PLOS ONE

Economic and financial viability of a pig farm in central semi-tropical Mexico: 2022-2026 prospective

--Manuscript Draft--

Manuscript Number:	PONE-D-23-21718
Article Type:	Research Article
Full Title:	Economic and financial viability of a pig farm in central semi-tropical Mexico: 2022-2026 prospective
Short Title:	Prospective economic and financial outcomes of a pig farm in Mexico
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Keywords:	Planning horizon; forecasting; competitiveness; Livestock
Abstract:	To estimate the economic and financial viability of a pig farm in central sub-tropical Mexico within a 5-year planning horizon, a Monte Carlo simulation model was utilized. Net returns were projected using simulated values for the distribution of input and product processes, establishing 2021 as base scenario. A stochastic modelling approach was employed to determine the economic and financial outlook. The findings reveal a panorama of economic and financial viability. Net income increased by 555%, return on assets rose from 3.36% in 2022 to 11.34% in 2026, and the probability of decapitalization dropped from 58% to 13%, respectively in the aforesaid periods. Similarly, the probability of obtaining negative net income decreased from 40% in 2022 to 18% in 2026. The technological, productive, and economic management of the production unit allowed for a favourable scenario within the planning horizon. There is a growing interest in predicting the economic sectors worth investing in and supporting, considering their economic and development performance. This research offers both methodological and scientific evidence to demonstrate the feasibility of establishing a planning schedule and validating the suitability of the pork sector for public investment and support.
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Question	**Response**
Financial Disclosure Enter a financial disclosure statement that describes the sources of funding for the work included in this submission. Review the submission guidelines for detailed requirements. View published research articles from *PLOS ONE* for specific	-FEMC is awarded author - Grant number: 6498/2022CIB - Funder: Universidad Autónoma del Estado de México -URL:uaemex.mx - NO - The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

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Economic and financial viability of a pig farm in central semi-tropical Mexico: 2022-2026 prospective

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Abstract

To estimate the economic and financial viability of a pig farm in central sub-tropical Mexico within a 5-year planning horizon, a Monte Carlo simulation model was utilized. Net returns were projected using simulated values for the distribution of input and product processes, establishing 2021 as base scenario. A stochastic modelling approach was employed to determine the economic and financial outlook. The findings reveal a panorama of economic and financial viability. Net income increased by 555%, return on assets rose from 3.36% in 2022 to 11.34% in 2026, and the probability of decapitalization dropped from 58% to 13%, respectively in the aforesaid periods. Similarly, the probability of obtaining negative net income decreased from 40% in 2022 to 18% in 2026. The technological, productive, and economic management of the production unit allowed for a favourable scenario within the planning horizon. There is a growing interest in predicting the economic sectors worth investing in and supporting, considering their economic and development performance. This research offers both methodological and scientific evidence to demonstrate the feasibility of establishing a planning schedule and validating the suitability of the pork sector for public investment and support.

Introduction

Mexico is a country with a supply deficit in pork. According to statistical data, 2021 ended with an import volume (not including skin, brine, or other subproducts) of 969,358,505 kg of pork (SIAVI, 2023), representing just over 12 million pigs (Martinez et al., 2020). While food production in Latin America mainly stems from small-scale farms (FAO, 2022), only 30% of these farms make it to a second generation, and only between 10% and 15% make it to a third generation (Camacho and Vega 2023). In developing countries, the livestock sector encompasses almost 1 billion small-scale livestock production units that contribute with 40% of the agricultural GDP, and between 2% and more than 33% of the household income (Rota, 2016). Given the complex scenario regarding generational transition in farms, methodic planning and economic and financial forecasting represent important tools for decision-making.

According to official data, medium-scale pig farming (between 81 and 1500 animals) contributes between 20 and 30% of the total pork production in Mexico. Since the opening of trade in the said country, pig farming has been one of the most affected productive sectors and has lost a large part of its production capacity (Hernández-Martínez et al., 2008; Bobadilla-Soto et al., 2013; Martínez et al., 2020). Rebollar-Rebollar et al. (2020a) concluded that a subsidy to the supply function of pork carcass would improve the benefit to society by increasing production and protecting consumers. Similarly, the latter authors evaluated the application of a 20% *ad valorem* tariff, concluding that the sector is sensitive to such tariff and the current policy protects national producers; however, it has a negative impact on both importers and consumers (Rebollar-Rebollar et al., 2020b), in a market with a deficit in pork supply. According to Sosa et al. (2017), pork production is an economic sector that has a total multiplier of 3.40, which strategically positions it as a driving force of the economy. Therefore, it is crucial to assess whether to implement support and transfers to this sector.

