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ON THE STATISTICAL PROBLEMS OF ESTABLISHING ECONOMIC MEASURES OF NATURAL RESOURCES[1]

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INTRODUCTION

Information on the nature of supply of natural resources and demand for natural resources is vital in economic development planning. The effects of limitations of natural resources on the progress and composition of economic development of the country and prospects for the future are important knowledge of decision makers, economists and other social scientists. Presentation of such information has, in the past, been handicapped by lack of consistent and readily available data and appropriate statistical techniques. There was tremendous volume of statistical information but much of it was scattered and contradictory. There is also a considerable number of appropriate statistical techniques but they are untried and are not studied[2].

The widely accepted doctrine that the continuously increasing use and development of natural resources have a tendency to impair the nation's power and reduce the future standard of living of the people indicates the necessity of presenting such pieces of information in readily available forms. Counter

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arguments, however, state that modern technology can overcome the increasing shortages of natural resources, ad infinitum[2].

It is not possible to resolve such controversy with statistics, but it is hoped that the proper statistical analysis and measures will enable the user to have better insight than has been possible and will avail him with the basic knowledge needed for the consideration of a multitude of problems related to natural resources.

1. **The Basic Problem: Statistics are indirect measures.** The basic problem of the statistical analysis of time series data of natural resources is that these data do not measure natural resources, e.g., land, water, mineral resources, etc. directly but measure their products. Another problem encountered in the analysis of natural resources data is that natural resources are parts of the earth's crust and statistics of natural resources reflect only the changing knowledge of the location, utility, technology of extraction, cultivation, transportation and processing of natural resource materials. Besides, the magnitude of errors of measurements may be large and statistics on natural resources reserves are beyond the margin of economic significance. Thus data on the economic products of natural resources are more useful than those on the resources as such[2].

For example in the classic economic theory "pure rent of land" is a direct measure of the value of natural resource contribution to the value of products. However, "pure rent of land" is only a theoretical construct and statistics are almost wholly lacking. Furthermore, rent of land, even in theory, represents the excess of its productivity over that of marginal land and this in turn depends on technology, transportation, location of population, etc. Pure rent aggregates would represent the chance concurrences of these factors and the chance sizes of differentials among different kinds of land.

2. **Utility Requirement of Natural Resource Data.** The most useful data on natural resources are those data on products

of natural resources. Such data reflect the effects of human knowledge and technology. Price statistics on products of natural resources reflect heavily values added by labor and enterprise. For example, on the value of iron, man has added values through exploration, discovery, mining, concentration and refining before the material reaches a stage at which it can be meaningfully priced. In the case of rice man has contributed values through breeding, clearing, land improvements, plant husbandry and harvesting. As a result the prices of inputs such as labor, capital, fuels, etc, are important in the analysis of natural resource price series.

Quantity series of natural resources is important in the determination of quantity available for future use and in evaluating scarce resources. However, scarcity is relative to population. If the population doubles, scarcity doubles. Any mineral ore that is used becomes scarcer than before it was used. If factors like developing technology, transportation, etc. are ignored, Malthusian conclusions are inevitable. Many predictions of calamity in relating resources to population stem from over-simplified assumptions on the availability of natural resources.

STATISTICAL PROBLEMS OF THE COLLECTION OF NATURAL RESOURCES DATA

3. **Fishery Statistics.** Data on commercial fisheries production are compiled by the Bureau of Fisheries (now Fishery Commission) on the basis of the reports on the amount of fish caught monthly by commercial fishing vessels. Fishpond production is estimated on the basis of the area of fishpond in operation and a fixed average annual yield per hectare of fishpond. For estimating production from municipal fisheries and sustenance fishing as well as for miscellaneous fishery products, the monthly reports of Municipal Treasurers and Fishery District Officers are used[9].

the case of most large game species under most conditions, the observer in the airplane cannot see all the animals, so the count obtained is somewhat less than the number of animals present there.

In addition to the quadrat method, wild life biologists use many other sampling methods such as strip censuses, roadside counts, flushing counts, etc.

