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A Methodology for Measuring Benefits of Integrated Rural Development Projects

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Food shortages underscore the necessity to stimulate agricultural output in developing countries. Other countries can make up food deficits in the short run, but collectively these countries have to increase their own production in order to maintain projected population levels.

Although increasing agricultural production has been the goal of governments of developing countries and international assistance programs progress has been slow. While each country and region is unique, agriculture development programs would be facilitated if essential factors for development can be identified and their affects on production measured. Knowing these relationships could assist policy makers identify key factors and to evaluate the development impact of alternative policies.

In recent years some efforts of international agencies have taken the form of regional integrated (multi-component) rural development projects. These projects are often characterized by regional investment in various public infrastructure components such as roads, credit, technical assistance, and marketing centers. Although the integrated rural development projects are capital intensive requiring large investments, there is limited emperical evidence on the development impact of the components either individually or collectively.

The purpose of this paper is to present methodology which could assist in the empirical measurement of hypothesized relationships which are assumed to underlie the development process. The primary focus is the agricultural

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infrastructure and its relationship to development. The premise is that a minimum infrastructure is necessary to stimulate and maintain development. If a favorable economic environment is created farmers will be motivated to make decisions resulting in capital accumulation and increased output at the farm level. Application of the methodology is demonstrated using data collected in Colombia.

Data Source

Data used to test the methodology were obtained from a 1968 farm-level survey of farmers in the Caqueta Colonization Project of the Colombian Agrarian Reform Institute (INCORA). The objective of the Caqueta project was to encourage regional development in a sparsely settled jungle region of Southern Colombia by providing roads, credit, technical assistance, market centers, and health-education facilities.

Average farm size in the region was about 70 hectares and colonists had been on their farms an average of seven years. During this period the average amount of credit received per farm was about 27,000 pesos and the colonists received an average 2.5 technical assistance visits from a credit supervisor the year prior to the survey.

Most credit was used to establish a cattle enterprise. Improved pasture was usually planted after a harvest of corn or rice which was marketed and also consumed on the farm. When the colonists began farming they had improved pasture and cattle valued at $82,000 pesos (1968 prices) per farm. At the time of the survey (seven years later) they had cattle and improved pastures valued at $282,000 pesos (1968 prices) per farm, an increase of 200,000 pesos. The model was used to identify the extent to which farm level development as represented by the cattle enterprise was associated with specific infrastructure services such as roads, credit, and technical assistance.

Development Model

The basis of the methodology is a regression model which utilizes farm level data. The purpose is to demonstrate or predict how infrastructure components impact on farms. The basic challenge was to select and measure independent variables which represent the availability of infrastructure services at the farm level.

Basic influences hypothesized to affect farm level development in the model were:credit, technical assistance, roads, market centers, number of years the farmer had used credit, length of time on the farm, farm size, and education of farmer. The formulation of the model and definition of the specific independent variables are shown: 1/

$$DF = a_1 + b_1C + b_2I + b_3IC + b_4YC - b_5C^2 - b_6I^2 - b_7K\log A - b_8M\log A + b_9H\log A + b_{10}E\log A$$

where:

DF = Farm Development Index

a_1 = Constant

C = Total Credit Received by Farmer

I = Number of Credit Supervisor Visits in 1968

Y = Average Weighted Years with Credit

K = Kilometers from Farm to Road

A = Number of Years on Farm

M = Kilometers from Trail-Road Junction to Market Service Center

H = Total Hectares in Farm

E = Years of Education of farmer

1/ Peter E. Hildebrand collaborated in development and testing of the model.

Credit and technical assistance were hypothesized to have positive effects on development. The credit influence was measured in terms of the total value of loans (C) received in constant pesos from all sources while on the farm. Technical assistance was measured by the number of annual visits (I) the farmer received from the extension agents (credit supervisors). Credit and technical assistance were hypothesized to have both independent and joint affects on development and an interaction term was included in the model (IC). Because farmers that had credit for long time periods would be more developed, the weighted average years with credit (Y) was also included as an interaction term in the model (YC).

The influence of roads and market centers at the farm level were measured by distance from the farm. Because farms closer to roads and markets have more access to these services it was hypothesized that such farms would develop at faster rates. Hence, inverse relationships between distance and development were expected. The "road" variable (K) was the distance between the farm and road, and the "market" variable (M) was the distance between the market and the point the farm trail joined the road. Because both the road and market influences were assumed to increase over time, years on the farm (A) was included as an interaction term with each of these variables.

