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Testing of a Grain/Hog Alternative in the Meta Altillanura Model

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Introduction **-** The Altillanura region has the potential to produce maize, soybeans, rice and other grains, but transport costs are very high and consequently the profitability of shipping out grain to other parts of Colombia or exporting is questionable. In the US, Canada and other parts of the world, grain producing regions that have high transport costs often turn to livestock feeding as a way to add value to their products and simultaneously reduce transport costs by shipping out a small quantity of a higher value product (i.e., meat). This is the strategy followed by the Aliar company (http://www.aliar.com.co/WebAliar/site/index.html) at their La Fazenda farm in Meta department. La Fazenda is producing maize and soybeans which are processed into feed and fed to hogs. The hogs are slaughtered at the company's abatoir in Puerto Gaitán and sold as branded pork products throughout Colombia. The question being asked in the Colombia Ministry of Agriculture, the National Planning Department, Pork Colombia and other organizations is if La Fazenda is a "one-of-a-kind" development that exists mainly because it has been created by a well managed and well capitalized parent company with access to Brazilian technology and expertise, or if this is a model that can be adapted? In particular, many Colombians are asking if small and medium sized grain and hog farms should be promoted in the Altillanura?

To begin the process of answering this question, the Purdue Team started with the Meta Altillanura baseline linear programing model. This model includes activities for cow-calf production, cattle finishing, integrated crop/cattle, oil palm, rubber, cacay, rice-soybean rotation, and maize-soybean rotation. Linear programming is a methodolgy that has been widely used around the world to help farmers identify and plan for the most profitable combination of farm enterprises. In more complicated models, farm linear programming is also used to analyze profitability of new technology, optimization of environmental criteria, management of risk and other farm management decisions.

The linear programing model used by the Purdue Team in the Orinoquia is based on the Purdue Crop-Livestock Linear Programing (PCLP) model (Preckel et al., 1992). This type of model has been used with thousands of farmers in the US Midwest (see for instance, McCarl etal, 1977), in Brazil and in many African countries. This is a relatively simple model that can be understood as automated budgeting. It focuses on profitablity of alternatives given land, labor and other resources. Risk is handled mainly through the determination of the number of good field data given rainfall and soil conditions.

Estimating a Purchased Feed Pig Activity - The baseline Meta Altillanura model was modified to test the potential for integrated grain/hog farms by adding a purchased feed pork production activity based mainly on data from Pork Colombia and an integrated grain/hog activity created by combining the purchased feed pork activity with the existing maize-soybean activity. The purchased feed pork activity assumes that all feed is purchased. With the exception of La Fazenda, this is the typical case for commercial pork production in Colombia. The resource requirements, labor use and other parameters are drawn from a 100 sow farm example provided by Pork Colombia. The labor requirement is assumed to be 3 permanent workers, or 0.84 workers per sow. Pigs are assumed to be sold at 105 kg. Productivity is estimated at 218 pigs per month for the 100 sow unit, or 26.16 pigs per sow/year. Sows are assumed to be replaced every three years. The price of finished hogs is assumed to be 5347 pesos/kg sold on the hoof based on Pork Colombia price data for 2016 to 2017. The current version of the model can use only one annual price for each output; it does not allow for price seasonality.

Costs of production are estimated from the cost data for 2016-2017 from Pork Colombia (Table 1). This covers all the costs including faciltities. The monthly cost for one sow and its offspring was estimated as the weight of finished hogs per sow per month (=2.18 x 105) multiplied by the average per kilogram cost (4775 pesos/kg). This overestimates the cost of production for modeling purposes because the costs from Pork Colombia include labor, which is calculated elsewhere in the model.

Because land allocation is a key aspect of the model and even pork production with purchased feed requires some space, the land required was estimated per sow and offspring (Table 2) at about 10.5 m^2 or about 0.001 ha. To allow for offices, feed storage, walkways, driveways and other space around buildings, the space requirement was doubled to 0.002 ha per sow and her offspring.

The resulting per sow purchased feed pork production activity requires 0.002 ha, 10.08 person days of labor/year and direct costs of 12,115,970 pesos per year. If the purchased feed pork activity in introduced into the steady state Meta Altillanura model, it enters the solution if adequate labor is available. The availability of labor is key to standalone pork production because the labor requirement is constant throughout the year. For purchased feed pork there is no synergy between it and the labor requirements of seasonal enterprises. In the steady state it can be financed out of cashflow because there are hog sales every month.