(b) **The indirect count.** Since it is impossible to obtain accurate visual counts of many species of animals, much use has been made of indirect signs, the abundance of which may be related to the size of the animal population. These indirect signs include a multitude, there are the numbers of shed antlers, doe's tracks, drumming sites, mating or other calls, or amount of food consumed. All these are of value, but it may be difficult to compare the signs from one period to another unless their natural variations are considered. Yet, in the case of secretive, timid or nocturnal animals, the indirect counts may be all the investigator may have a contribution toward a population estimate. Occasionally, wildlife biologists have used the Raunkiaer method. Instead of counting all the animals or animal signs in a quadrat, the investigator records the presence or absence of the species there.

(c) **Notion of effort.** Total kill of animals such as total catch of fish are not representative of any fluctuations in the abundance. Often the catch has increased because more effort was expended and new and more distant grounds were exploited.

As a measure of the population size, the catch per unit effort has been used with considerable success. It is common experience that, as a population becomes depleted, the return from a given amount of sampling effort declines. Any attempt at exploiting this empirical fact for the purpose of estimating population size requires a definition of a unit of effort and some facts or assumptions about the manner in which the members of the population respond to the effort.

Many possible assumptions might be entertained regarding the response of the population to whatever effort is applied. The only one to receive much attention up to the present time is that a unit of effort takes a fixed proportion of the population, apart from a sampling error. This is of course the simplest assumption that can be made and seems, as a side, to be received with disfavor by biologists, apparently on the ground that the effectiveness of a unit of effort varies widely from day to day. This may be granted, but it seems preferable to treat fluctuations of this sort as error rather than to try to formulate involved assumptions to account for them. The constancy assumed is then equivalent to absence of persistent trend during the sampling period.

If this assumption holds and if, further, the population is closed, then the catch per unit effort is linearly related to the accumulated catch. Specifically if $c_1, c_2, \ldots, c_t, \ldots$ are the catches made during a number of consecutive intervals and if $w_1, w_2, \ldots, w_t, \ldots$ are the efforts expended in making them, we can calculate, for each interval, the catch per unit effort $C_t = \frac{c_t}{w_t}$ and the accumulated catch $K_t - c_1 + c_2 \div \ldots + c_{t-1}$. It follows from the definition that $\gamma_t = kN_t$ where k called here the "catchability" stands for the constant proportion taken by a unit of effort. If the amounts of effort w_t vary from one time to another, this relation requires that the various units of effort shall not compete with one another, an important restriction on the sampling procedure. Clearly, also $N_t = N_1 - K_t$, it follows that

$$\gamma_t = kN_1 - kK_t$$

Methods employing the notion of effort to make estimates of population size have been used so infrequently that little is known about those features of the behaviour of a population that may interfere with their successful operation.

(d) **Tagging.** The tagging technique is a valuable method of population estimation and is being used on an increasing scale. The principles of the method are rather simple. A number of animals are caught and marked in some manner. They are then released in the area from which they were taken. Later, more animals are caught and the ratio between the number of marked and unmarked animals affords an estimate of the population. A figure for the population of animals in the following formula:

$$p = \frac{nh}{r}$$

where p is population, n is the number of tagged animals, h is the number caught, and r is the number of tagged ones recaptured.

Assumptions to be met for the population estimates to approach their true values:

1. Mortality is the same among marked and unmarked animals. There may be increased mortality among the marked animals because of injuries received in capture, confinement, or handling.

2. The marked individuals do not lose their marks.

3. The marked individuals are caught at the same rate as the unmarked ones.

4. The marked animals are randomly mixed with the unmarked.

5. All marks are recognized and returned to the investigator.

6. There is only an insignificant amount of recruitment to the catchable population during the time the recoveries are being made[3].

A variant of Petusen type of tagging plan is described as follows: Suppose that a number X_t of tagged individuals are released at time t and recaptures of them recorded at times

$t + 1$, $t + 2$, ... The sequence of sample rations X_{t+1} / n_{t+1}, X_{t+2} / n_{t+2} ... decreases according to the rate of recruitment.

