THE EFFECTS OF A CONSTRAINED OPERATING BUDGET ON THE OPERATING EFFICIENCY OF LARGE AGRIBUSINESS OPERATIONS

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In an era of constrained financing for agriculture operations, limited operating budgets are a reality for many agribusiness firms. Managers must routinely make decisions about how to allocate limited budgets. In a firm with many non-related departments, doing so should not be that difficult -- the most profitable departments should receive the most money. For many large agribusiness firms, however, budgeting decisions are more complicated. The apparent difficulties are associated with two or more departments in such firms often being inter-related. That is, products produced by one department are used in another department, and so forth. For example, corn produced might be fed to swine which would then be slaughtered by a packing plant, representing three linked-profit centers of the same total business. Cutting back on either the crop enterprise and/or the swine operation may have effects on the packing plant. To make the optimal budgeting decision, the inter-relationship among all of the enterprises must be considered.

In this paper, we consider using a systems model to 1) find the effects on the profitability of the firm as a whole when the operating budget of one department is limited, and 2) investigate how to maximize profits within one department with a constrained operating budget. To

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accomplish this, we use a particular case, the Texas Department of Criminal Justice's Agriculture Operations (TDCJAG). First, a brief background is provided regarding the TDCJAG, followed by a short description of the model. Then, a description of the experimentation and the results are presented.

Background

The Texas Department of Criminal Justice (TDCJ) must provide for the dietary and other requirements of over 120,000 inmates. Part of this need is filled by the TDCJAG, with the remainder of the needs externally purchased. Figure 1 is an illustration of the general structure of the TDCJAG. TDCJAG has a highly-diversified and vertically-integrated agricultural operation including: 38,300 acres of vegetable and field crops; 67,700 acres of pasture; two feed mills; livestock operations including swine, poultry, and beef; an egg-processing facility; two meat-packing plants; two cotton gins; an alfalfa dehydrator; four grain elevators; and a vegetable cannery. The goals of TDCJAG are threefold: 1) to provide agricultural commodities and processed products for inmate consumption, reducing the cost of buying outside products, 2) to provide employment "outside-the-cell" for the inmates, and 3) to efficiently manage TDCJAG resources, maximizing returns to State-owned capital investments.

In recent years, TDCJ, like many other state and federal agencies in the United States, has been subjected to increased scrutiny in terms of budget. The general overall tightening of State funds, coupled with a rapidly expanding prison population,[2] has led to a need to increase the

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[2]   In 1978, the TDCJ inmate population was approximately 25,164.

efficiency of TDCJ, including the TDCJAG operations. In particular, operating funds have not expanded as fast as have the demands on the Agriculture department.

Analytical Framework

In an effort to improve management of its agricultural operations, TDCJAG funded development of a linear programming systems model of the total agriculture and food/fiber supply system in a joint project with the Texas Agriculture Experiment Station (TAES) (Texas Agricultural Experiment Station and Texas Department of Criminal Justice). The model resulting from this study is used here to analyze the consequences of alternative levels of operating-funding support for the TDCJ Agriculture department.

Table 1 is an illustration of the general structure of the TDCJAG linear programming systems model, hereafter called PRISAG. PRISAG is designed to identify optimal levels for the various types of enterprises so as to maximize the sum of net returns in the Agriculture department, plus minimize the cost of food, fiber, and broom corn purchased to meet the requirements of other TDCJ departments. The enterprise levels chosen include: a) acres of vegetable crops, field crops, and pasture alternatives; b) size of the various livestock operations; c) levels of processing undertaken; d) internal commodity transportation; e) diet composition; and f) commodity purchases. The enterprise levels are chosen so as to maximize net returns subject to a) dietary requirements; b) balance constraints on commodities, livestock, vegetables, canned goods, meat, etc. which force the use of an item to not exceed supply; c) capacity constraints limiting the operation size; d) inmate labor availability; and e) land availability. A general description of the interaction of the activities is provided below.