Preliminary Grain/Hog Activity Estimate - A rough estimate of an integrated grain/hog activity was created by combining the corn-soybean rotation activity and the purchased feed pork activity. The link between those two components is the maize production and consumption. If the maize yield in the maize-soybean rotation is 7 tons/ha, feed required per sow/month is 460 kg and the feed is about 70% cereal grain, then each hectare of the corn-soybean rotation could support about 1.8 sows and their offspring. Feed composition will vary depending on prices and other factors, but 70% cereal grain is a rough estimate (Maglioni, 2007). This estimate assumed that maize produced on farm is used in the feed and the soybeans produced by the maize-soybean activity continue to be sold to processors and that soybean meal is purchased to make the pig feed. There are various scenarios that would allow maize produced on the farm to be used in the feed including: 1) on farm feed milling and mixing or 2) maize is hauled to a central feed mill for feed manufacturing. The most profitable feed milling and mixing alternative depends on equipment costs, farm feed making expertise, transportation costs and other factors. Given the poor roads in most of the Altillanura and the possibility that feed deliveries may be impossible during some periods in the rainy season, on-farm feed milling would need to be considered in spite of the enormous economies of scale in feed making. In the integrated grain/hog activity, the direct cost estimate of the purchased feed pork activity is reduced by about 70% assuming that cereal grain is about 70% of the total costs. Sensitivity testing is used to determine if solutions change if grain is a lower percentage of total costs.

In terms of hectarage each unit of the integrated grain/hog activity is 0.036 ha devoted to pork production (i.e., space for 1.8 sows and their offspring) and 0.9964 ha of corn and soybean production. Labor is 99.64% of the corn and soybean activity each month, plus the labor for 1.8 sows and their offspring (i.e., 1.512 person days/month). The direct cost is 99.64% of the corn-soybean direct cost per hectare, plus 60% of the purchased feed pork direct cost. This results in an activity with 13,736,590 pesos direct cost/year and 19.59 person days of labor. Because of the corn-soybean production, the direct cost and labor now show seasonality with peak labor and cash demands in April and May at corn planting, August with corn harvest and soybean planting, and November with soybean harvest.

Table 1. Per pig production cost for a complete cycle operation.

Cost Category	16-Nov	16-Dec	17-Jan	17-Feb	17-Mar	17-Apr
	Pesos/pig	Pesos/pig	Pesos/pig	Pesos/pig	Pesos/pig	Pesos/pig
Feed	$392,880	$392,994	$392,994	$383,502	$383,558	$383,596
Offspring	$20,737	$20,294	$22,234	$22,413	$22,819	$23,326
Infertility	$3,650	$3,810	$3,849	$3,838	$3,839	$3,839
Labor	$30,206	$30,206	$31,563	$31,563	$31,563	$31,563
Installations	$16,459	$16,459	$17,536	$17,536	$17,536	$17,536
Medicines	$15,400	$15,400	$16,209	$16,209	$16,209	$16,209
Mortality	$5,409	$5,401	$5,576	$5,508	$5,521	$5,537
Commercialization	$11,517	$11,517	$11,197	$11,408	$11,408	$11,408
Others	$6,506	$6,498	$6,661	$6,573	$6,588	$6,607
TOTAL	$502,765	$502,578	$507,821	$498,550	$499,041	$499,621
$/kg produced	$4,788	$4,786	$4,836	$4,748	$4,753	$4,758
Cost category	**17-May**	**17-Jun**	**17-Jul**	**17-Aug**	**17-Sep**	**17-Oct**
	Cost Pig farm complete cycle	**Cost Pig farm complete cycle**	**Cost Pig farm complete cycle**	**Cost Pig farm complete cycle**	**Cost Pig farm complete cycle**	**Cost Pig farm complete cycle**
	Value	**Value**	**Value**	**Value**	**Value**	**Value**
Feed	$383,450	$383,454	$383,460	$383,460	$383,477	$383,537
Offspring	$24,093	$24,141	$24,129	$23,859	$23,751	$23,489
Infertility	$3,744	$3,653	$3,686	$3,837	$3,837	$3,897
Labor	$31,563	$31,563	$31,563	$31,563	$31,563	$31,563
Installations	$18,079	$18,079	$18,604	$18,604	$18,604	$18,604
Medicines	$16,207	$16,207	$16,207	$16,207	$16,207	$16,207
Mortality	$5,570	$5,569	$5,584	$5,580	$5,577	$5,571
Commercialization	$11,495	$11,495	$11,495	$11,495	$11,495	$11,495
Others	$6,643	$6,641	$6,657	$6,653	$6,649	$6,643
TOTAL	$500,844	$500,802	$501,383	$501,258	$501,160	$501,006
$/kg produced	$4,770	$4,769	$4,775	$4,774	$4,773	$4,771
Average total cost	$501,402					
Average pesos/kg	$4,775					
Average feed cost/kg	$3,675					

Source: Pork Colombia website - https://asociados.porkcolombia.co/porcicultores/index.php?option=com_porcicultores&view=cifras&Itemid=104&layout=2&costo=2017

Table 2. Space per stage of production and calculation of space per sow and her offspring.