Consider now numbers of tagged individuals X_{t-1} X_{t-2} ..., released at times t - 1, t - 2, ... and sampled at time t. The sequence of sample ratios $X'_{t-1} / n_{t.}$ $X'_{t-2} / n_{t.}$ .... where X'_{t-1} stands for the number of tagged individuals released at time t - 1, taken in the sample at time t, does not reflect the effects of recruitment but does contain information on the mortality rate.

4. **Forestry Statistics.** The vegetative cover map for each province is updated every now and then by the district forester assigned to the province. This vegetative cover map is also checked with the latest information of the Domain Use Division of the Bureau of Forestry. Estimates of mass of timber are based on valuation surveys conducted by the Bureau of Forestry. These valuation surveys covered the entire Philippines, embracing all categories of forests (forest reserves, national parks, communal forests, proclaimed timberlands and unclassified public forests). An area of about 14,000 kilometers was covered and strips of 20 meters wide were used[9].

Foresters engaged in cruising and ground mapping do not favor doing an appreciable amount of extra work for the sole purpose of providing a valid basis for computing sampling error. Many feel that it should be possible for statisticians to devise satisfactory methods for evaluating the sampling error of systematic surveys.

In an analysis of variance study, it was observed that within a stratum, correlation with place generally exists; strips or plots that are close together vary less than strips or plots that are farther apart. Hasel (1938) conducted a variance analysis of nine sections of complete inventory data for an experimental forest. The nine sections were subdivided into 36 blocks of 20 x 80-chain dimensions, and for each cruise a single 2½ x 80-chain strip was taken in the same relative position in each block. With 12½% samples, eight samples included the total population, and the variance between them was

$$\sigma_s^2 = 64,868$$

The corresponding figure for a random sample, taking one strip per block and including the finite correction was found to be

$$\sigma_R^2 = 65,520$$

Another approach to the problem is to fit a curve, taking strip volume as the dependent variable and distance of strip from one side of the area as the independent variable, using terms in the polynomial up to the degree that does not reduce the residual mean square significantly at the 5% level. To test this method, forest sections were grouped into four units, in north-south tiers a mile in width and the north boundary for each unit was taken as the origin in fitting curves to represent volume trend with location. Strips in each section were numbered in order from 1 thru 32, beginning with the north strip. Strip direction was east-west. For the first systematic sample, strip numbers 4, 12, 20, and 28 were taken in each section, giving one strip in each 20 x 80 chain block. The variance of the sample total in the j-th unit was estimated by the equation

$$S_{T_2}^2 = n \frac{S^2}{2} (1 - v)^2$$

where n = number of sample strips.

Item	Sample a	Sample b
Range of number of sections in unit	1 to 3	1 to 3
Sum of sample strip volumes in 1,000 bd.ft., T_j	12,178.7	11,881.3
Standard error of T_j, ST_j	253.89	252.81
Population volume	11,752.8	11,752.8
t value	0.17	0.51
Range of number of strips in a sample in each unit	4 to 12	4 to 12

Source of data: Hasel, *Forest Inventory: From the Statistical Point of View.*

S^2 = sum of squares of differences in volume between successive sample strips (an approximation to twice the sum of squares of deviations from a polynomial of appropriate degree.

$\bar{v}$ = estimated average correlation between a sample strip and all other strips within the same block. The true standard error between eight possible 12½ per cent cruises is $\sigma_8 = 254.69$. The results of estimates from two systematic surveys are given in the above table.

In intensity, management surveys are between intensive surveys made for timber sale or purchase and extensive surveys that cover a complete region or area. Usually maps prepared from aerial pictures are available before management survey field plots are established. It is possible to vary the degree of sampling according to timber type, stand size, accessibility zone, or by other classifications. In a management survey of two German forests the following statistical analysis were obtained:

(a) Comparison of sampling accuracy of optimum and proportional allocation.

Basis	Coefficient of Variation	
	Volume	*Growth*
Optimum for volume	2.85	2.95
Proportional	3.10	2.87
Optimum for growth	3.27	2.60
Intended optimum on volume basis (Based on judgment estimate of average volume and range of volume by compartments)	3.27	3.77

The better results obtained with proportional sampling is due to the fact that optimum sampling values of the stratum sample sizes are approximate.

(b) Comparison of sample estimates with population values for six sections.