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A set of commodity balance constraints reflects supplies of commodities from crop and livestock production, purchases, and processing against uses in feeding livestock, processing, consumption, and sales. Also, most commodities can be shipped in from or out to other operations. The livestock-balance constraint forces the use of any type of animal at a farm to be less than the supply. Producing livestock at an operation uses certain animals to supply others. For example, the cow-calf operation uses replacement heifers and supplies calves. The supply of most types of animals may be increased by purchasing additional animals. Selling animals is a use and decreases the supply. Animals can also be shipped out to and shipped in from other operations. The vegetable-balance constraint dictates that the supply of vegetables produced can be either sold or shipped out to either cold storage or the cannery to produce canned goods. The canned-good-balance constraint requires that the cans produced plus the cans purchased must be greater than the canned goods required by the inmates' diet. The meat-balance constraint requires that the meat produced plus the meat purchased must be greater than the meat requirement of the diet. Capacity constraints exist for most of the enterprises. Crop-capacity constraints include restrictions on the land and machinery available. Livestock capacity is limited by the capacities of the facilities, and the availability of pasture land for cattle. Capacity constraints for processing operations include the capacities for the feed mills, the alfalfa dehydrator, the cannery, the packing plants, and the cotton gins. Each of the packing plants has a constraint limiting the yearly production of each type of meat and the production of all meat at the packing plant. The production of canned goods must be such that the machinery time available are capable of satisfying the use. There are also constraints on the inmate labor available.

The objective function accounts for system-wide activities involving Agriculture and activities of other departments for which Agriculture may substitute its own production and/or processed commodities. Several cash flow constraints are included in the model, one each for the various departments represented. The objective function provides an accounting of returns above specified costs. Returns originate from the sale of commodities and/or processed products. Cost considered are those specified for production, processing, shipping, and other activities included in the model. Only variable costs are considered inasmuch as the model is designed to aid in enhancing the efficiency of current operations. The model is solved to maximize the objective function value.

Producing crops, producing livestock, processing commodities, processing meat products, and processing canned goods appear as a use of cash in both the objective function and the Agriculture cash flow constraint. Selling goods supplies revenue in the objective function, but does not add to the cash available for operations.[3] Buying and/or shipping goods shows up as a use of cash in both the objective function and cash flow constraints.[4]

Experimentation and Results

While the total operating budget available to TDCJAG in FY96 was $32,837,00, a significant part of this budget is used for management salaries and other costs not considered in the model. In regards to the costs included in the model, the modified budgeted allocation was

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[3] State law requires all such sales revenues be deposited into the State General Revenue account as opposed to being reinvested in the agency responsible for generating the funds.

[4] Depending on the type of good purchased, the cash outflow may be assigned to either the Agriculture, Food Services, Industry, or Security department.

$26,831,000. After obtaining a model solution for this budgeted level of cash operating funds, additional analyses are obtained for budgets lowered by the amounts of one million, two million, five million, and ten million dollars. It is assumed in each analysis that only the operating money available to Agriculture changes. Everything else is based upon a typical year. Further, budget allocations to other departments of TDCJ are considered unconstrained.[5]

Results. In Table 2, the "Base" column summarizes the operating levels of the various enterprises within TDCJAG when the operating budget is at its initial amount of $26,831,000. Crop enterprises are planted on over 38,000 acres of crops. Over 6,000 acres of vegetables are grown. The livestock operations include over 193,000 hens, 3,000 sows, and 12,000 cows. Processed pork products total almost 5 million pounds. Processed beef products occur at plant capacity of 10 million pounds. Results for the other budget-constrained analyses are compared to these results below.