Over time development at the farm level reaches a maximum as farm capacity is reached. Because farm size (H) is an important determinant of capacity it was hypothesized to be positively related with development. Farm size was included as an interaction term with number of years on the farm to depict development over time.

Education of the farmer was assumed to be an important factor positively related to development. Education was measured in terms of number of years of schooling (E) attained by the farmer. The average number of years was 2. Education was included as an interaction term with years on the farm (A).

Findings

The general model was tested using six different development indices as a dependent variable. The independent variables and model formulation were identical in each case. The dependent variables used to measure production potential were measures of farm capital which were closely associated with production levels and agricultural development. Because cattle production was the dominant agricultural enterprise in the region the following dependent variables were used: (1) value of cattle, (2) value of pasture, (3) value of cattle and pasture, (4) change in capital value of cattle, (5) change in capital value of pasture, and (6) change in capital value of cattle and pasture.

Forty to 64 percent of the variation in the dependent variables were explained by the independent variables in the models (table 1). In general, the analysis indicated that credit, roads, technical assistance, and market centers have positive influences on farm-level development as represented by farm capital accumulation. The effect of education on development was not consistent, possibly because of the low educational levels of the farmers. Farm size, an important noninfrastructural variable was positively associated with capital accumulation.

Credit Impact

The relationship between credit and development are illustrated in figure 1 using equations I.1, I.2, and I.3 from table 1. The capital value of cattle and improved pasture for alternative credit levels for a typical farm is shown. The curves may underestimate impacts of credit since they do not show the impact of these credit levels on annual income or on other capital items such as native pasture, corrals, fencing, hogs, mules, etc.

The relationship depicted in figure 1 is for a 70 hectare farm located 8 kilometers from a road and 14 kilometers from a marketing cooperative. Furthermore the colonist was assumed to have 2 years of education, credit was outstanding an average of 3 years, and the farmer had received three

TABLE 1(

INFRASTRUCTURAL DEVELOPMENT MODEL I: INDEPENDENT VARIABLES, COEFFICIENTS, DERIVED FROM REGRESSION ANALYSIS OF 132 FARM UNITS FROM CAQUETA INFRASTRUCTURE SURVEY

equation number	dependent variable b/	constant	Independent Variables a/										R^2
			C	I	IC	YC	C^2	I^2	KlogA	MlogA	HlogA	ElogA	
I.1	DF_1	2.24	.024**	1.533**	.00183	.00270**	-.000009	-.051**	-.697**	-.648**	.242**	.754	.60
			(.00017) c/	(.7298)	(.000005)	(.000002)	(.000000)	(.00066)	(.0512)	(.0488)	(.0012)	(.7637)	
I.2	DF_2	-3.14	.029**	.931	.00235	-.00047	-.000018**	-.066**	-.573**	-.256	.340**	-.452	.57
			(.00019)	(.8466)	(.000005)	(.000002)	(.000000)	(.00077)	(.0594)	(.0566)	(.0014)	(.8858)	
I.3	DF_3	-.90	.054**	2.464*	.00419	.00223	-.000027**	-.117**	-1.270**	-.904**	.582**	.301	.64
			(.00052)	(2.2892)	(.000015)	(.000005)	(.000000)	(.00208)	(.1606)	(.1531)	(.0037)	(2.3951)	
I.4	DF_4	.13	.023*	1.333*	.00313*	.00352**	-.000011*	-.063**	-.516**	-.780**	.227**	1.526*	.58
			(.00020)	(.8625)	(.000005)	(.000002)	(.000000)	(.00079)	(.0605)	(.0577)	(.0014)	(.9024)	
I.5	DF_5	2.96	.018*	-.503	.00886**	.00174*	-.000029**	-.127**	.043	.221	.142**	-1.83**	.40
			(.00018)	(.7983)	(.000005)	(.000002)	(.000000)	(.00073)	(.0560)	(.0534)	(.0013)	(.8353)	
I.6	DF_6	3.1	.040*	.830	.01199**	.00525**	-.000040**	-.190**	-.473	-.558*	.369**	-.306	.56
			(.00052)	(2.2819)	(.000015)	(.000005)	(.000000)	(.00207)	(.1600)	(.1527)	(.0037)	(2.3875)	

*Significant at 80% level, one-tail test

**Significant at 90% level

a/ The independent variables are:

