature and extent to which pig producers abate pollution depends on whether farms operate on a small or large scale and whether they are contract growers or independent producers. We reject hypothesis (ii) because contract growers actually spent less per unit of output on mitigating pollution than did independent producers. Hypothesis (iii) is likewise rejected because although the total environmental mitigation costs spent by large producers are higher, it is the smallholders who significantly spent more on a per unit of output basis. Table 6 clearly shows there are economies of scale with respect to mitigation expenditures. Smallholders actually spent more per 100 kilograms of output. This is presumed to be due, in large part, to the relatively lower volume of output that these subgroups are able to generate considering that the economies of scale arise basically because large farms can spread out the fixed cost of, say, pollution abatement facilities over a much larger volume of output. But does this finding lead to the conclusion that smallholders pollute less than commercial (large-scale) producers?

Assuming that a unit of output (e.g., 100 kilograms) generates, on average, the same amount of physical waste and environmental cost, smallholders pollute less than large producers per unit of output under the condition that the value of environmental damage (cost) reduced per unit expenditure on environmental mitigation is the same. Under conditions where cost-effectiveness enters into the equation and its direction with respect to scale is biased in favor of large-scale producers, smallholders still end up mitigating larger amounts of environmental cost per unit of output if the technologies of the large producers are only, at best, three times more cost-effective than the technologies or waste management and disposal practices that smallholders currently use. The already relatively high mitigation costs per unit of output internally borne by smallholders should warn against a strict and purely institutionalized approach to reducing environmental externalities from wastes in hog production.

The imposition of waste treatment facilities (e.g., biogas digesters) on small-scale hog producers would further increase their per unit expenditures on environmental mitigation, with direct adverse impacts on profits per unit of output. This arises mainly from the lumpiness of such investments. A pure and strict institutional solution to environmental problems from hog waste would hit hardest the operations where scale is small and constraints to expansion exist. The large producers at least have the scale to cushion the impact of large investments, other things being equal.

Using the mass balance approach, Figure 3 illustrates the difference by scale of production in assimilating the N from hog manure into the available land. In terms of the N contained in the manure applied, only 1 percent of large-scale swine producers sampled had enough land to potentially absorb all the N produced on the farm, whereas 14 percent of the small-scale swine producers had the potential to absorb all the N produced. Most of the remaining small-scale swine producers had only a minimal amount of the manure (0–5 metric tons) that they needed to find markets for. Of the large-scale households interviewed, though 42 percent had only 0–5 metric tons of manure that they needed to dispose of, 12 percent of them had over 20 metric tons that they needed to dispose of.

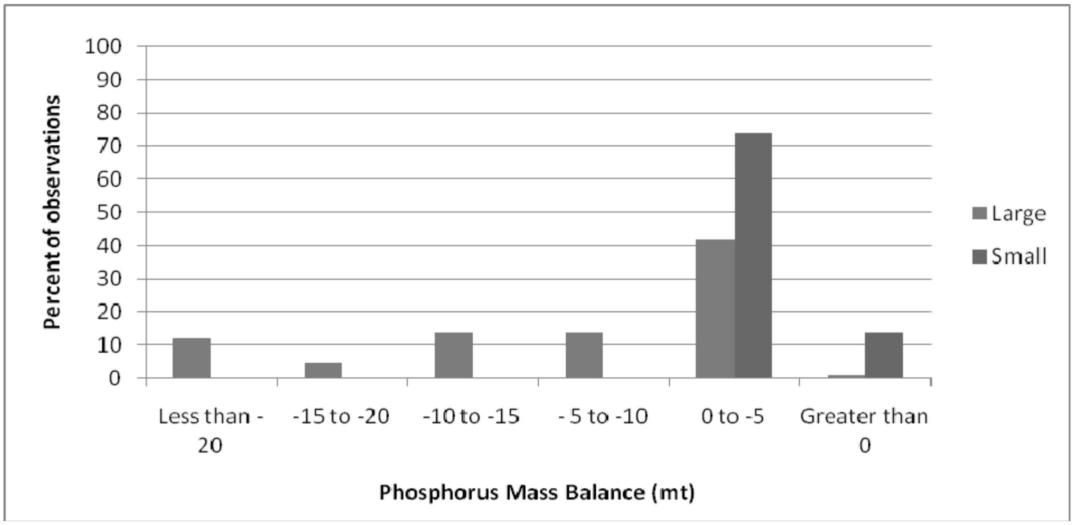
Figure 3. Mass balance calculations for large and small hog producers in terms of nitrogen



Source: UPLB-IFPRI LI Field Survey, 2002–2003.

In terms of P, none of the large-scale swine producers had enough land to potentially absorb the amount of P found in the swine manure produced. Only 9 percent of the small-scale swine producers had that potential (Figure 4).

Figure 4. Mass balance calculations in terms of phosphorous for large and small hog producers



UPLB-IFPRI-LI Field Survey, 2002–2003.

