ON MEASURING ECONOMIC DIVERSIFICATION

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Abstract

Theorists contend that economic diversification fosters regional economic stability and renders the regional economy less sensitive to outside influences. Much regional growth policy revolves around strategies designed to induce greater economic diversification. In this paper we propose the use of the Shannon entropy function for measuring economic diversification. This measure is then utilized to assess the impact of resource development programs on four river basins of Wyoming.

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1. Introduction

Regional business cycle theorists contend that as a region becomes more economically diversified, the economy of the region becomes less responsive to fluctuations in extra-regional economic activity. Economic diversification, therefore, fosters regional economic stability by making the regional economy less sensitive to outside influences.

Much discussion regarding regional growth policy revolves around strategies designed to induce greater economic diversification. This is particularly true for rural areas which have realized frequent economic activity fluctuations. Often times, these areas specialize in primary products. Business cycle fluctuations of other areas are transmitted via changes in demand for products of the region. As a result of specialization, the regional economy can react dramatically to external influences such as demand changes for one product. Such a scenario is contrasted with a balanced economy which may be affected by changes in external demand, but much less dramatically. Consequently, the advocacy of policy leading to economic diversification continues.

The regional growth and diversification process normally involves, as a first step, a reduction in the relative importance of primary products and an

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increase in industrial and service activity. Colin Clark¹ has viewed the development process as a transition from dependence on "primary" (extractive) activities to specialization in "secondary" (processing and fabricating) industries and finally to specialization in "tertiary" or service activities. As the development process continues and the regional economy becomes more diversified or "balanced", the regional economy is less affected by business cycles of other regions.

Thus, diversification, defined as an equalization of each sector's share of total employment, should indicate less economic dependence on other regions. Moreover, increased diversification enhances the potential for regional economic stability.

The objective of this paper is to develop a natural method for measuring economic diversification. The measure is then utilized to evaluate the economic diversification impact of resource development programs on four river basin areas of Wyoming. The diversification analysis is achieved by evaluating sectorial employment changes during the period studied. Relative changes in employment diversification for resource project counties and non-project counties within each basin were calculated in order to isolate the structural impact of the resource development projects during the period 1940 to 1960. Concomitantly, the study serves to evaluate the success of the resource development projects in achieving greater economic stability via enhanced structural diversification.

¹Colin Clark, The Conditions of Economic Progress, (London: Macmillan and Co., 1940).

2. Entropy as a Measure of Economic Diversification

A measure of economic diversification should depend only on the number of economic sectors n and the relative share of each sector $p_1, p_2, \dots, p_n$. Let $D(p_1, p_2, \dots, p_n)$ denote the measure of diversification. We would require first that D be a symmetric function of the p 's depending only on their relative magnitudes and not on their order. Second, we would require D to be continuous in each variable so that small changes in the economic structure produce small changes in the measure. Third, suppose that one sector, say the n^{th} , is divided into two components with relative share q_1 and q_2 . Then we require

$$D(p_1, p_2, \dots, p_{n-1}, q_1, q_2) = D(p_1, p_2, \dots, p_n) + p_n D\left(\frac{q_1}{p_n}, \frac{q_2}{p_n}\right),$$

so that the increase in diversity measure is a fraction p_n of the diversity within the n^{th} sector.

These three conditions are sufficient to uniquely determine the function D , up to a multiplicative constant which is only a choice of scale of measurement, as

$$D(p_1, p_2, \dots, p_n) = c \sum_{i=1}^n -p_i \log p_i.$$

The function D , usually called the entropy function, was discovered by Shannon² in 1948, and has since been shown to have important application in physics, chemistry, biology, psychology, and other scientific disciplines.

The maximum value of D is attained when $p_1 = p_2 = \dots = p_n = 1/n$ as

$$D(1/n, 1/n, \dots, 1/n) = c \log n,$$

and is obviously an increasing function of n . Taking $\lim_{p \rightarrow 0} p \log p = 0$ as the

²Shannon, C. E., "A Mathematical Theory of Communication," Bell System Tech. J. Vol 27 pp 379-423, 623-656, 1948. Reprinted in Shannon, C. E., and Weaver, W., The Mathematical Theory of Communication, Univ. of Ill. Press, Urbana, Ill., 1949.

value for $0 \log 0$, we have

$$D(1, 0, \dots, 0) = 0$$

so that a measure of diversity of zero corresponds to total employment in one sector.

In the present study, ten sectors used are: (1) agriculture and forestry, (2) mining, (3) contract construction, (4) manufacturing, (5) transportation, communications and utilities, (6) wholesale and retail trade, (7) finance, insurance and real estate, (8) services, (9) public administration and armed forces, and (10) industry not reported. The percentage share of occupation groups were calculated.³ Since there are ten sectors we take logs base ten and choose $c = 1$. Thus the maximum value of

$$D(p_1, p_2, \dots, p_{10}) = -\sum_{i=1}^{10} p_i \log_{10} p_i$$

is one, and observed values may be directly interpreted in this scale.