Describe stage of production	Number of Animals Per stage	Space Required per Animal (m^2)	Space for 100 sow herd
Replacements	11.2	1.5	16.8
Gestation	86	Stalls 1.65	141.9
Nursing Sows	13.8	5.4	74.52
Weaned Piglets	367.1	0.35	128.485
Finishing	668.2	1	668.2
Boars	2	Pen: 8	16
Total, m^2			1045.9
Space per sow, m^2			10.5

Unidad Agricola Familiar (UAF) Sized Farm with Integrated Grain/Hog Option - To examine the potential for grain/hog production on farms of various sizes in the Puerto Gaitán area, a scenario was created of a UAF sized farm. The UAF range for the Puerto Gaitán area is 680 ha to 920 ha. For the scenario, the lower end of that range is used. It is assumed that 680 hectares of land are usable, excluding morichal, caños and other protected areas. Family labor is assumed to be 2 persons. For the first run, availability of hired labor is assumed to be limited: 10 permanent workers and 90 temporary workers per month (about 3 per day). The wage for permanent workers is set at the minimum wage (737,717 pesos/month). The wage for day labor is set at 50,000 pesos to allow for taxes and social payments. The initial capital and potential borrowing are retained at the levels in the Altillanura baseline (i.e., 1,000,000,000 pesos initial capital, and 2,000,000,000 pesos borrowing capacity).

Before pork activities are included in the model, the solution is 656 hectares of rice-soybean, 23 hectares of cacay and 1 hectare of rubber with a net return of 1,083,500,000 pesos. Temporary labor is a binding constraint in January for cacay harvest and in May for rice planting. A net return of over 1 thousand million pesos would undoubtedly sound like a bonanza to the average Orinoquia campesino, but it probably does not even cover the opportunity cost of land ownership. For example, if the land is worth 10 million pesos/hectare, then at a 20% opportunity cost of capital the opportunity cost of ownership of a 680 hectare farm is 1,360,000,000 pesos. At a land value of 5 million pesos per hectare the opportunity cost is 680 million pesos. The 20% opportunity cost of capital is a common target rate for medium scale agricultural investment in the Orinoquia region. For owner operated farms, if the farm business does not at least cover the opportunity cost of landownership, then there is motivation to sell to someone who will convert it to a higher profit use. This motivation to sell becomes particularly strong when a new generation takes over. The older generation may have been comfortable and satisfied in a low profit farm setting, but the younger generation often has other aspirations.

If annual crops (i.e., rice, soybean, maize) are not in the model, the solution is 638 hectares of cattle finishing, 18 hectares of cacay and 23 hectares of rubber. Two permanent workers are hired and temporary labor is a binding constraint in January for the cacay harvest. The net return on the no pork/no annual crops solution is 565,079,295 pesos, which may not cover the opportunity costs of land ownership.

Table 3. Land allocation in the first run of the Meta Altillanura UAF sized farm with purchased feed and integrated grain/hog activities.

---- VAR produce Produce enterprise e on land type l (ha)

	LOWER	LEVEL	UPPER	MARGINAL
NoIr.OilPalm	.	.	10000.000	-3.088E+4
NoIr.Rice_Soybeans	.	.	10000.000	-3056.920
NoIr.Corn_Soybeans	.	.	10000.000	-3284.671
NoIr.Crop_Beef	.	.	10000.000	-1990.596
NoIr.Caucho	.	.	10000.000	-8.605E+4
NoIr.Cacay	.	8.275	10000.000	.
NoIr.Cow_Steer	.	.	10000.000	-987.366
NoIr.Ganado_Ceba	.	.	10000.000	-917.422
NoIr.Beef_Silage	.	.	10000.000	-3200.176
NoIr.Beef_Nat_Savannah	.	.	10000.000	-845.174
NoIr.Porcino	.	.	10000.000	-4529.626
NoIr.Integrated	.	166.722	10000.000	.

The solution of that base run of the UAF sized farm with annual crops and pork activities shows 167 ha of integrated grain/hog production, eight hectares of cacay and the remainder of the 680 hectares unused (Table 3). The maximum number of permanent workers are hired (i.e., 10) and temporary labor is at the maximum in February when cacay is being harvested and April when corn is planted (Table 4). Cacay enters the solution as a profitable way to use off season crop-labor during the December, January, February period. Estimated net return 3,292,643,299 pesos, which probably would cover the opportunity costs of land ownership. Because of the regular pig sales, there is no borrowing in steady state.