Two types of results are evident from limiting the operating budget of TDCJAG: the change in the overall objective function value and what happens to the level of various enterprises. The TDCJ-system cost response (i.e., greater negative objective function) to a lowered operating budget for Agriculture appears marginal at $1 and 2 million decreases in the operating money available. However, as further reductions are assumed, the cost response becomes much larger. Table 2 includes the shadow price on Agriculture operating money,

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[5] In some business situations, budget allocations to individual departments may be cut after the overall impact on the total system has been assessed. In the TDCJ case, however, whereas budgeting cuts are initially allocated across departments without total-system-impact assessment, most of the Departments (except for Agriculture) have some maneuvering ability in terms of seeking additional budgets to meet the costs of providing services to inmates, effectively representing unconstrained cash budgets for such departments. Such additional contingency allocations normally are not extended to TDCJAG, however. It is in that context the analyses and implications presented in this paper are developed.

representing the net value of an additional dollar available to TDCJAG. When the operating budget is decreased $1 million, an additional operating dollar is only worth $0.02 above its costs, i.e., marginal value product (MVP) is $1.02 versus a marginal input cost (MIC) of $1.00. As the operating budget of Agriculture is decreased further, the net marginal value of operating funds rises until it reaches $0.98 at the assessed $10 million reduction in funds.

Assuming an opportunity cost on the State's use of money at the State's bond rate of 4.6 percent suggest that decreasing the operating money available to the Agriculture department by $1 million could be economically justified, i.e., the MVP of $0.02 is less than the MIC of $0.046. However, decreasing the operating budget by $2 million does not appear economical. The shadow price (MVP) at the $2 million decrease is $0.12, meaning that at the margin, an additional dollar of operating funds is generating a net $0.12 of either revenues and/or cost savings, substantially exceeding its $.046 cost (MIC). This study suggests there is a breakeven point of acceptable budget cuts below the current budget somewhere between $1 and $2 million in terms of overall TDCJ system impact.

In evaluating what happens to levels of the different enterprises as the operating money available to the Agriculture Department is decreased, it is important to understand the accounting system of TDCJ. This system determines the costs that come out of TDCJAG's operating budget and those that are passed on to another department. In this analysis, only the operating budget of TDCJAG was limited. The other departments were allowed to use as much operating money as they needed. TDCJAG bears the cost of producing all of the agriculture products. It also bears the cost of purchasing the beef and pork products required. The cost of purchasing other meat products as well as any canned goods is charged against the Food Services department

budget. The transportation costs are incurred by the Transportation department. The cost of buying lint and broomcorn is incurred by the Industry department. As the operating money available to TDCJAG is reduced, costs are shifted from TDCJAG to other departments.[6] As a consequence, as illustrated in this paper, it is not apparent that the budget cuts on an individual-department basis are automatically cost effective.

Table 2 is a presentation of the solutions and operating levels of the different enterprises for the base budget and several reduced levels of the operating budget of TDCJAG. The enterprise most sensitive to budget cuts is cattle. This result is somewhat intriguing in that the cattle enterprise, unlike most others, is not linked to other enterprises nor does it provide meat products for feeding inmates. It just uses operating money, resources, and generates revenue through the sale of calves and cull animals. The number of cows consistently decreases as the operating money is decreased, however. This decreases the demand for feed and pasture, reducing operating expenditures. Initially at the $1 and $2 million decreases in the operating budget available to TDCJAG, the amount of feed mixed rises slightly. This is because feed for Security horses and dogs that was marginally less expensive to purchase than to produce is mixed by TDCJAG when cash is constrained. The big decreases in the feed mixed by TDCJAG (reflecting the decrease in the demand for cattle feed) are seen, however, at the $5 and $10 million levels of decreases in the operating budget.

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[6]   Such a budgeting allocation system obviously creates incentives for TDCJAG to react to budget cuts by first reducing and/or eliminating those enterprise activities which require considerable cash and for which it is perceived Agriculture receives little credit, e.g., cotton lint produced for the Industry department. It is apparent that a budgeting allocation system and associated management decisions related to production levels of individual enterprises should be coordinated across departments, taking into consideration system-wide impacts, as opposed to being left to independent decisionmaking on a department-by-department basis.

The level of the several field crops grown remain relatively constant at the $1 and $2 million reduction levels in the operating budget. They drop off at the $5 and $10 million decreases, particularly with respect to the lesser amount of grain crops associated with the decline in feed requirements resulting from reductions in the cattle enterprise.