³County employment data were obtained from the United States Department of Commerce, Office of Business Economics, Growth Patterns of Employment by County, 1940-50 and 1950-60, Rocky Mountain, vol. 7 (Washington, D.C.: USGPO, 1965).

3. Impact of Resource Development Programs

In Table I the calculated mean diversification values by decade for the basin and comparison groups within each basin are shown. It is noted that for the first two decades (1940 and 1950), non-project counties exhibited greater diversification than project counties. However, in 1960, the project counties had greater diversification as shown by the project county diversification measure of .8900 compared to the non-project county measure of .8700.

TABLE I

BIG HORN BASIN: CALCULATED MEAN DIVERSIFICATION
VALUES FOR 1940, 1950 and 1960

	1940	1950	1960
Mean Diversification for the Basin	.7440	.8604	.8823
Mean Diversification for Project Counties	.7300	.8600	.8900
Mean Diversification for Non-Project Counties	.7520	.8800	.8700

As resource project developments did not take place in the Belle Fourche-Powder River Basin until 1960 (Table II), group comparisons were only made for 1960. For 1960, non-project counties exhibited a greater diversification of .8488 compared to .8129 for project counties.

TABLE II

BELLE FOURCHE-POWDER RIVER BASIN: CALCULATED MEAN
DIVERSIFICATION VALUES FOR 1940, 1950 and 1960

	1940	1950	1960
Mean Diversification for the Basin	.7118	.7904	.8428
Mean Diversification for Project Counties			.8129
Mean Diversification for Non-Project Counties	.7118	.7904	.8488

In the Green River Basin, relative mean comparison group diversification values fluctuated between 1940 and 1950 (Table III) reflecting very similar diversifications for both groups. In 1960, project counties had a relatively high diversification measure of .8800 compared to .8300 for non-project counties.

TABLE III

GREEN RIVER BASIN: CALCULATED MEAN DIVERSIFICATION
VALUES FOR 1940, 1950 and 1960

	1940	1950	1960
Mean Diversification for the Basin	.7238	.7815	.8506
Mean Diversification for Project Counties	.7380	.7730	.8800
Mean Diversification for Non-Project Counties	.7200	.7850	.8300

Project counties had consistently higher mean diversification values than non-project counties for all decades analyzed in the Platte River Basin

(Table IV). However, it is noted that the degree of diversification differential between comparison groups in this basin was less in 1960 than it was during the two earlier decades.

TABLE IV
PLATTE RIVER BASIN: CALCULATED MEAN DIVERSIFICATION
VALUES FOR 1940, 1950 and 1960

	1940	1950	1960
Mean Diversification for the Basin	.7708	.8369	.8601
Mean Diversification for Project Counties	.7900	.8600	.8605
Mean Diversification for Non-Project Counties	.7600	.8200	.8595

4. Conclusions

The following observations are made regarding the changes in relative economic diversifications within river basin regions in the state of Wyoming based upon the diversity measure: (1) within each basin, employment patterns became more diversified during the period studied, and (2) no pattern was recognized regarding the impact of resource projects on relative economic diversification as no consistent differences between comparison groups appeared. It is noted, however, that in 1960, project counties had greater diversification in three of the four basin regions. The only basin where non-project counties had greater diversification was the Belle-Fourche-Powder Basin which did not have resource projects until 1960. Therefore, it might be concluded that resource projects have a positive influence on diversification but that

a lag is involved in achieving greater diversification through resource development.

TABLE V
MEAN DIVERSIFICATION VALUES FOR THE STATE OF WYOMING
FOR YEARS 1940, 1950 and 1960

	1940	1950	1960
Mean Diversification for All Wyoming Counties	.8662	.9120	.9200
Mean Diversification for Project Counties of Wyoming	.8670	.9139	.9236
Mean Diversification for Non-Project Counties in Wyoming	.8504	.8951	.9113

In Table V the diversification values for the state and for comparison groups by decade are shown. The following conclusions are drawn: First, during the 1940 to 1960 period in Wyoming the trend was toward a more diversified employment pattern or more stable economic structure overall as well as for project and non-project county groupings as witnessed by the progressively higher diversification values. Second, taken together, project counties appeared to be slightly more structurally diversified than non-project counties in the years 1940, 1950, and 1960. It is further noted that the mean diversification values for the state are higher than the comparable river basin values. This reflects the fact that larger regions tend to have more balanced employment structures than do smaller more economically specialized regions.

If economic diversification is thought to be a desirable growth policy goal, because of its economic stability implications, the entropy measure of

diversity provides an analytical tool for measuring success of the policy. Beyond this application, the entropy measure provides a basis for a more precise definition of economic diversification. It does not, however, answer the question of what constitutes an optimal diversification pattern.

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