A stochastic modelling approach of agricultural systems is a method used to evaluate agricultural management practices considering different risk factors, and to understand how such factors could affect the economic and financial viability, as well as the performance of the said systems in the future (Jonasson et al. 2014). The stochastic model developed by Nadal-Roig et al. (2020), was used to aid vertically integrated pork companies in decision-making and coordination of production, taking into account the uncertainty associated to future price of pork. Zavala-Pineda et al. (2012) used both Monte Carlo simulations and econometric models to assess the economic viability in the long term of Mexican pig farms considering four scenarios: Base scenario; hiring-in labour scenario; purchased inputs scenario: and zero subsidies scenario. Similarly, Posadas-Dominguez et al. (2016) evaluated the economic and financial viability of small-scale dairy systems in central Mexico. Callejas-Juárez and Rebollar-Rebollar (2020) conducted an analysis of competitiveness, profitability, and risk analysis in the cow-calf production system. While both the aforesaid studies demonstrated the importance of carrying out a prospective analysis that included the economic, financial, and political spheres, they were also useful for identifying improvement strategies in the productive and technical activities within the farms. The objective of this study was to evaluate the economic and financial performance of a Representative Pig Production Unit with an average inventory of 150 sows (RPPU150), located in a semi-tropical region of Mexico, considering a planning horizon of 2022-2026.

Materials and methods

RPPU150 description

The studied farm is located in a semi-tropical region of the State of Mexico, with an annual average temperature of 20.3°C, an altitude of 1,100 meters above sea level, a precipitation of 1,158 mm, and coordinates 18°59' and 19°14' north latitude, and 99°49' and 100°14' west longitude.

The production system is a farrow-to-finish operation (piglets that are reared to a weight of 110 kg). Pigs are housed in total confinement and separated according to physiological stage. The cycle begins in the breeding phase with insemination of the sows, once gestation is confirmed, pregnant sows are moved to gestation barns for 116 days, and one week prior to farrowing are transferred to maternity barns for a 23-day lactation period. On average, 12.5 live piglets are born per litter, with a mortality rate of 16%, meaning that 10.5 piglets are weaned at the end of the phase.

Piglets are weaned with an average weight of 7.37 kg, then transferred to nursery barns to consume pre-starter feed for around 26 days until they reach an average weight of 19.28 kg. Subsequently, the developing pigs are moved to a starting area to receive a starter diet for 26 days until they reach an average weight of 35.45 kg. Ultimately, pigs are transferred to fattening barns for 78 days: during the initial 26 days, pigs are fed with a growing diet until they reach a weight of 55.78 kg. Over the subsequent 26 days, they are fed a developing diet until a weight of 80.27 kg is reached. Lastly, pigs are provided a finishing diet for another 26 days until they reach market weight of 110 kg.

Ethics statement

The Ethics Committee of the Universidad Autónoma del Estado de México (México) approved the research protocol and information gathering tools. Prior to participation, the owner of the farm that conformed the analyzed RPPU150 was provided information about the overall aim and expected outcome of the present research. Due to the nature of the study, no animals were used to obtain data.

The model

A Stochastic simulation approach was carried out to evaluate the economic and financial viability of a representative medium-scale pig farm, using Zavala-Pineda et al. (2012) and Posadas-Domínguez et al.

(2016) probability distributions. Historical data for the probability distributions were taken from the SIACON (2022) database, that comprised 42 years of information (1981–2022). The studied model included data pertaining to the Mexican government to represent the national macroeconomic variables, while data from the IMF and USDA were used for the international macroeconomic variables.

The model projected economic and financial viability and provided information on trends for macroeconomic variables. In order to reduce estimation errors, trends in regional variables were estimated for the period of 2022-2026. The model operates annually at a strategic level and generates financial pro-forma reports that contain results used to calculate key output variables such as net incomes in cash, final cash reserves, change in net real capital, net present value (NPV) and rate of return over assets (RRA), which can inform decision making at both the farm and policy levels. The said financial reports are generated from functional equations that link pig production, sales, production and purchase of inputs, capital operations, and consumption and financing operations.