The mass balance calculations for N and P excreted on pig farms reveal that, in general, smaller farms generate lesser excess nutrients per hectare than do larger farms. This is because most small-scale pig farms are mixed systems where some croplands are available to assimilate the N and P nutrients produced in the livestock operations. Large commercial farms tend to be “pure land-intensive” systems.

Determinants of Pig Farm Environmental Mitigation Expenditures

Table 7 presents the Tobit regression results of the determinants of environmental mitigation by pig farms. For the pooled sample, the significant factors are the classification of farm site as agricultural, the existence of cropland, and the distance from farm to residential communities.

Farms established on agricultural land and the existence of croplands increase environmental mitigation expenditures through the cost of labor to spread manure on land. On the other hand, the distance from a farm to the nearest residential community carried the opposite expected sign and may warrant further investigation since the distance factor may be capturing something else. The positive coefficient for distance to nearest residential community conflicts with the original hypothesis of community centers bringing pressures to individual producers to internalize mitigation measures. This puzzling result needs deeper investigation. The definition of "residential community" as a point of reference is generally identical to the town center. As such, the town center would already connote some formal regulations on disposal of pig waste and dead animals or indicate the likely presence of community pressure. That the expected negative sign did not come out may mean that the formal or informal pressures, if they exist, are not working in the desired direction that is, corresponding to mitigation. The positive sign may imply that the accumulation of pig waste is not just a public bad but also a private bad, from the viewpoint of the producer. In this case, the private economics of disposing of it would also affect the cost of disposition or the proper disposition. Based on observation, at least, those in the peri-urban areas already have the infrastructure (canal networks) to dispose of the pig waste. Farther out in the rural areas, one has to either build the facilities, dig longer canals to the closest river, or transport pig waste to where it can be deposited or sold. Where transport costs are involved in the cost of building the waste disposal facilities, distance to the town center would add to cost. Thus, we conjecture that although there may be public/community pressures to deal with a public bad, the private calculations may outweigh the impact of these pressures.

The non significance of the dummy variable capturing the effect of the presence of such regulatory agencies as the LLDA allows us to reject hypothesis (iv). The result implies that there is no variation in the environmental mitigation behavior between pig farms inside and outside the LLDA jurisdiction. As readily identified and easily targeted entities, large pig farms in particular would have to respond more sensitively to legal authorities and to actual and potential community (residential) pressure. However, we did not see this in the regression results, and a plausible explanation for this is that all the large farms in the sample already have waste facilities and technologies installed, such as lagoons and biogas digesters, and some sell the manure or use it on croplands (see Table 4); thus, not much variation across commercial farms would occur.

The pooled regression results offer important insights into the factors affecting capture of environmental externalities by all hog farms in the sample. However, we performed a segregated analysis by production arrangement and scale because farms cannot be lumped together in extracting the determinants of environmental capture particular to them as they behave and respond differentially in the internalization of externalities.

With respect to the effects of production arrangement on environmental capture, the factors that significantly influenced mitigation costs varied between independent and contract farms. Only the operation of croplands mattered for independent producers. For contract farms, land classification as agricultural carried the expected positive coefficient sign. Mortality rate is significant but has a negative coefficient sign. An explanation is not forced here at this point, as this may warrant further empirical investigation. Smallholder pig farms under contract spend less on environmental mitigation expenditures than do large contract farms. The direction of causality, however, is unclear.

Regarding scale effects, the Tobit results reveal that for large farms, no single factor significantly influenced mitigation costs. An interpretation of why this is so or what this result implies apparently cannot be achieved without ambiguity. Thus, we do not attempt to do so, and we leave the matter for further investigation. For small farms, only the operation of croplands significantly influenced the mitigation of environmental externalities in the positive direction.

Table 7 Determinants of farm expenditure on mitigation of environmental externalities from hog production: Philippines, 2002

Explanatory Variables	Pooled Sample (N=203)	All Independents (N=152)	All Contracts (N=51)	All Large Farms (N=95)	All Small Farms (N=108)
Education of HH Head (yrs)	ns	ns	ns	ns	ns
Age of HH head (yrs)	ns	ns	ns	ns	ns
Land class is agricultural (dummy)	2364.60 (1416.86)*	ns	1905.29 (852.86)**	ns	ns
Has cropland (dummy)	1302.17 (603.96)**	1311.72 (656.66)**	ns	ns	345.91 (148.59)**
Within LLDA region (dummy)	ns	ns	ns	ns	ns
Wage rate (Php per hr)	ns	ns	ns	ns	ns
Mortality rate (%)	ns	ns	-58.33 (30.27)*	ns	
Distance to nearest residential community (kms)	17.22 (10.38)*	ns	ns	ns	ns
Dummy for small-scale (1 if small)	ns	ns	-2014.59 (916.90)**	-	-
Constant	ns	ns	ns	ns	ns
Log pseudo-likelihood	-1641.06	-1254.55	-343.63	-942.08	-576.13
Wald chi-squared (9)	14.96*	10.67	20.15**	7.72	25.63***
F-test	1.66*	1.19	2.24**	0.96	3.20***
Sigma	9776.49	11054.21	2147.71	12792.8	988.17

Source of basic data: UPLB-IFPRI-LI Field Survey, 2002–2003.

