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A COMMENT ON THE CLEMENTE (MFD) AND GIBBS-MARTIN (MID) MEASURES OF THE DIVISION OF LABOR

Their Relation to Amemiya's Index of Economic Differentiation (IED)

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Clemente (1972) argued that the division of labor (DL) could be operationally defined as having two dimensions: (1) functional specialization (DL1), the number of different sustenance-producing *activities* in a population and (2) functional dispersion (DL2), the actual distribution of *individuals* among these sustenance-producing activities. Clemente further argued that DL2 could be empirically measured by using his measure of functional dispersion (MFD), and application of the measure of industrial diversification (MID) developed by Gibbs and Martin (1962) to measure the distribution of individuals among industrial categories. Clemente observed that, while MFD had several properties recommending its use as an empirical indicator of DL2, it was subject to certain limitations detracting from its usefulness. One important limitation acknowledged by Clemente is that the maximum possible value of MFD varies and

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is a function of the number of industrial categories employed. The fact that the upper limit of MFD can never reach unity and varies depending on the number of categories employed restricts MFD's usefulness in any comparative analysis between units having a different number of industrial categories. (A similar criticism would, of course, apply to the Gibbs and Martin MID measure). This paper will attempt to show that these shortcomings in the MFD and MID measures can be surmounted when they are recognized to be equal to Amemiya's (1963) untransformed index of economic differentiation (IED) (subtracted from 1, see below).

IED was developed by Amemiya to measure the economic differentiation of an area based on the proportionate distribution of the labor force throughout the industrial categories characteristic of the area. It should be apparent that Amemiya was attempting to measure what Clemente calls DL2 and Gibbs and Martin called industry diversification. When the equivalency of the two measures to Amemiya's measure is proven it should also be apparent that the limitations of MFD and MID can be resolved by restating them in terms of IED and using Amemiya's method of measuring DL2.

$$MFD = 1 - \frac{\Sigma Xi^2}{(\Sigma Xi)^2}$$

Note: the Gibbs and Martin MID is defined the same as MFD.

where Xi = the number of persons in industry i
and ΣXi = the total number of persons in the i industries.
$IED = \Sigma(n/(n-1) \cdot (Pi - (1/n))$
where n = the number of industries
Pi = the proportion of persons in industry i
and $\Sigma Pi = 1.00$.

In discussing IED, Amemiya (1963: 85) states:

> Since $0 \leqslant Pi \leqslant 1$, then $Pi^2 \leqslant Pi$ for all Pi, and $\Sigma Pi^2 \leqslant 1$. The quantity ΣPi^2 can be shown to attain a unique relative minimum value when all Pi have the same value $Pi = 1/n$. Hence the range for

ΣPi^2 is from the minimum value $1/n$ to the maximum value 1. Hence the following transformations are necessary:

Let $Pi' = Pi - 1/n$,
so that $\Sigma Pi' = 0$;
and $\Sigma Pi'^2 = \Sigma(Pi^2 - (2Pi/n) + (1/n)^2)$
$= \Sigma Pi^2 - (2/n)\Sigma Pi + n(1/n)^2$
$= \Sigma Pi^2 - (2/n)1 + 1/n$
$= \Sigma Pi^2 - 1/n.$

Hence the maximum value of $\Sigma Pi'^2 = \Sigma Pi^2 - 1/n$ is $1 - (1/n) = (n-1)/n$ (since the range for Pi^2 is from a minimum of $1/n$ to a maximum of 1) and the minimum is 0. Now make the transformation $Pi'' = n/(n-1) \cdot Pi'$ or $Pi = (n/(n-1)) \cdot Pi'^2$ so that $\Sigma Pi''^2$ ranges from a minimum of 0 to a maximum of 1 where $\Sigma Pi''^2 = \Sigma(n/(n-1) \cdot (Pi-(1/n))^2$.

Amemiya thus shows that ΣPi^2 when transformed to $\Sigma Pi''^2$ attains a minimum value of 0 when all Pi have the same value $1/n$ and a maximum value of 1 when all of the workforce is concentrated in one industrial category for any n number of categories.

It is the contention of this paper that Clemente's MFD = $1 - (\Sigma Xi^2)/(\Sigma Xi)^2 = 1 - \Sigma Pi^2$ [e.g., MFD is equal to Amemiya's untransformed IED subtracted from 1 and that the limitation of MFD having a varying maximum value < 1 and being dependent upon the number of industrial categories employed can be resolved when $(\Sigma Xi^2)/(\Sigma Xi)^2$ is restated in the form ΣPi^2 and transformed to $\Sigma P''^2$]. Thus by showing the equality between $(\Sigma Xi^2)/(Xi)^2$ and ΣPi^2, MFD can be reconstructed and become a viable measure of DL2.

Disregarding the first term 1 and the negative sign of the second term $-(\Sigma Xi^2)/(\Sigma Xi)^2$ (since the second term subtracted from the first merely reverses the scores of minimum dispersion and maximum dispersion–i.e., it is a functionally symmetrical operation) the next step is to show that $(\Sigma Xi^2)/(\Sigma Xi)^2 = \Sigma Pi^2$:

Since $Pi = Xi/\Sigma Xi$

$$\text{then } \Sigma Xi^2/(\Sigma Xi)^2 = \frac{1}{(\Sigma Xi)^2} \cdot \frac{(\Sigma Xi^2)}{1}$$

$$= \frac{1}{(\Sigma Xi)^2} \cdot \Sigma(X_1^2 + X_2^2 + X_3^2 + \ldots + X_n^2)$$

$$= \sum\left(\frac{X_1^2}{(\Sigma Xi)^2} + \frac{X_2^2}{(\Sigma Xi)^2} + \frac{X_3^2}{(\Sigma Xi)^2} + \ldots + \frac{X_n^2}{(\Sigma Xi)^2}\right)$$

$$= \sum\left[\left(\frac{X_1}{\Sigma Xi}\right)^2 + \left(\frac{X_2}{\Sigma Xi}\right)^2 + \left(\frac{X_3}{\Sigma Xi}\right)^2 + \ldots + \left(\frac{X_n}{\Sigma Xi}\right)^2\right]$$

$$= \Sigma(P_1^2 + P_2^2 + P_3^2 + \ldots + P_n^2$$

$$= \Sigma Pi^2$$

Hence the only difference between MFD and IED aside from the operation of functional symmetry already discussed lies in the transformations performed by Amemiya so that the range of the measure is from 0 to 1 and the lower and upper limits are independent of the number of industrial categories employed.

MFD is thus recognized to be an incomplete version of IED. MFD lacks the necessary transformations which would give it a range from 0 to 1—e.g., a constant minimum and a constant maximum independent of the number of categories employed. When MFD is displayed in the ΣPi^2 form its transformation is readily accomplished and it becomes the complete IED (MFD″), a measure offering clarity in interpretation, usefulness, and validity when used for comparative analysis even when the units or areas compared have a different number of industrial categories throughout which their respective work forces are distributed.

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