Stochastic variables of the model

The inputs prices and yield of crops in the RPPU150 were obtained via meetings with producers and direct interviews. A Multivariate Empirical Distribution (MVE) was used to simulate the cost of crops and pigs. The probability distribution parameters were estimated with the Latin hypercube method, used as a sampling procedure for the simulation of pseudo-random numbers.

The use of such method ensures that the coefficient of variation (CV) and the mean for the simulated random variables are equal to the CV and the mean for the historic variables.

Economic and financial viability indicators

The indicators analysed were total income (TI), total costs (TC), net income in cash (NIC), reserves in cash (RIC), NPV, RRA and cost to benefit ratio (C/B).

Model assumptions

The analysis took into account the following assumptions: (1) scale of production; (2) productivity; (3) farm infrastructure capacity and utilized; (4) technical coefficients are held constant during the planning horizon 2022-2026; (5) the technological level was also held unaltered; and (6) discount rate was established at 12%.

Economic values used were transformed in USD with a currency rate of 19.4143:1 USD:MXN according to Banco de Mexico (December 30, 2022).

Results and discussion

Table 1 shows the economic viability with a noticeable increase in all accounting entries. Gross income grew by 27.93% within the planning horizon, while expenses had a 16.09% reduction, this allowed for a 36% average annual growth of net income. The probability of falling into negative indicators was considerably reduced, with the cash flow deficit dropping from 40% in 2022 to 18% in 2026; the probability of refinancing decreased by 16 percentage points, and the probability of a return on assets less than zero dropped from 58% in 2022 to 13% in 2026.

Table 1. Economic viability of a RPPU150 (Thousands USD).

	2021	2022	2023	2024	2025	2026
Gross income	869.05	911.74	960.46	1,015.28	1,058.45	1,111.82
Total expenditure	849.98	889.93	903.38	926.69	958.39	986.76
Net income	19.07	21.81	57.08	88.59	100.07	125.06
Return on assets (%)	3.36	1.50	6.59	10.21	10.24	11.34
P(Cash Flow deficit) (%)	-	40.00	34.00	24.80	24.00	18.00
P(Refinancing) (%)	-	20.60	17.80	10.80	6.00	4.60
P(Return on assets < 0) (%)	-	58.00	46.00	32.20	21.20	13.00

P=Probability.

Net cash income performance within the planning horizon, according to the risk evaluation, showed that it is possible to fall in bankruptcy (5th percentile). However, 2026 economic panorama is a viable one (Fig 1).