Table 4. Temporary labor in the first run of the Meta Altillanura UAF sized farm with purchased feed and integrated grain/hog activities.

---- VAR thire Temporary labor hired in period t (man days)

	LOWER	LEVEL	UPPER	MARGINAL
Jan	.	79.655	90.000	.
Feb	.	90.000	90.000	398.939
Mar	.	.	90.000	-50.000
Apr	.	90.000	90.000	10144.999
May	.	84.703	90.000	.
Jun	.	42.585	90.000	.
Jul	.	53.597	90.000	.
Aug	.	53.598	90.000	.
Sep	.	18.610	90.000	.
Oct	.	.	90.000	-50.000
Nov	.	30.477	90.000	.
Dec	.	16.063	90.000	.

Sensitivity Test for the UAF Sized Farm - Sensitivity testing with the UAF sized farm shows:

- The UAF sized farm solution is stable with respect to the assumption of about the cost saving with on-farm grain production. If percentage of cost saving with on farm grain is reduced to 50%, the solution is identical to that with 70% cost savings.
- If more labor is available, the purchased feed pork activity comes into the solution, combined with grain/hog integrated activity.
- If no permanent labor available (only 90 days of temp per month), the integrated grain/hog activity is cut back to 68 ha, combined with 2 hectares of cacay. Net return is 1,348,280,327 pesos. As in the base solution, temp labor maxed in February and April.
- With more intensive farming, it may be possible to create profitable farms that are smaller than the UAF. For example, if only 100 ha is available, but permanent labor can be hired, the solution is integrated grain/hog, plus pork production with purchased feed. Temporary labor is at the maximum in April. Ten permanent workers are hired for purchased feed pork. Net return is 2,557,971,567 pesos.
- If 100 hectares is available, but no permanent workers and 90 days/month of temporary labor, the solution is 68 ha integrated grain/hog 2.2 ha. Cacay and remaining area unused.
- If only 50 ha is available, but labor can be hired, then solution even more purchased feed pork production. Net return: 2,091,599,504 pesos.

- If land is increased, and labor is available, the solution is all swine activities, all the crop land in integrated grain/hog activities, plus some stand-along hog production. This is essentially the La Fazenda solution and would be available to farms with land and labor available.

Next Steps – To explore if these results are practical it is important to understand the following:

- *Costs and practicality of on-farm feed processing* – Various types of on-farm feed processing are used in other parts of the world. In high rainfall areas of Europe electrified on-farm feed milling and mixing under the same roof with grain storage was commonly used. In the past, pull type-tractor powered grinder mixers were used on US Midwest livestock farms. Such tractor powered equipment is still used there on organic and other specialized farms. Because of high rainfall, stationary grinding and mixing equipment under the same roof with grain storage may be the most practical, but because of lack of electrification it would need to be powered by a generator or directly by a diesel or gasoline engine. Because of high power requirements it is unlikely that grain grind and feed mixing equipment could be powered by electricity generated by a solar array or small wind turbine.
- *Practicality of using extruded soybeans to produce soybean oil meal on the farm* - This would avoid the expense of transporting soybeans to market and hauling soybean meal back to the farm, but it would require on farm extrusion capacity and labor for frequent soybean processing. Most soybeans cannot be used directly in hog feed because they contain an antinutritional trypsin inhibitor that reduces rate of gain. Because the soybean oil meal created by extrusion of whole soybeans has a high oil content it can become rancid quickly at tropical temperatures. Also, feeders may need to be checked and cleaned frequently to avoid bridging and accumulation of rancid feed.
- *Effects of hog manure on soil fertility* - This estimate does not estimate a value for the impact of swine waste on soil fertility. The National University manual on use of swine manure in crop production would be helpful in making this estimate (Grisales et al., 2016). In the longer run, application of swine waste may increase soil organic matter levels and lead to higher crop productivity.
- *Practical potential for sharing grain production equipment* – There are enormous economies of scale in grain production. These economies of scale continue up to the maximum size equipment that is usable in a given topography. Because the Altillanura is relatively flat, very wide planters, sprayers and harvesters can be used. This suggests that small to medium sized integrated grain/hog farms may be operating under an economic disadvantage if they are forced to use smaller (narrower) crop equipment. Alternatives which are used by small to medium sized crop farms in other parts of the world include: 1) reliance on custom equipment operators (i.e., contratista), 2) machine “rings’ in which a group of farmers own equipment together. In an area where the window for field operations is narrow, one of the key issues in making equipment sharing work is to develop a mechanism for determining the order in which fields are planted, sprayed or harvested. One option is to use UBER style differential pricing in which farmers who received services at optimal times also pay more. Another

alternative is to determine the sequence of fields by least cost/least time optimization.

References:

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