The poultry enterprise occurs at the same level for all budgets. The swine enterprise raises fed hogs that can either be killed or sent to the packing plant. The size of the swine enterprise remains the same at 3,170 sows until operating funds are decreased by $10 million, at which point it drops off to 2,277 sows. What happens to the fed hogs, however, changes dramatically. Initially, most of the fed hogs are sold, with only 1,691 sent to the packing plant. The packing plant can slaughter the fed hogs or buy pork trim and produce pork products needed by the diet. Under base assumptions, it is marginally more economical to sell the fed hogs and buy pork trim and other pork products.[7] As the operating money is decreased, however, more fed hogs are sent to the packing plant, reducing the need for operating funds to buy pork trim and finished pork products. That is, feeding and processing hogs are more efficient uses of limited cash monies than is producing hogs to sell and purchasing pork products.

The meat produced at the Michael's Packing Plant increases as the operating budget becomes more constrained. In Table 3, the cost of operating the packing plant includes both the variable costs and the cost of buying trim. Even though production increased at the packing plants, the packing plant costs decreases. This is due to the decrease in the need for pork trim. Substitution between some beef and pork products is allowed in satisfying inmates' diet requirements. Food Services allows such substitutions in its diet menu to facilitate Agriculture

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[7]   Both such purchases are demands on the Agriculture department operating budget.

being better able to use a whole hog in an efficient manner. For example, polish sausage which requires pork trim can be substituted for pork roast. As more hogs are sent to the packing plant, more pork roasts are available and the need to purchase pork trim for polish sausage is decreased.

The Clements Packing Plant produces beef products. It buys beef trim and does not slaughter any live animals. Initially, the Clements Packing Plant is operating at capacity and remains at capacity until the operating budget is decreased by $10 million. At that point, its production decreases slightly. This is because some pork products produced at the Michael Packing Plant are substituted for beef products that would have been produced at the Clements Packing Plant. Such substitution reduces the need to use operating funds to buy beef trim

The remaining enterprises include vegetable production and the cannery. They both produce goods that can be used in the diet to satisfy the requirement for side items in the dietary menus. Whatever is not produced by these enterprises must be purchased by the Food Services department, with the exception of Irish potatoes which are purchased as a fresh vegetable by TDCJAG. Purchases by Food Services do not come out of the TDCJAG budget. As the operating funds available are reduced, vegetable production remains fairly constant until the operating budget is reduced by $10 million. At that point, vegetable production drops considerably. In contrast, cannery production drops steadily as the operating budget is decreased. The purchase of vegetables for use at the cannery decreases consistent with the decrease in cannery production as does the variable cost of the cannery (Table 3). This shows that the first side items shifted to the Food Services department are the most expensive, those where fresh vegetables are purchased for use by the cannery. The variable cost of vegetable production stays about the same or decreases in all but one case—when the operating funds decrease by $5 million,

vegetable production actually increases. This result is associated with Irish potatoes. Since Irish potatoes must be purchased by the TDCJAG if they are not grown, production increases so purchases can decrease.

Concluding Comments

This study investigated the effects of decreases in the operating budget available to the TDCJAG. It was found that the annual operating budget of TDCJAG could be economically reduced by a million dollars, but reductions of $2 million or more are detrimental to the overall economics of the total TDCJ system. As the operating money available to the TDCJAG decreased, expenses were shifted from the TDCJAG to other departments within TDCJ. Food Services had to increase purchase of canned goods to satisfy the dietary requirements as fresh vegetable production and canned vegetable processing were reduced. The TDCJAG also shifted production away from enterprises that provided revenue to ones that produced something needed by another enterprise. This reduced the revenue generated and increased the need for outside purchases. The results found here may be typical of what happens in State agencies and commercial businesses as operating budgets are decreased for an individual Agency or department basis as opposed to considering the comprehensive consequences. That is, the agencies (departments) shift costs to other agencies (departments), increasing the overall cost to the State or business.

This study found that a comprehensive systems model is able to capture the inter-linkages between the various enterprises. It was also able to answer questions about the effects of reducing the operating budget of one or more departments. This study also highlighted the need

to consider the potential management decisions that could result to shift in costs from one department to another. The systems model used here proved a useful tool for managers to consider the effects and responses to constrained financing.

