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Economic impact of porcine epidemic diarrhea in Mexico

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ABSTRACT

Objective: The number of pre- and post- outbreak weaned piglets was evaluated, as well as return to productive normality, cost of weaned piglets, and economic impact (implications) of Porcine Epidemic Diarrhea (PED).

Design/Methodology/Approximation: The data were obtained from 24,597 farrows of weaned piglets from Mexican pork farms under conditions of technification. A mixed effects design was used with the time variable as class variable to determine the return to productive normality. The costs were determined with the general cost formula with emphasis on the number of weaned piglets (NWP). The economic impact was estimated using data from the Input-Product Matrix in Mexico.

Results: The average NWP before the outbreak was 9.75 per sow and birth, and from weeks 1 to 6 post-outbreak it was 2.43, 2.07, 2.87, 4.42, 6.22 and 8.07, respectively, with a weekly production cost of $114, $134, $97, $64, $46, $36 and $33 USD. The farms returned to normality in terms of NWP during week 7 post-outbreak.

Study Limitations/Implications: For every $77 thousand USD that cease to be invested in the demand, the amount that will cease to be generated is $96 thousand USD; therefore, an effect in the offer would be equivalent to a loss of 12,675 USD.

Conclusions: The statistical model allowed establishing the return time to normality of the farms being studied. Likewise, the methodology of costs with emphasis in the weaned piglet allowed to determine the cost of the piglet from the farms affected regardless of the physiological state of the other sows in production.

Keywords: sow performance, economic performance, productivity, livestock.

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INTRODUCTION

Outbreaks of Porcine Epidemic Diarrhea (PED) disease decrease, firstly, the number of weaned piglets in the farms and, as consequence, there are less finalized pigs, less kilograms of meat in the market, a decrease in the pork meat offer, and a negative economic effect both in the farm and in the markets. Despite the measures for control and prevention that have been applied, the disease continues affecting pork producers.

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PED was identified in Europe in 1971 (Lee, 2015) and the first strains were isolated in 1976 (Pensaert and Bouck, 1978) as *Alphacoronavirus*. During the decade of the 1970s and 1980s, the disease was reported in Europe, although without paying closer attention since its consequences were not significant (Pensaert and Bouck, 1978). Two devastating outbreaks of the disease took place in 2010 in Asia and 2013 in North America (Stevenson *et al.*, 2013). The outbreaks continued since then and extended to Canada and Mexico (Stevenson *et al.*, 2013; Perri *et al.*, 2014; Trujillo-Ortega *et al.*, 2016).

PED is a transmittable disease that causes acute diarrhea, vomit, dehydration and high mortality in newborn piglets (Bertasio *et al.*, 2016; Li *et al.*, 2016). The losses range from 1 to 3% as a result from the disease, causing approximate losses of 1 billion dollars both for producers and for consumers (Paarlberg, 2014).

Weng (2016) has estimated the cost of interventions to face the PED disease for production systems under conditions of technification; however, there are still few studies in the matter and the methodologies to attain data vary in their countable and financial structure.

Porcine meat production in Mexico has been classified in many ways: for its zootechnics aims, technification level, geopolitical regionalization, economic contribution, among others. The classification based on technification level has been used by the official sectors as reference to explain the dynamics and production of pork meat in Mexico. Thus, three strata are defined: 1) backyard system that contains between 20 and 30% of the stock, with low or "null" technification and 15 to 20% of production; 2) semi-technified system with 20 to 30% of the stock, and from 25 to 30% of the volume where the technological level is variable; and 3) the technified system that produces more than 50% of the volume of pork meat in Mexico (FIRA, 1997; Bobadilla Soto *et al.*, 2010). The recent dynamics and level of specialization of pork meat production places the Northeastern, Center-West and Peninsula Regions as those of greatest specialization, dynamics and technological consolidation, economic and volume of national production (Rebollar *et al.*, 2014; Rebollar *et al.*, 2016). These systems include different measures for prevention and control, as well as biosafety protocols; however, the disease has emerged in all types of productive systems.

In this study the productive effects of the PED disease are described in farms specialized in breeding-finalization of pork meat under conditions of technification, in different states of the Republic. The objective of the study was to evaluate the productive and economic effects of the Porcine Epidemic Diarrhea (PED) in specialized and technified farms for pork meat production located in the regions with highest specialization in Mexico.

MATERIALS AND METHODS

The study was conducted during 2013 and 2014 in pork meat production farms in different regions in Mexico specialized in breeding and finalization, including states such as: Sonora, Veracruz, Puebla, Jalisco and Guanajuato. The productive information of 24,597 farrows at weaning (equivalent to 3% of the national stock under conditions of technification) was analyzed, which showed their first outbreak of PED.

Information referred to the number of weaned piglets was used, classified into: a) pre-outbreak or week "zero", which averaged productive information of 26 previous weeks;

and b) post-outbreak, where the production of each week after was recorded, until week 26 after the outbreak (Goede and Morrison, 2016).