Section No.	Average Volume in 1,000 bd.ft. per Sampling Unit of 2½ Acres x_i	Population Volume per Sampling Unit i	t
3	41.79	45.21	1.01
13	42.51	43.92	0.42
14	37.38	37.23	0.04
15	33.39	35.15	0.52
23	43.36	45.17	0.53
24	43.67	48.89	1.54
Average	40.35	42.59	

Note: Variance per plot is 196.36. 16 plots were selected from a total of 256 plots.

Extensive surveys of forest resources are conducted mainly for periodic inventories and for growth prediction. For periodic inventories, the survey is to provide an estimate of the net change in volume, with the net change attributed to its components, including growth of trees that survive, mortality, volume of trees that deteriorated to the cull class, and commodity drain. Net change, in area that are not cut over during the period, is made up of (Growth of trees that survive through the period + growth on trees prior to death during the period + in growth trees that grew into growing stock size) — (Mortality + live sow timber that deteriorated to the cull class).

Commodity drain is determined by a survey of commodity production, such as lumber, veneer, pulpwood, poles, piling, etc., and by use of converting factors that allow for manufacturing waste, logging waste and other items, production figures are converted to terms of growing stock inventory. Because of difficulty in working out converting factors, measurement of drain is based on stump-diameter tally of cut trees.

Growth predictions are based on growth tables and yield tables. Growth tables are based on the method of regression applied to present tree diameters and classifications; and yield tables are growth tables prepared on a stand basis, classified by species, stand density, age and site quality.

5. **Mineral Statistics.** The Bureau of Mines sends forms to be accomplished by individual mining companies and by the treasurers of the different municipal governments throughout the country. These forms are data on mine production and value, cost of mining, number of mineral claims, operated mine and null capacity, extent of development, ore reserves, chemical analysis and authorized capital. Non-metallic mineral production and value are also collected through the above forms.

The information obtained through the mailed forms are supplemented with field geological and mining data collected from time to time by the engineers and geologists of the Bureau of Mines[9].

Ore reserves are proven ore bodies of a mine. Such reserves are classified into:

(a) Positive ore reserve is a block of ore-body, 100 ft. x 100 ft., which value on its foursides was checked and 100% of its volume considered as reserves.

(b) Probable ore reserve is a block of ore body, 100 ft. x 100 ft., which value on its three sides was checked and 66 2/3% of its total volume considered as reserves[4].

6. **Common Problems.** The basic problem of the collection of the different resources statistics is one of sampling. The estimation of fish population should be approached by careful planning and with as much knowledge of the behavior and habits of the population as can be gathered. Emphasis on assumptions and likelihood of fish behavior and habits as tied to the sampling method used casts a gloomy shadow on the current methods used. It may be argued that the expense of carrying out pilot surveys would often be more than the population estimate could be worth. On the other hand, it is an expensive impropriety to maintain that an untrustworthy estimate is better than none[3].

Forestry statistics are essentially based on the results of systematic samples. The most useful contribution to the collection of forest statistics is to develop a generally applicable method for evaluating the accuracy of systematic samples that is not too heavy mathematically[7].

Collection of natural resources statistics seems to be concentrated on the collection of production statistics. Price statisics seem to be collected incidental to the collection of quantum statistics.

ESTABLISHING ECONOMIC MEASURES OF NATURAL RESOURCES

Christy and Potter[2] presented a comprehensive consistent long-term series of the principal economic aspects of major natural resources commodities, from which they have derived aggregate measures for all resources and for major groups of resources throughout a significant period of the growth of the United States. They have chosen the following measures:

1. Deflated price series,
2. Employment per output series,
3. Output per capita series, and
4. Consumption per capita series.

7. **Problems in Weighting.**

Potter and Christy presented summaries of their data in their "all extractive" indices of price, output, etc. and in the subaggregate measures for agriculture, minerals, timber, and fishing and their principal groupings. Weights were chosen in such a way that weights approximate the values of the resource commodities at the earliest extractive level, e.g., the value of metals at the ore-concentrate stage, before refining; the value of logs delivered at the mill, before manufacturing into lumber or paper, etc. This weighting procedure is an attempt to minimize the fabrication costs included in the relative weights of the differences in weights due to chance variations in the degree of fabrication at which price, output, etc. figures are collected. There is, however, no way of determining how well this method of weighting has accomplished this minimization of fabrication since there is no criterion of just what a "raw" material is or to what extent fabrication costs have been included in the measures for the value of raw materials.

