APPENDICES

FOR

DESIGNING AN INDUSTRIAL POLICY FOR DEVELOPING COUNTRIES: A NEW APPROACH

Appendix A [For Online Publication]

Measurement of Technology Content Added

A model for the assessment of the Technology Content Added (TCA)

According to [Asian and Pacific Center for Transfer of Technology (APCTT)[1]] "The technology atlas team, 1987 p37: "The recognition of technology as an important strategic variable in development has led to the developing countries accepting the need for integrating technological considerations in the national socioeconomic planning process. However, one of the factors that has hampered these efforts appears to be the lack of suitable measures of technology".

"Technology can be considered to be the engine of growth for the national economy. Ordinarily technology is considered as something physical. Only rarely is it understood as a transformer of resources-not just the physical tools and facilities (hardware). In addition to the hardware, transformation of resources for economic growth requires human skills, accumulated knowledge, and institutional arrangements. The study presents a framework of the four basic components of technology for resources transformation, namely: 1) Technoware (object embodied technology); 2) Humanware (person embodied technology); 3) Infoware (document embodied technology); and 4) Orgaware (institution embodied technology)". (APTTC, 1986, p19)

"Technoware consists of tools, equipment, machines, vehicles, physical facilities, etc. Humanware refers to experiences, skills, knowledge, wisdom, creativity, etc. Inforware includes all kinds of documentation pertaining to process specifications, procedures, theories, observations, etc. Orgaware is required to facilitate the effective integration of Technoware, Humanware, and Inforware, and consists of management practices, linkages, etc." (Ibid, p22)

"If the pattern of the development of each of the four components of technology are examined, it is possible to perceive certain distinct phases in their growth process. These phases taken together may be called the Technology Life Chain and it is possible to describe a Life Chain for each component of technology." (Ibid, p29)

"The analysis of components of technology and the strength of life chain of each component give better insights for technology decision making. Such analysis can be applied to a variety of situations: assessment of technological capability in a specific field; assessment of national technological capability to generate technology; assessment of technological gap with respect to countries/industries/firms; assessment of technology content added in areas of relevance." (Ibid, p35)

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[1] Asian and Pacific Center for Transfer of Technology (APCTT). 1987. "The Technology Atlas Project." Technological Forecasting and Social Change journal, Volume 32, Issue 1, p1-109. https://doi.org/10.1016/0040-1625(87)90003-5 https://doi.org/10.1016/0040-1625(87)90004-7 https://doi.org/10.1016/0040-1625(87)90005-9 https://doi.org/10.1016/0040-1625(87)90006-0 https://doi.org/10.1016/0040-1625(87)90007-2 https://doi.org/10.1016/0040-1625(87)90008-4

“It has been proposed in earlier in this issue that the four components of technology, namely, Technoware, Humanware, Inforware, and Orgaware, are in fact the transformers of the inputs of a production system into outputs. Thus, any attempt to evaluate the transformation activity of a production system would have to necessarily examine the attributes of these four components.” (Ibid, p38)

Economists have used the concept of value added to evaluate the monetary contribution of a transformation facility to the national economy. One definition of value added states that if the competitive condition that price equals unit costs is satisfied, the value added may be considered to be equal to the total cost of the factors of production used in the input-output transformation[2]. Since the four components of technology may be considered to be the equivalent of the factors of production, it may be useful to propose the measurement of the amount of “Technology Content” that is added at a transformation facility by these four components. (Ibid, p38)

Since the four components of technology, taken together, contribute towards the Technology Content of a transformation facility, a Technology Content Coefficient (TCC) may be defined by a multiplicative function as follows to describe a transformation facility:

$$TCC = \alpha \,.\, T^{\beta_1} \,.\, I^{\beta_2} \,.\, H^{\beta_3} \,.\, O^{\beta_4} \quad , \qquad \text{(A.1)}$$

where the β_i’s may be called the intensity of contribution of each component towards the TCC and α is the “climate factor,” which is an index of the country’s commitment to technology as evaluated by the effectiveness with which technology activities are facilitated by the national environment. The multiplicative model is intuitively appealing due to the fact that it satisfies the properties listed below:

Property 1

T, I, H, 0 should all be strictly nonzero to ensure that TCC is nonzero. This is in accordance with the postulate that no transformation is possible without all four components of technology.

Property 2

Partial differentiation of TCC with respect to T results in the following expression:

$$\frac{\partial (TCC)}{\partial T} = \beta_1 \frac{(TCC)}{T} \qquad \text{(A.2)}$$

Similar expressions can be obtained if partial differentiation is carried out with respect to H, I, and 0. Thus, if

$$0 < \beta_i < 1 \quad ,$$

then it meets the condition of the simultaneous requirement of all four components while satisfying the practically recognized phenomenon that the law of diminishing returns operates when attempts are made to increase technology levels by upgrading the level of only one component while keeping the others constant.

Property 3

The total differential of TCC may be expressed as follows:

$$d(TCC) = \frac{\partial (TCC)}{\partial T} . dT \; + \; \frac{\partial (TCC)}{\partial I} . dI \; + \; \frac{\partial (TCC)}{\partial H} . dH \; + \; \frac{\partial (TCC)}{\partial O} . dO \qquad \text{(A.3)}$$

Thus,

$$d(TCC) = \beta_1 \frac{dT}{T} \; + \; \beta_2 \frac{dI}{I} \; + \; \beta_3 \frac{dH}{H} \; + \; \beta_4 \frac{dO}{O} \; . \qquad \text{(A.4)}$$

The proportionate increase of TCC would thus be equal to the sum of the proportionate increases of the four components weighted by the β_i’s.

