Complementarity between production activities and resource use: Partial Budget Analysis vs. Linear Programming

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ABSTRACT

Farm owners and managers often make decisions regarding how to improve their agribusiness enterprises. Two common tools are: **partial budget analysis** [**PBA**] and **linear programming** [**LP**]. PBA addresses possible financial impacts of individual enterprises or management practices. LP seeks to optimize net returns by finding the best possible enterprise mix given farm-level resource constraints. In a collaborative effort with the Colombian government and institutions, we used both tools to evaluate agricultural enterprises for farmers in the Orinoquia region of Colombia. This region was selected for its underdeveloped agricultural potential with 33% of the country's total area. Our results from both tools suggest that the LP approach provides major advantages over a PBA: (i) It generates higher [and optimal] net revenues due to the combination of enterprises, (ii) It makes use of resources more efficiently by simultaneously considering different periods of time, and finally, (iii) it computes shadow values that gives us a better idea of the opportunity cost of each resource endowment.

Objective

This study examines differences in economic revenues from activities and use of resources from PBA and LP in an experimental application for a whole economic region.

QUESTIONS ADDRESSED

1. Are the recommendations for enterprise adoption significantly different between the two tools?
2. To what degree is the complementarity between resource use for activities important?

ORINOQUIA

Orinoquia covers about 33% of Colombia. Among the economic activities developed are farming, mining, energy and oil extraction. The Colombian entity 'Departamento Nacional de Planeacion [DNP]' has elaborated different national plans with the objective of decreasing economic inequality through the implementation of profitable agricultural activities. Among these efforts, DNP has established the 'Plan Maestro de la Orinoquia' with the intention to improve agricultural production and afforestation in Orinoquia while being environmental sustainable.

Orinoquia region (in green)
Source: Colombian government

THE EVALUATED TOOLS

PARTIAL BUDGETING ANALYSIS [PBA]

PBA is a useful tool to assess whether new enterprises or management practices can increase net returns to fixed factors. Typically, the enterprise with the highest net return is recommended. Advantages of this tool are that it is simple to perform in a spreadsheet and requires lower amount of data compared to other types of budget analysis. Nevertheless, this method suffers from major limitations: [i] it does not address the question of whether the resource is used optimally by the firm, [ii] the results are not additive – when implementing two changes simultaneously, the interaction effect is not captured. Thus, PBA cannot provide optimal farm planning when contemplating possible combinations of different practices or enterprises.

LINEAR PROGRAMMING [LP]

LP is commonly used for the task of optimizing resources while finding the best possible enterprise mix, i.e. one that maximizes net revenues. It also provides relevant information such as shadow prices (i.e., valuations of endowments of resources). However, this method assumes that any combination of enterprises can be pursued within the resource restrictions.

TOOLS FOR ORINOQUIA

In 2016, Purdue University signed an agreement with ESAP (Escuela Superior the Administración Pública), to provide the Colombian Government through the DNP with applied research tools to support their decision making process, and to promote understanding of the agriculture and tourism development opportunities in the Orinoquía region. The Orinoquía is part of the territory that was occupied by the FARC, and the region is in need of economic development.

As part of the Purdue-ESAP agreement, Purdue developed an Agricultural Linear Programming Model (ALPM) for the Orinoquía. This planning tool facilitates the evaluation of alternatives at the farm level by optimizing the returns of the producer subject to initial endowments of labor, land, and capital. This model has been delivered to Colombian government and research personnel, and there is great potential for using this tool for assessing agricultural opportunities in the diverse agro-climatic zones of the Orinoquía.

In addition, financial budgets for major potential enterprises were developed for regions in Orinoquía. This elucidates a clear idea of the economic feasibility or each potential enterprise.

DATA COLLECTION

Our team has participated in this plan by (i) collecting data on the possible agricultural enterprises that can be profitably implemented in different sub-regions of Orinoquia, (ii) summarizing and developing the budget of each economic activity, and (iii) constructing the LP model that helps to evaluate these agricultural activities in an integrated fashion.

We collected information of major agricultural activities that are feasible for the Orinoquia region: guayaba, citrus crops, coffee, cacao, pineapple, fish, livestock, eucalyptus, palm oil, among others. The resources considered were: land (irrigated and rainfed), labor (family labor, permanent and temporal workers), monetary capital, and raw materials. All values are represented in Colombian pesos. We also recognize that some enterprises may provide many outputs (e.g., pineapple plants provide pineapple of high and low quality).

THE MODELING STRATEGY

For our modeling strategy, our models are based on a one-year planning horizon, with a year divided in twelve months. In order to compare crops with multi-year enterprises (i.e. such as tree crops), we use the ***steady-state*** principle. For example: *If cacay is a 10-year crop, then in steady state 1 hectare [Ha] of cacay is made up of 1/10Ha of first year cacay, 1/10Ha of second year cacay. 1/10Ha of third-year cacay, etc. We also choose a representative farmer that possess 1 Ha of irrigated land and 15 Ha of rainfed land.*

MODEL RESULTS

Table 1. Partial budget analysis

Enterprise	Net Revenue (million pesos)	Extra labor hired (days)
Guayaba	0.0	806
Citrus	56.6	2688
Coffee	156.3	515
Cacao	0.0	389
Oil Palm*	7.8	0
Pineapple	0.0	596
Fish**	0.1	758
Caucho	84.4	660
Rambutan	92.4	1340
Mangostino	138.4	860

Table 2. Linear programming analysis

Enterprise	Linear programming: Irrigated land (Ha)	Linear programming: Rainfed land (Ha)
Cacao		
Coffee	0.4	6.7
Cacay		
Pineapple	0.6	
Oil palm*		
Fish		1.9
Caucho		
Mangostino		1.4
Eucalyptus**		4.1
Beef Cattle**		1.0
Hectares produced	1	15
Total Net revenue	173.1	

* Oil palm is not produced in rainfed land

** These enterprises are not produced in irrigated land

For both tools, the same quantity of land is planted: 1 Ha of irrigated land and 15 Ha of rainfed land.

- ✓ For the PBA case (table 1), we can see that there are many enterprises in which the net revenue is low due to the additional labor that needs to be hired which is a very crucial factor that increases cost. Thus, many enterprises are labor intensive in which in some instances such as cacao or pineapple, the enterprises only reach breakeven.
- ✓ LP provides (in table 2) a mix of different enterprises that (i) provide a significant higher net revenue for the farmers, about 11% more by using LP over BPA [i.e., 173 million pesos from LP vs. 156 million pesos which is the highest value from the PBA] and (ii) make use of all available resources as efficient as possible. LP combination results in the use of both types of land which is a result of implementing at least two enterprises.

Thus, LP provides an optimal mix with a higher net revenue over time that considers different limited resources compared to the PBA.

CONCLUSIONS

As observed from our study, implementing a linear programming model provides major advantages over a partial budget analysis:

- ✓ It generates higher net revenues by selecting the combination of enterprises that exploits the resource endowments in an economically advantageous way, and
- ✓ It computes shadow values that gives us a better idea of the opportunity cost of each endowment, and in the case of labor, it does this period by period.