External Sales

Buy From External Sources

Regional Farm Unit Production

- Field Crops
- Vegetables
- Livestock

Processing Plants

- Cannery
- Meat Packing
- Cotton Gin
- Dehydration
- Egg Processing
- Feed Mill

Warehouses

Food Consumption in Unit Kitchens

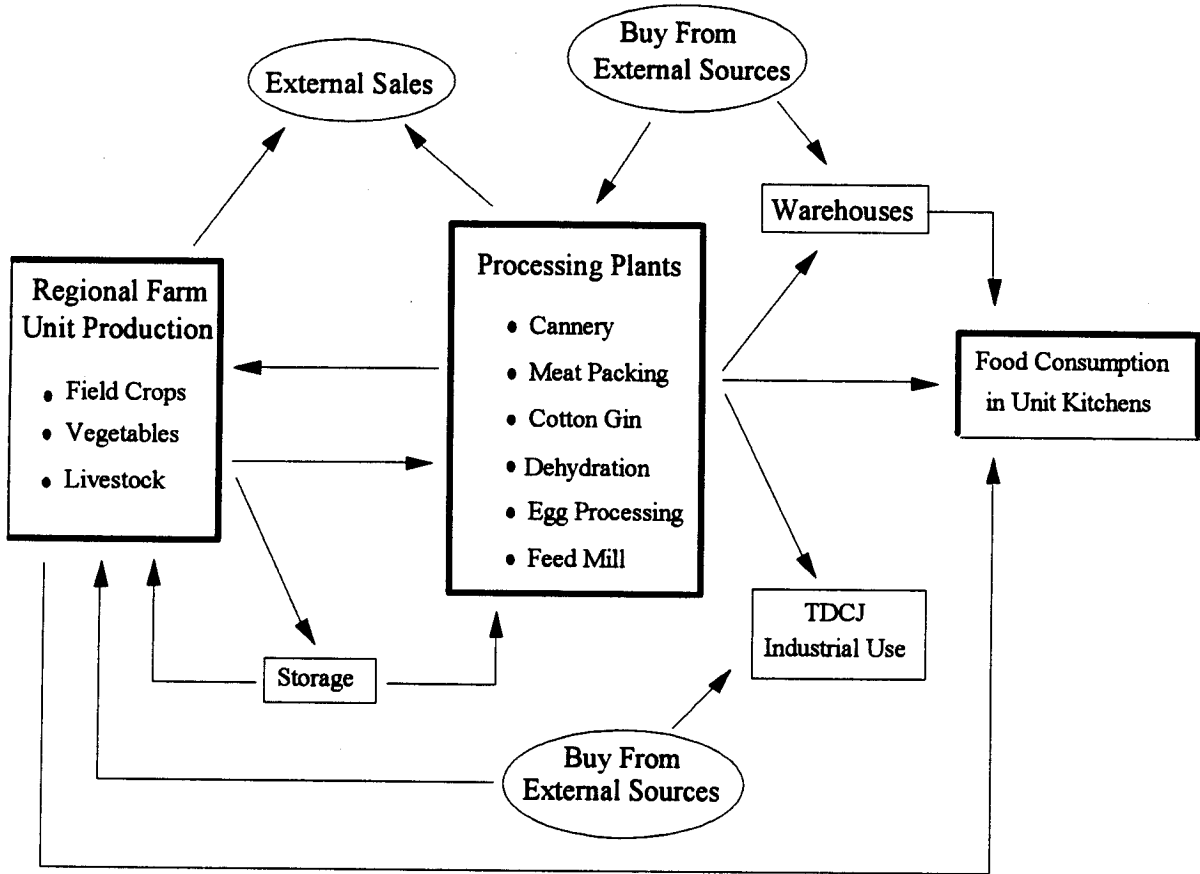**Storage**

TDCJ Industrial Use

Buy From External Sources

Figure 1. Scope of TDCJ Agricultural Operations, 1997.

Table 1: General Linear Programming Model.