Note: Numbers in parentheses are robust standard errors; *,**, and *** indicate significance at 10, 5, and 1 percent levels, respectively; ns = significant; HH = household head; PhP = Philippine pesos; LLDA = Laguna Lake Development Authority.

6. POLICY IMPLICATIONS

A few policy implications follow from the analyses described above. Smaller farms tend to respond to opportunities to make use of manure as fertilizer on their own farms and crops. Thus, integration of pig farming systems with arable production seems to be a good option aimed at reducing negative externalities from pig production. However, depending on local circumstances, this integration option may be limited by increasing costs of equipment or transport for manure handling and infrastructural constraints. Larger farms appear to respond to the existence of an institution that makes and effectively enforces rules against environmental pollution; and although this response did not distinctly come out in the regression results, we can conjecture that this behavior is indirectly manifested in the number of mortalities that large farms clearly have to dispose of. It has been observed that all the large farms in the sample have already installed waste treatment facilities, such as lagoons and biogas digesters, and some sold the manure or applied it on croplands, presumably in response to pressures from regulatory authorities.

Such formal institutional instruments work on large or commercial entities possibly because they are more easily targeted for the imposition of sanctions (as permit sources) and because they have the size and capacity to invest in facilities and structures to minimize the potential magnitude of externalities on others. Thus, if the technologies are developed and are commercially supplied, when decision makers are well informed and the rules are made clear in matters of environmental pollution, commercial producers are likely to respond by spending more on environmental abatement.

Smallholders, on the other hand, will probably experience an institutional solution, such as enforcement of pollution standards, as an additional burden that increases their production costs. Nonetheless, they may respond if there are opportunities for them to benefit from the disposition of livestock waste through its use on croplands. Since no functioning market for hog manure exists of the stature of the domestic chicken manure market, it is tempting to suggest a policy direction toward the development of a feasible market for processed hog manure alongside increased smallholder access to croplands. However, the market for processed manure may present difficulties, particularly in a developing country setting where transport of large quantities of pig manure to areas where they can be efficiently used may be impossible because of poor infrastructure and high costs of processing equipment. In the Netherlands case,[8] large-scale manure processing was an expensive option because of investments required. Moreover, the end product had to be sufficiently competitive with cheaper options such as local manure application. Optimistic calculations estimated the cost price of processing pig manure in the range of US$13–20 per ton, and it was highly uncertain if it could be sold at a price that could recover processing costs.[9]

The environmental problems created by industrial systems—which account for 80 percent of total livestock sector growth—derive mostly from their concentration in peri-urban areas because of market access or feed availability. Industrial livestock units should be located as close as possible to cropland that can be used to dispose of the waste. Policy options include zoning, mandatory nutrient management plans, licensing or limiting the number of animals raised per production unit, and contractual agreements between livestock producers and crop farmers.

However, the zoning of pig farms takes strong political will to execute, and the Philippines does not seem to have a history of success along this line. Zoning of pig farms would probably succeed if the government motivated or make it obligatory for feedmillers to relocate or spread out to reduce their concentration in peri-urban areas. Pig farms are said to have grown in areas close to input markets (Costales et al. 2007).

The mass balance calculations for N and P excreted in pig farms reveal that, in general, smaller farms generate less excess nutrients per hectare than larger farms do. Large commercial farms tend to be

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[8] For other examples of schemes done in European countries, see http://www.fao.org/WAIRDOCS/LEAD/X6110E/x6110e07.htm.

[9] Feenstra et al. (1992) as cited in http://www.fao.org/WAIRDOCS/LEAD/X6110E/x6110e07.htm.

“pure land-intensive” systems. A regulation that mandates farms, large farms in particular, to devise nutrient management plans will certainly facilitate the monitoring of nutrients assimilation by the environment where the pig farms are established. The other option is to set a limit on the number of animals per production unit, which might encourage pig farmers to integrate their production with other agricultural activities. The Tobit regression results show that the existence of croplands and the establishment of pig farms on lands classified as agricultural significantly affect the level of environmental expenditures positively. Thus, the possibility of establishing agreements between crop farmers and livestock producers (especially those that do not have croplands) may facilitate the spreading and disposal of pig waste onto agricultural lands. This strategy may be mutually beneficial as crop farmers would potentially save on chemical fertilizer since, with proper enhancement, pig waste can be a good soil conditioner.

Needless to say, though, the effectiveness of the aforementioned regulations will largely depend on the degree to which they are enforced and on an accompanying well-developed system of education and extension with focus on proper manure management systems and dead animal disposal.

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Fax: +1-202-467-4439
Email: ifpri@cgiar.org

IFPRI ADDIS ABABA
P. O. Box 5689
Addis Ababa, Ethiopia
Tel.: +251 11 6463215
Fax: +251 11 6462927
Email: ifpri-addisababa@cgiar.org

IFPRI NEW DELHI
CG Block, NASC Complex, PUSA
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