To statistically determine the return to productive stability, a mixed effects design was used with the time variable as class variable (Park *et al.*, 2009), which allowed establishing the statistical comparisons between each week after the outbreak. The best structure of covariance was determined and an adjusted Tukey's test was used to determine the significance (Kraemer, 1956).

In the cost analysis the methodology by Muñoz and Rouco (1995) for one weaned piglet was used, which emphasizes the variations of variable costs per weaned piglet. The mathematical expressions are the following:

$$TC = F + V$$

where: TC=cost of weaned piglet; F=fixed costs; and V=variable costs.

The fixed costs were formed by:

$$F = L + S + Co + R + A + Fi + CO + Ot$$

where: L=labor costs; S=supply costs; Co=energy and fuel costs; R=repair and maintenance; A=amortization of fixed assets; CO=opportunity costs; and Ot=other lower costs.

The variable costs were established by the items:

$$V = \left(AR + AM + AV + AMV + AL + M + T + CO / \left(TOTCER * W\right)\right) * z$$

where: AR=amortization costs of breeders; AM=diet of the sows; AMV=boar diet; AV=amortization of the boar; AL=diet of piglets; M=medicines; T=transport; CO=opportunity costs; $TOTCER$=total number of sows in the farm; W=weighting factor by virtue of all the variable costs referring to the production unit of a commercial piglet; and z=number of weaned piglets.

The depreciation of breeding animals was calculated as follows:

$$AR = \left(PH - \left(PD - \left(1 - MORR\right)\right)\right) / \left(PARM / PAR\right) - REP$$

where: PH=purchasing price of the sow; PD=discard price of the sow; $MORR$=mortality of breeders expressed in percentage; $PARM$=average number of births of the sows; PAR=number of births per sow and year; and REP=replacements of breeders.

The average of births per reproducing farrow can be calculated in any moment of the production, notwithstanding the physiological stage in which sows are found.

$$PARM = \sum(CER * n) / TOTCER$$

where: CER=number of sows; and n=number of birth. $PAR = 365 / \left((114{,}5 + LAC + INT) * (1 - NAB + VAC / CUB)\right)$; LAC=duration of lactation; INT=weaning-fertile mounting interval; NAB=total number of abortions; VAC=number of empty sows; CUB=number of mounts carried out. In turn, INT is formed by the sum of the intervals between weaning and first mounting (INT1); percentage of first repetitions*21 (INT2); percentage of second repetitions*42 (INT3); percentage of third repetitions*63 (INT4); and percentage of acyclical repetitions mean days of appearance.

$REP = PAR/PARM$ and the weighting factor is:

$$w = PAR * VIV * (1 - MOR) * (1 - MORT)$$

where: PAR=number of births per sow and year; VIV=piglets born living by birth; MOR=mortality in lactation; $MORT$=mortality in weaning-commercial piglet transition expressed in percentage points.

The monetary units are expressed in United States Dollars (USD) with an exchange rate Mexican Peso:US Dollar of 1:12.97, with date of June 30, 2014, according to the Bank of Mexico. The economic implications measured as the economic impacts were estimated with the information contained in the values from Leontif's inverse matrix of Mexico's Input Product Matrix (Sosa *et al.*, 2017) and their multipliers (Sosa, 2016).

RESULTS AND DISCUSSION

Number of weaned piglets

The average of weaned piglets before the disease was 9.75 piglets per sow and birth. The number of weaned piglets was severely affected (Table 1), with the highest productive losses standing out in the first three weeks post-outbreak.

Table 1. Number and cost per weaned piglet.

Week	Number	Cost (US$)
0	9.75	30.47
1	2.43	114.50
2	2.07	133.94
3	2.87	97.31
4	4.42	64.09
5	6.22	46.29
6	8.07	36.28
7	8.72	33.77

Source: Prepared by the authors with field data.

The potential impact of the disease in mortality stopped at the sixth week post-infection ($P<0.05$).

This reduction in production in farms with PED was similar to the one reported by Perri *et al.* (2014) and Weng *et al.* (2016). The prevalence of the disease can range between 30 and 40% and with higher occurrence in small-scale farms (Van Reeth and Pensaert, 1994), indicating that it is possible to relate technical and biosafety controls, as well as the size of the farms with the impact and the prevalence but particularly in the duration of the disease. In the United States, by June 2014 a high impact of the disease had been reported in farms of the Midwest, region where the specialized farms in pork production with largest stock are found (Hill *et al.*, 2014). Since the PED outbreaks analyzed in this study are primary outbreaks, the mortalities in some cases were 100% in piglets less than one week old, basically due to the piglets not having any protection (Geiger and Connor, 2013).

If the farm is in excellent conditions of management and biosafety, the total losses of piglets can be reduced to only 4 weeks, although the mortality can be prolonged until week eight in farms whose management is not adequate, showing mortalities of 100% from week two to eight (Engele and Whittington, 2014).