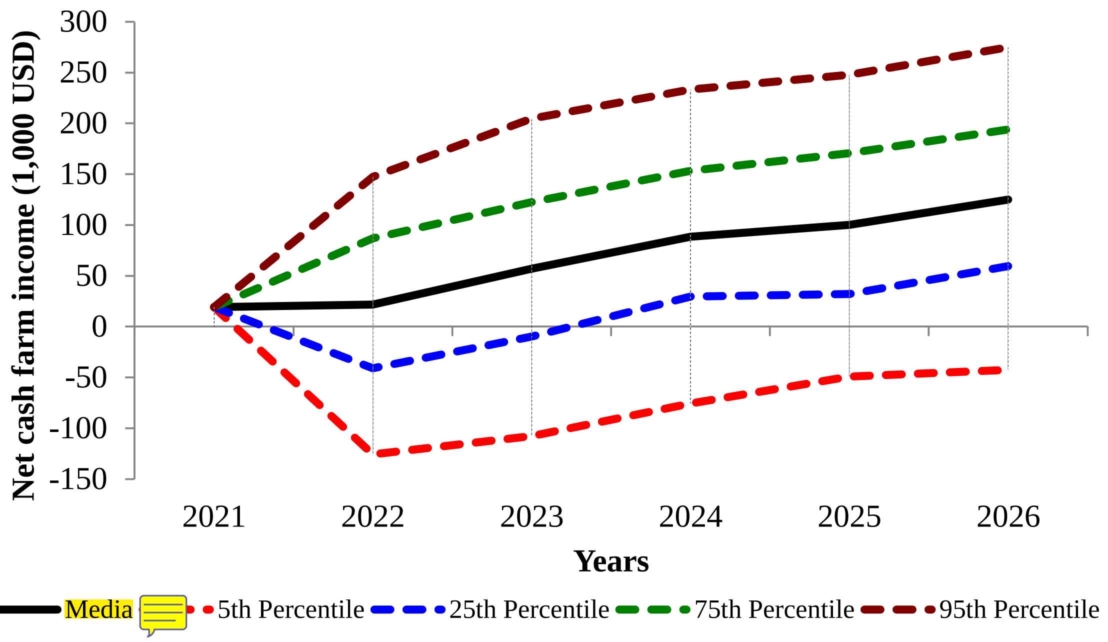

Figure 1. Net cash farm income performance according to percentile and risk simulation.

The cost structure was mainly composed of feed (88.17% of total), followed by labour costs (5.79%), breeding costs (3.46%), and fuel costs (1.26%). Other concepts such as maintenance, veterinary service expenses, indirect expenses, transportation, and land costs, accounted for 0.79%, 0.47%, 0.03%, 0.02%, and 0.005% of the total costs, respectively.

In the evaluated RPPU150, there is a null probability of obtaining a negative Net Present Value (NPV). The NPV in 2026 finished in 46.9964 thousand USD. The Internal Rate of Return (IRR) was 11.06%. The Cost/Benefit ratio was 0.98 and the Real Rate of Return was 0.07%.

Around 1.7 million tons (MT) of pork were produced in Mexico in 2021 (SIACON, 2022), and the State of Mexico contributed with just over 22 thousand tons. Specifically, the said country had an average annual growth rate of 0.74, while the State of Mexico had a growth rate of -3.32 from 1980 to 2021.

In Mexico, the pig farming sector can be described in three historical and conjunctural periods (Bobadilla et al., 2010): an initial period of growth driven by the structural policies established in the second half of the 1970s; a second period of crisis in the sector that began in 1985 and ended in 1991; and a third period starting from 1991 with a growing trend until 2021, mainly driven by the consolidation of corporate pig farming systems.

The macroeconomic and sectoral policies adopted by Mexico in the last two decades has led to a change in the production structure of pig farming at the national and local level. While the State of Mexico is in the Central East region of Mexico, where growth and dynamism had positive effects during 1994 to 2012, the average annual growth rate for the said state was -1.31%.

One of the main effects observed in the Mexican pig industry was the impact of trade liberalization on the sector, mainly due to the competitive advantages of the United States over Mexico (Tinoco, 2004). The difference between harm to producers and the benefit to consumers, namely $14.0 billion USD, remained in the hands of pork importers and traders, as in Mexico, among other causes, an asymmetric price transmission exists due to an oligopolistic market where retailers tend to quickly pass on price increases to consumers, while delaying the decrease in prices when they have decreased for the producer (Gómez-Tenorio et al., 2020). Such is the dependence on the external market that a 15% and 21% currency depreciation of the Mexican Peso would only imply an increase in national production of 0.3% and 0.4%, respectively (Almazan-Figueroa et al., 2018).

The transition in the pig farming structure in the State of Mexico is mainly derived from technological progress, defined as feed conversion, and to a lesser extent, the price of feed and the price of pork, with average elasticity values of 1.174, -0.039, and -0.099, respectively (Rebollar-Rebollar et al., 2014).

In this regard, Rebollar-Rebollar et al. (2007) determined that the best profit for pig farmers was obtained by producing animals with a range in live weight between 66 and 162 kg. However, the production of heavier carcasses did not necessarily imply a higher profit (Rebollar-Rebollar et al., 2014). The latter authors also found that the Technical Optimum Level (TOL) and Economic Optimum Level (EOL) for pork carcass weight were 94.47 kg and 90.96 kg, respectively, with profits of USD$ 162.1 and USD$ 173.0. In the case of secondary cuts, TOL and EOL were obtained with respective carcass weights of 85.4

kg and 85.3 kg, with profits of USD$ 236.7 and USD$ 236.9, while for tertiary cuts, 82.38 kg (TOL) and 82.26 kg (EOL) were equivalent to profits of USD$ 217.6 and USD$ 217.9.