C: total credit received ($100)
I: number of INCORA Credit Supervisor visits, 1968
Y: average weighted years with credit
A: number of years on farm
K: kilometers from farm to road
M: kilometers from trail-road junction to INCORA market-service center
H: hectares in farm
E: years of education

b/ The dependent variables are:

DF_1 = capital value of cattle ($1000)
DF_2 = capital value of improved pasture ($1000)
DF_3 = capital value of cattle and improved pasture ($1000)
DF_4 = change in capital value of cattle ($1000)
DF_5 = change in capital value of improved pasture ($1000)
DF_6 = change in capital value of cattle and improved pasture ($1000)

c/ The variance of the coefficients are in parenthesis.

NOTE: All money values are in Colombia Pesos (1968)

Source:

Feaster, J. Gerald, An Analysis of the Relationship between Infrastructure and Agricultural Development in Caqueta, Colombia, Ph.D. dissertation, University of Kentucky, 1970.

supervisor visits during the past year. The capital values for selected credit levels are shown in table 2.

Table 2--Relationship between credit and selected development Indices, Caqueta Colonization Zones, 1968

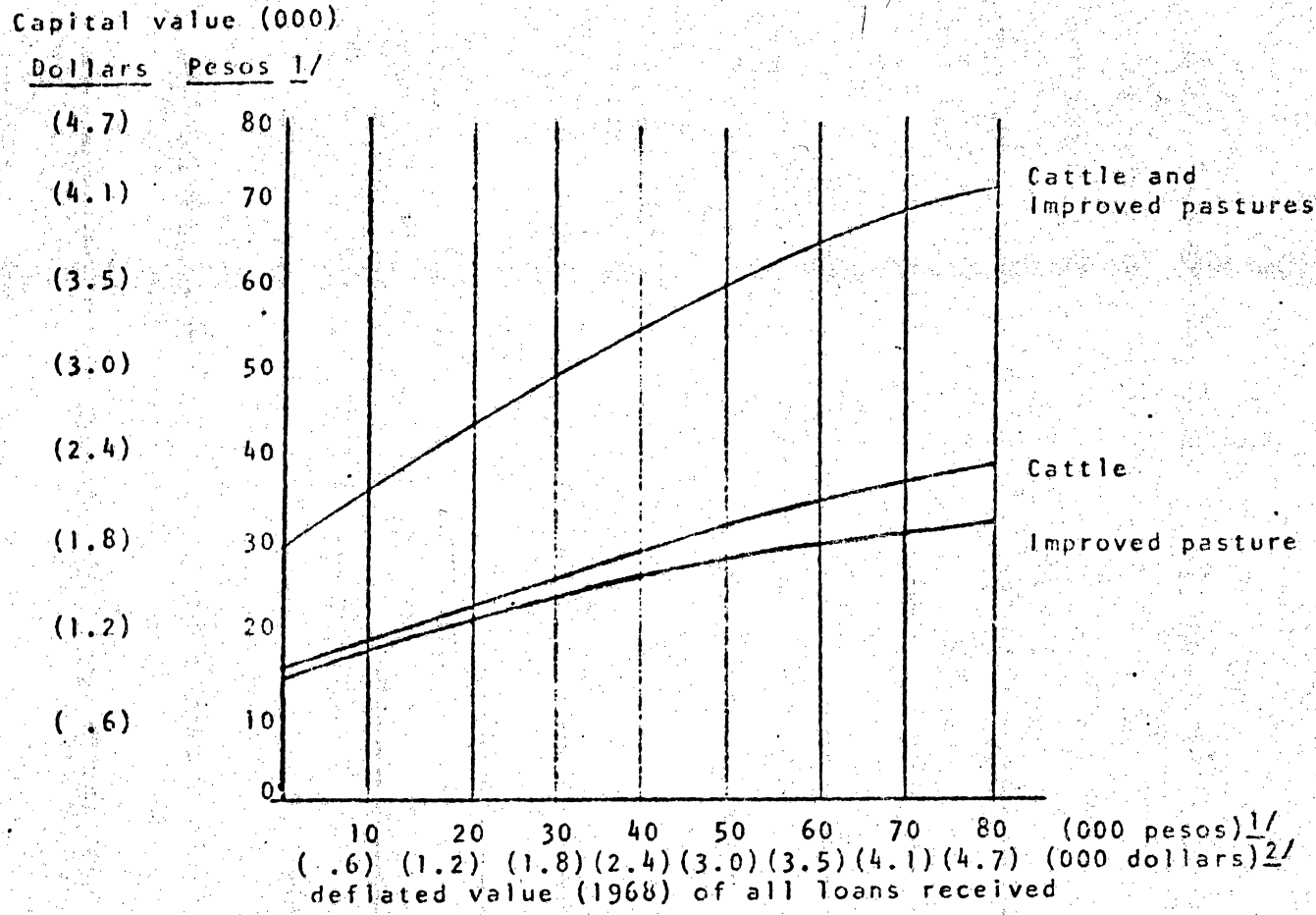
Total credit received	Cattle (value)	Improved pasture (value)	Cattle & improved pasture (value)
	1968 pesos		
0	14,500 ($ 860) 1/	14,000 ($ 830)	28,500 ($1,680)
20,000 ($1,180)	21,600 ($1,270)	20,200 ($1,190)	41,800 ($2,460)
40,000 ($2,360)	28,000 ($1,660)	24,900 ($1,470)	53,000 ($3,130)
60,000 ($3,540)	33,800 ($1,990)	28,300 ($1,670)	62,100 ($3,600)