One of the procedures to determine the state of the disease is not only the return to productive stability; the moment when the diagnosis sampling of the disease is negative must be considered (Linhares *et al.*, 2014). In the case of PED, it has been reported that the virus stays endemic in the farm for a very variable time after the outbreak, although the production stabilizes due to the maternal immunity that is generated (Goede *et al.*, 2015). Weng *et al.* (2016) report a stabilization period of eight weeks, and Goede and Morrison (2016) of six weeks with intervals that range from the fourth to the eighth week.

Costs of the weaned piglet

The economic impact of the disease at the farm level is reflected in the increase of the cost per weaned piglet. Table 1 presents the costs per weaned piglet and week. The highest cost was recorded in the first three weeks, with a maximum cost of US$114 in week 2 post-outbreak. The cost before the outbreak was US$30 and in week 7, that is, in productive stabilization, of US$33.77. In general terms, there were less weaned piglets after the disease and more expensive piglets for the farms. Although it was statistically shown that since week seven post-outbreak, there was no difference in the number of weaned piglets per sow, the cost of the weaned piglet was US$3.3 more expensive.

Rogers (2018) reported average costs of US$29.36, 37.97 and 30.32 US before, during and after the outbreak, with losses that range from US$25.62 to US%292 in the weeks with 100% mortality.

The loss of piglets due to the disease, using as unit of reference one thousand producing sows, was 1,533 piglets, figure similar to the 1,688 reported in other studies (Goede and Morrison, 2016) using this same reference.

The production cost of a piglet in a farm from their birth to their finalization is impacted by the number of births that the sow has per year and in its productive life. The change

in these factors will generate the difference in the number of piglets weaned and sold per sow per year. Considering this information, the total cost from birth to finalization can reach values of US$8.86 to $71.80 and the productivity can be reduced from 25 to 80%. Furthermore, the producers must include the cost not only of the losses of productive life of the farm but also the expenses generated by the interventions (Weng *et al.*, 2016). In this sense, the loss of piglets will represent great losses for the producers. For a farm with 700 reproducing sows, the loss from the effect of PED will result in losses of $166 dollars per sow. In this study, the estimated cost per sow amounted to $142.20 dollars.

IMPLICATIONS

The demand multiplier (Sosa *et al.*, 2017) of the economic branch of "Porcine farm" was 2.2419 and of the offer 1.1644. In the case of the demand this implied that for each US$77,101.00 invested in the porcine farm (purchase of food, fuel, supply inputs, etc.), US$95,751.73 were promoted in the other sectors related. Thus, considering an average cost of US$192.76 per fattened pig (110 kg of live weight), a stock of 1,000 sows and 9.75 fattened pigs per sow and birth, the total invested in this operation would add up to US$1,879,405.49, which would promote a total of US$2,334,033.68 to the rest of the economic sectors related.

The offer multiplier, in its part, was 1.16; that is, for each US$77,101.00, an amount of US$12,675.40 is promoted in the economic sectors related, and therefore, the lack of this economic activity would reflect its negative impact with the amount mentioned.

PED is a disease with an impact in the supply chain and the pork meat product. The total number of pigs sacrificed in 2014 in the United States of America was 4.64% less than in 2013 (Schulz and Tonsor, 2015), producing changes in the prices of the product in the short term (Marsch, 1999) and price-production asynchrony (Martínez-Castañeda and Lorga, 2016).

If a decrease of 1, 2 and 3% in the production from the effect of PED is considered for the economic impact of the disease, the amounts of US$2,310,827.27, US$2,287,485.58 and US$2,264,143.89 respectively, would cease to be generated for every 1.000 sows at birth (Table 2).

Table 2. Economic impact due to PED*.

	Percentage variation			
	0	**−1**	**−2**	**−3**
Invested (USD)	$1 879 410.00	$1 860 615.90	$1 841 821.80	$1 823 027.70
Balance	0	−$18 794.10	−37 588.20	−56 382.30
Impulse to other sectors (USD)	$2 334 168.96	$2 310 827.27	$2 287 485.58	$2 264 143.89
Difference	0	−$23 341.69	−$46 683.38	−$70 025.07

*=1.000 sow, $192.76 pig production cost; 9.75 Total number of pigs sold by sow and farrow. Source: Elaborated with field data.

CONCLUSIONS

In the regions studied, where pork farming is carried out in technified systems, the effect of PED had a duration of six weeks, reaching productive statistical stability since week seven. The number of weaned piglets during the disease outbreak was 2.43, 2.07, 2.87, 4.42, 6.22 and 8.07 in weeks one to six post-outbreak. The costs per weaned piglet in the weeks since the outbreak were US$114.50, US$133.94, US$97.31, US$64.09, US$46.29, and US$36.28 from week one to six post-outbreak. For every US$77 thousand that ceases to be invested in the demand, slightly less than US$95,751.73 and US$12,675 would cease to be generated in the offer.

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