In presenting a series of indices of natural resources consisting of mining and quarrying fishing and forestry and logging, the weights may be leased on gross receipts, total payrolls and gross value added in the industry. The percentages of total weight assigned to the resource sector by these aforementioned criteria are as follows:

Sector	Weights		
	Gross Receipt	Total Payrolls	Gross Value Added
Mining and quarrying	40	44	41
Fishing	21	21	24
Forestry and logging	39	35	35
Total P(1,000)	541,015	117,632	313,822
Total Percentages	100	100	100

Source of basic data: Economic Censuses, Bureau of the Census and Statistics.

The weights can also be based on value of production for a base year. Three base years are given below:

Year	Resource Sector			Total
	Fishing	Forestry*	Mining	
1950	54	26	20	100 (P404,805,131)
1955	27	62	11	100 (P1,393,016,604)
1953-57	22	65	13	100 (P1,450,303,427)

* Value based on average export price.
Source of basic data: NEC — Survey of Raw Materials.

The "consistency" of the weights using gross receipts, total payrolls, gross value added is better than in using the value of production for different years and average over a period of years.

There is also the problem of what formula to use: Laspeyres, Paasche, Edgeworth, or Fisher's Ideal.

8. **Price and Production Statistics.**

Of the statistical series pertaining to natural resources, price statistics, perhaps, needs a lot of improvement both in terms of collection and in quality.

Retail price index of fish in Manila for 1955 and 1960-66 is as follows:

Year	Index
1955	100.0
1960	113.5
1961	121.0
1962	141.8
1963	153.5
1964	157.6
1965	174.4
1966	180.7 (Jan. to June)

Sources of data: CB, Fishery Commission

An indication of the variability of retail prices of fish in Manila may be seen in the following series for 1965:

Month	Index	Month	Index
January	187.4	July	181.2
February	181.3	August	170.8
March	174.6	September	175.3
April	168.6	October	170.5
May	160.2	November	173.3
June	163.5	December	189.7

The export prices for 1955 and 1960 to 1966 of lumber and logs in 1,000 bd. ft. are as follows:

Year	Lumber	Logs
1955	₱233.67	₱151.47
1960	272.73	198.06
1961	277.01	203.04
1962	272.59	232.10
1963	299.11	259.93
1964	328.01	280.10
1965	333.42	251.58
1966	340.64	282.12

The monthly export prices of lumber and logs in 1,000 bd. ft. for December, 1964 to June, 1966 are as follows:

Year and Month	Lumber	Logs
1964		
December	₱333.39	₱281.05
1965		
January	333.39	281.05
February	333.39	281.05
March	333.39	281.05
April	333.39	281.05
May	333.39	281.05

Year and Month	Lumber	Logs
1965		
June	₱333.39	₱281.05
July	339.45	282.12
August	339.45	282.12
September	3339.45	282.12
October	339.45	282.12
1965		
November	339.45	282.12
December	339.45	282.12
1966		
January	339.45	282.12
February	339.45	282.12
March	339.45	282.12
1966		
April	339.45	282.12
May	343.03	282.12
June	343.03	282.12

Sources of data: Central Bank of the Philippines; Bureau of Forestry.

Price analyses of forestry products using export prices will indicate a very stable forest economy particularly if released on a monthly basis. Yearly volumes of production and export of logs and lumber seem not to be in agreement with the result price analyses as can be seen in the following production and export series:

Year	Logs		Lumber	
	Production	Export 1,000,000 bd. ft.	Production	Export
1955	1,663.5	655.7	338.3	70.6
1960	2,696.7	1,454.8	445.1	60.6
1961	2,786.1	1,742.7	404.1	43.7
1962	3,072.9	1,771.7	384.8	80.4
1963	3,945.2	2,308.7	612.0	53.9
1964	2,761.5	2,320.0	481.1	61.2
1965	3,123.8	2,963.2	426.1	50.1
1966	1,673.1*	1,732.8*	236.2*	26.6*

* January to June only.
Sources of data: Central Bank of the Philippines;
Bureau of Forestry.