The State of Mexico used to be one of the main pork producing states. Unlike national pork production, that recovered from 1991, the aforesaid state's pork industry was not able to do so, mainly due to the closure of a large part of its production units. While pork production at the national level grew an average annual rate of 2.63% from 1990 to 2021, it decreased by 1.20% in the State of Mexico. The observed trend in the production volume of pork in Mexico support global projections that estimate an increase of pork mainly in low and middle-income countries (OECD/FAO 2022), but the outlook is not the same for the pork industry in the State of Mexico. In this context, the estimation of financial projections has become a useful tool for assessing economic and financial viability of livestock systems. However, models must consider the conditions which prevail in the studied regions in order to reduce variability (Zhang y Wang 2020).

While the State of Mexico is a large consumer of pork, much of the said product is not produced in the state. One of the most significant changes from 2000 to 2019 was the concentration and commercialization of 21% of the slaughterhouses within the state. Additionally, 17 distribution centres and 24 slaughterhouses were located in the Central region of Mexico, representing 90% of the national traded volume (Callejas-Juarez et al., 2020).

Since 2006, a significant increase in the analysis of data pertaining to the pork sector has driven the development of models to assist decision-making (van Klompenburg and Kassahun, 2022). The focus of these models is mainly related to diseases, DNA analysis, and feeding strategies.

Several studies have been conducted to measure the competitiveness of the pork industry at both the national and State levels in Mexico. By the end of the 2000s, Hernandez-Martinez et al. (2008) reported favourable private profitability indicators in small, medium, and large-scale pig farms in the State of Mexico. Meanwhile, Bobadilla-Soto et al. (2013) reported private gains in the sale of weaned piglets in small-scale pig farms (5 to 100 breeding sows). However, non of the aforesaid studies included a risk analysis component like the present study.

In Brazil, Ali et al. (2018) applied a stochastic model in a typical full-cycle farm (1500 sows) to evaluate the impact on private and social profits of using locally produced co-products in finishing diets, finding a high coefficient of variation (75-87%) in profits due to volatility in prices and variations in pig biological parameters. These results demonstrate the importance of considering risk factors in strategic planning for livestock businesses.

On the other hand, Calderón Díaz et al. (2019) generated a predictive model to evaluate the effect of making changes in the production system (increasing housing area to reach a higher market weight vs. feeding finishing feed at an earlier age), finding that the modification of feeding systems is the best alternative to increase farm income with a reduced investment. In our study, feeding represented 88% of the total cost structure.

The models of Calderón Díaz et al. (2019), Rebollar-Rebollar et al. (2007), and Leen et al. (2018) allow for a clear visualisation, in economic and biological terms, which option offers greater productivity. Davoudkhani et al. (2020) reported that optimizing strategies related to feeding and distribution can increase gross income per pig by up to 10%. All the aforesaid models developed to estimate profitability do not consider micro and macroeconomic variables, and are focused on biological components, as well as the price of some inputs for livestock feed.

The results of Jia et al. (2021) warn that with the increase in the price of feed and land, the advantages of large-scale pig farms gradually become prominent, thus forcing small and medium-scale farms to close. Additionally, since pig farming is inevitably linked with the environment and productivity levels, environmental legislation could have a strong impact on the future development of the pork sector (OECD/FAO, 2022).

Leen et al. (2018) highlight the importance of individual farm modelling, since the combination of curves with different risk factors, production conditions, and payment curves in the same projection, could result in an underestimation of the economic and financial indicators.

Under the current technological, productive and management conditions, considering the macro and microeconomic outlook presented over the period 2022 to 2006, the RPPU150 showed favourable economic and financial indicators.

Conclusions

Our results showed a consistent economic and financial viability of the Scale farms under the current conditions in the horizon planning. Net income increased by 555%, return on assets rose from 3.36% in 2022 to 11.34% in 2026, and the probability of decapitalization dropped from 58% to 13%, respectively in the aforesaid periods. Similarly, the probability of obtaining negative net income decreased from 40% in 2022 to 18% in 2026. The technological, productive, and economic management of the production unit allowed for a favourable scenario within the planning horizon. Even those data, there is the risk (5^{th} percentile) of fall in bankruptcy. It is important to determine economic and financial performance yn an horizon planning because this size of farms are common in the State of Mexico and represents 30% of total inventory and 30% of pork production.

Acknowledgements

The authors wish to thank the pork producer that kindly provided the information for this study. and the research project 6498/2022CIB of the Universidad Autónoma del Estado de México for the financing of this research.

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