1/ Dollar equivalent. Source: table 1.

In the model it was hypothesized that technical assistance increased the effectiveness of credit. This relationship was represented by an interaction term (IC) combining credit received and number of visits from an extension agent during the year. If the number of extension visits were increased the curve would shift upward, illustrating both the direct effect of technical assistance on development and its interaction with credit.

Road Impact

The findings generally support the hypothesis that farms closer to a road develop at a faster rate than farms farther away. It was hypothesized that road benefits increase over time. This was represented by an interaction term in the equation (K log A). Using coefficients



1/ Constant pesos (1968 = 100).
2/ Dollar equivalent.

Figure 1--Relationship between total credit received and capital value of improved pasture and cattle, Caqueta, Colombia, 1968/69

Source: Table 1

coefficients in table 1, road benefits are illustrated in table 3 for various years. These values show the effect on farm development of being 1 kilometer closer to a road for selected years. For example, in equation I.3 the benefit of being an additional kilometer closer to a road is approximately $900 pesos the 5th year and increases to about $1,500 pesos after 15 years.

Table 3--Increase in farm capital per kilometer of reduction in distance between farm and road, selected years.

Equation number	Dependent variable	Year: 5	10	15	20
		pesos			
I.1	Value of cattle	487	697	820	907
I.2	Value of pasture	573	573	674	745
I.3	Value of cattle & pasture	888	1,270	1,494	1,652
I.4	Change in Value of cattle	261	516	607	671

Source: Table 1.

The relationship between roads and development is also shown in figure 2. This figure shows changes in value of cattle and distance to a road for a 10-year development period for alternative levels of credit and technical assistance. 3/ Case I illustrates a situation with no credit or technical assistance and Case II shows average credit and technical assistance levels.

3/ The curve is based on equation 1.4 in table 1. The value of the other independent variables in the equation are as follows: M = 6; M = 70; E = 2; A = 10 and Y = 5.