Monthly volumes of production of logs and lumber for 1965 are as follows:

Month	Logs		Lumber	
	Production	1,000,000 bd. ft. Export	Production	Export
January	295.6	165.1	25.7	3.0
February	219.3	178.9	36.5	4.0
March	182.8	207.0	58.7	4.5
April	197.4	272.6	30.7	4.2
May	304.8	257.6	62.4	5.5
June	185.4	254.7	51.3	3.7

Month	Logs		Lumber	
	Production	1,000,000 bd.ft. Export	Production	Export
July	412.0	262.5	30.6	3.9
August	279.5	245.2	42.3	4.9
September	520.3	312.7	23.4	3.5
October	107.1	307.2	21.8	4.2
November	66.3	293.2	21.1	5.2
December1	253.3	206.5	21.6	3.5

Sources of data: Central Bank of the Philippines;
Bureau of Forestry.

Selected statistics on mining and quarrying are as follows:

Year	Index of Physical Volume of Production	Gold Production 1,000 ounces	Cement Production 1,000 Bags of 94#	Iron Ore Production 1,000 m.t.
1955	100.0	416.1	7,435.4	1,432.7
1960	126.7	410.6	18,645.9	1,138.8
1961	134.3	424.0	23,900.1	1,170.5
1962	136.6	423.3	21,804.3	1,386.9
1963	138.6	376.0	22,311.7	1,384.7
1964	140.4	425.8	28,170.3	1,366.9
1965	150.3	435.8	33,257.8	1,437.7
1966	159.9*	216.8*	18,360.9*	742.6*

* January to June.
Sources of data: Central Bank of the Philippines; Bureau of Forestry.

The index of mining production includes the aggregate output of gold and base metals composed of chromite, manganese, copper and iron. The index covered approximately 70% of the total value of mining production in the country during the base period 1955. Non-metallic minerals covering the remaining 30% were excluded from the index because the data for these items are generally not available every quarter. The index is computed quarterly with the use of the following weights which are based on the 1952 production values:

All items	1.0000
Gold	0.4402
Base metals	0.5598
Chromite	0.1612
Manganese	0.0121
Copper	0.1811
Iron	0.2054

9. **Employment and Output Statistics.**

The economic censuses of the different sectors of the economy yielded detailed data on number of establishments, employment, costs and receipts, fixed assets, form of ownership and related information. The impression, however, that a user will get from these censuses is that they are primarily collected for the study of employment in different industries rather than for a general economic census.

A desirable piece of information which is missing from such economic census is the output by size of establishments. Output in relation to the overall employment situation in the industry is one of the economic measures which can be used in studying natural resources.

10. **Consumption and Foreign Trade.**

Consumption requirements of fish is based on the concept of disappearance, i.e., the quantity available for consumption is the difference between (production + import + re-export) and (non-food uses + exports). The concept of disappearance in establishing per capita consumption is reliable if there is a good series of stock statistics; otherwise it has to be supplemented by more objective methods, for example, protein requirement approach[6].

Local requirements for forestry and mineral and mineral products have to be established from the requirements of the different manufacturing and processing establishments. In other words, statistics on the capacities of the different establishments should be known. The maximum, optimum and current operating capacities should be the guiding factors in establishing local requirements.

Foreign trade statistics on natural resources seem to be satisfactory. However, the quality needs to be examined since a lot of these statistics are the by-product of a number of regulatory and administrative functions of different government offices.

SUMMARY AND CONCLUSION

The paper presented the common statistical problems met in establishing economic measures of natural resources. The basic problem is that statistics of natural reources are indirect measures. These statistics are measures of the products and not of the resources, thus they are to a certain extent dependent on the knowledge of the current technology involved in extracting natural resources products.

The problems of collection of statistics on natural resources are essentially sampling problems. However, the coverage and quality need to be improved to be able to establish better and sufficient number of economic measures.

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