	Produce Crop	Produce Forage	Produce Vegetable	Produce Livestock	Feed Mixing	Meat Packing	Cannery Production	Sell Goods	Buy goods	Cons Raw Vegetable	Cons Can Vegetable	Internal Shipping & Storage	
Objective Function	-	-	-	-	-	-	-	+	-				Maximize
Crop Balance	-			+	+			+	-			m	<=0
Forage Balance		-		+	+				-				<=0
Feed Balance				+	-				-			m	<=0
Final Livestock				-		+		+	-			m	<=0
Intermed. Livestock				m			+		-			m	<=0
Raw Vegetable Bal			-				-		-	+		m	<=0
Canned Veg Bal							+				+		<=0
Dietary Veg. Req.									-	-	-		<= -Vegetable Required
Dietary Meat Req.						-			-				<= -Meat Required
Crop Land	+		+										<=Land Available
Labor	+	+	+	+	+	+	+						<=Labor Available
Forage Land		+	+	+		+	+						<=Pasture Available
Capacity	+	+	+	+		+	+					+	<= Equipment Capacity
Operating Budget	+	+	+	+	+	+	+		+			+	<=Budget Available

* This includes processing dehydrated alfalfa and ginning cotton.

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Table 2.   Summary of operations when the operating funds available to TDCJ Agriculture are reduced.

Item	Units	Operating Budget Level				
		Base	-1 million	-2 million	-5 million	-10 million
Objective Function	$	-33,220,845	-33,236,838	-33,282,535	-34,014,487	-37,484,192
Operating Budget Shadow Price	$	n/a	.02	.12	.40	.98
Planted crops	Acres	38,555	38,521	38,633	34,874	28,427
Pasture	Acres	50,483	50,481	50,450	31,602	
Planted vegetables	Acres	6,738	6,771	6,451	6,888	4,630
Cows	Head	12,774	12,756	12,458	5,685	
Hens	Head	193,575	193,575	193,575	193,575	193,575
Sows	Head	3,170	3,170	3,170	3,170	2,277
Slaughtered hogs	Head	1,691	8,286	9,910	9,910	25,528
Pork Processed	Pounds	4,774,629	5,323,334	5,458,494	5,458,494	5,901,178
Beef Processed	Pounds	10,000,000	10,000,000	10,000,000	10,000,000	9,764,708
Meat Bought	Pounds	1,000,807	605,124	507,657	507,657	453,359
Canned Vegetables	Cases	501,280	501,280	453,385	425,531	177,797
Feed Mixed	Tons	42,663	42,827	43,217	38,227	26,807
Garbage Disposed	Tons	41,823	41,823	41,806	41,769	41,605

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Table 3. The use of operating funds by TDCJ Agriculture.

Activity	Operating Budget Level				
	Base	-1 million	-2 million	-5 million	-10 million
Crop VC	4,658,851	4,653,262	4,639,135	3,533,523	2,552,726
Vegetable VC	953,285	958,324	933,151	1,065,061	742,404
Cannery VC	2,111,797	2,110,797	1,910,417	1,793,887	727,337
Machinery operating VC	46,309	46,309	44,980	10,605	10,605
Buy Commodities	1,049,425	821,754	522,337	489,537	387,518
Buy Livestock	374,567	374,567	374,567	374,567	374,567
Buy Meat	1,495,263	877,999	725,950	725,950	648,303
Buy Vegetables	1,222,846	1,203,982	959,209	11,852	0
Storage Rent	10,645	22,321	31,717	22,484	6,220
Storage VC	6,482	7,223	8,294	8,898	8,393
Livestock VC	1,011,870	1,011,188	999,294	730,088	418,472
Pack Plant VC	9,812,804	9,666,507	9,630,470	9,630,470	8,601,038
Ginning VC	290,895	290,895	289,712	252,408	202,821
Dehydrator VC	22,308	22,308	22,308	22,309	18,943
Feed VC	3,548,788	3,547,700	3,523,593	2,943,496	1,915,789
Egg Processing	996	996	996	996	996
Minor Vegetables	215,418	215,418	215,418	215,418	215,418
Total	26,831,550	25,831,550	24,831,550	21,831,550	16,831,550

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