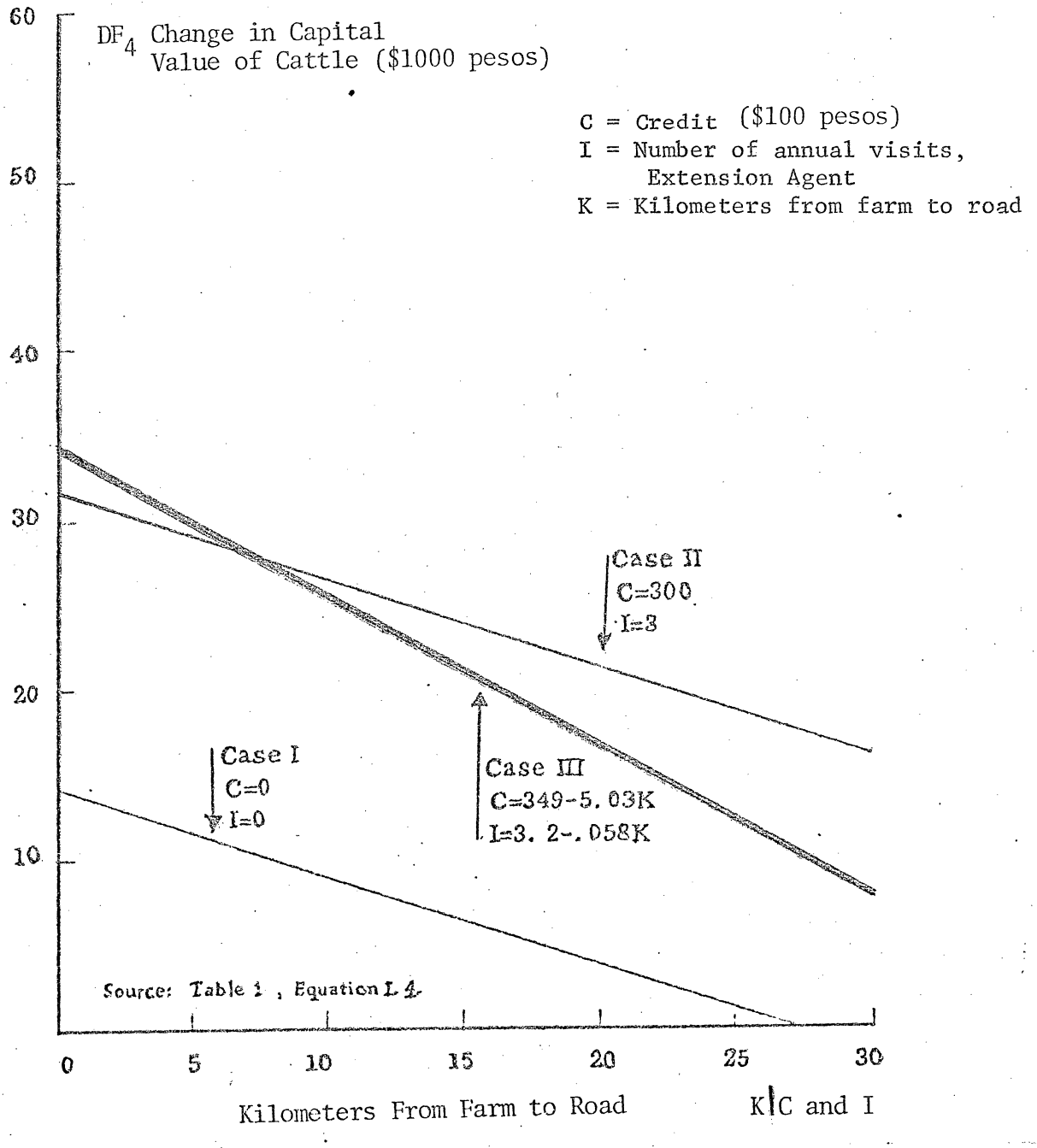


Figure 2 .--Relationship Between Distance to a Road and Development, Given Alternative Levels of Credit and Technical Assistance.

In Case III, both technical assistance and credit are functions of distance to the road. Distance-credit and distance-technical assistance relationships were derived from survey data. The equations used are:

$$I = 3.2 - .058K \quad (t = 1.4) \quad A$$

$$C = 349 - 5.03K \quad (t = 1.7) \quad B$$

Where:

I = number of annual visits from extension agent

C = total credit received

K = kilometers from farm to road

Although equations A and B were not highly significant statistically, they were substituted for the respective I and C terms in Equation I.4 (table 1) for illustrative purposes. In comparison with Case II (average credit and average technical assistance), farms near the road in Case III are more developed than farms farther from the road. The curve in Case III reflects the utilization of more credit and more technical assistance by farms near the road in addition to other advantages related to increased accessibility, such as lower transport costs.

Implications

The model generally supported the hypothesized relationships between infrastructure and development. The results indicate that the model could be useful in evaluating impacts of integrated rural development projects and for projecting impacts of alternative infrastructure investments.

An advantage of the model is that it measures the impact of key variables (e.g., roads, credit, technical assistance) affecting development which can be altered by policy makers in developing countries. The model can be applied in most developing countries or regions because it is comprised of independent variables that are common to most farm situations and

can be obtained through farm surveys. Also additional independent variables can be added to the model to account for other important factors affecting development such as irrigation water. The dependent variables in the model are forms of development indices which can be specified in terms of farm capital and/or annual production for different types of farming operations such as crops or livestock.

The model can be used to estimate benefits occurring to typical farms in a region. These estimates can also be aggregated to estimate regional benefits which can be compared to the cost of the integrated rural development project at various points in time which is information that should be of particular value to policymakers.