Property 4

If all the four components are increased by the same proportion $\mathcal{K}$, then eq. (A.3) would reduce to

$$\frac{d(TCC)}{TCC} = \mathcal{K}[\beta_1 + \beta_2 + \beta_3 + \beta_4] \, . \qquad \text{(A.5)}$$

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[2] Henderson, James Mitchell, and Richard E Quandt. 1980. Microeconomic Theory: A Mathematical Approach. Economics Handbook Series. McGraw-Hill. https://books.google.com/books?id=Fni7AAAAIAAJ.

Thus, if

$$\beta_1 + \beta_2 + \beta_3 + \beta_4 < 1 , \quad \text{(A.6)}$$

then the TCC function obeys the condition of decreasing returns to scale. The operationalization of the multiplicative models, however, requires that estimates be made of T, I, H, 0, the β_i's, and α. These estimation procedures are outlined next.

1. Estimation of T, I, H, 0: After an examination of the factors, using expert opinion, a score can be assigned for T, I, H, 0 on a range of 1-9. The highest value of 9 would refer to the best in the world, and all scoring would have to be done against this datum.

2. Estimation of the β_i's: Property 3 shows that the proportionate increase of TCC is the sum of the proportionate increases of the four components weighted by the β_i's. In any transformation facility, using expert opinion it should thus be possible to obtain estimates of the β_i's by understanding the relative contributions that could result due to increases in the four components. However, the sum of the β_i's should be less than unity according to Property 4. Well-established methods are available for arriving at such weightages using expert opinion[3].

3. Estimation of α: Any transformation facility can deliver its full technological capability only if the national technology climate is of a supportive nature. National level support may be implicit as well as explicit. At the firm level the extent of national support can be assessed by examining the effectiveness of relevant institutional services with respect to the functioning of the transformation facility. The maximum value of $\alpha = 1$ while its minimum value would be 0.

Based on the above considerations, it would be possible to summarize the important attributes of the TCC computation as follows:

Expert opinion should be used to obtain estimates for the values of T, I, H, 0, a, and the β_i's.

The maximum value attainable by T, I, H, 0 is 9.
The minimum value attainable by T, I, H, 0 is 1.
The maximum value attainable by α is 1.
The minimum value attainable by α is 0.
$0 < \beta_i < 1, \quad i = 1, 2, 3, 4.$
$B_1 + \beta_2 + \beta_3 + \beta_4 < 1.$
The theoretical maximum of TCC will be very close to 9.
The theoretical minimum of TCC will be 0.
The Technology Content Added (TCA) is thus defined as follows:

$$TCA = (TCC/9) \times EVA , \quad \text{(A.7)}$$

where EVA is the economic value added at the transformation facility. This implies that if the EVA has been obtained using the best technology (T, I, H, O), then the TCA is almost equal to the EVA. If not, the TCA is lower than the EVA. The value for EVA may be obtained quite easily from the management accounting system of a firm. (Ibid, p38-42)

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3 Eckenrode, Robert T. 1965. "Weighting Multiple Criteria." Management Science 12 (3): 180–92. https://doi.org/10.1287/mnsc.12.3.180.

Appendix B [For Online Publication]

Technology classification in terms of the competitive impact

Chris Floyd[4], 1997, by developing Arthur D. little's model[5], makes a classification of technologies in terms of their competitive impact. Technologies can be divided into four categories: base, key, pacing and emerging, indicating the scope of competitive advantage the technology offers and its level of maturity. Bellow, the definitions for these categories are followed:

Base technology: technologies that, although necessary and essential to practice well, offer little potential for competitive advantage. These technology are typically widespread and shared. Base technologies are commodity items which do not give significant competitive advantage but which are entry hurdles. Provided you have got them, you dot need to worry.

Key technology: technologies that are most critical to competitive success because they offer the opportunity for meaning full process or product differentiation. These technologies yield competitive advantage.

Pacing technology: technologies that have the potential to change the entire basis of competition but have not yet embodied in a product or process. These technologies often develop into key technologies. They are, may be, tomorrow's key technologies. They are technologies that are emerging from the R&D labs and beginning to be incorporated into niche products as a prelude to incorporate into the core product range if they prove successful. Well established players, strong in the base and key technologies can be caught out by other companies developing new substitute pacing technologies. It is very tempting to assume that your technology approach is the only viable one, and to fail to anticipate the threat of substitution posed by alternative technologies.

Emerging technology: technologies are those which may become tomorrow's pacing technologies. Still in the research stage, emerging technologies show promise, but are not guaranteed to become valuable.

the next step is to look at the maturity of the technologies, to identify those which are new and therefore of interest and those which are old, and therefore under potential threat. Building on the concepts developed earlier, classify the technologies as base, key, pacing or emerging, to identify those that have significant strategic impact. As discussed earlier, key and pacing technologies give a company competitive advantage. Emerging technologies could give competitive advantage in the future. Base technologies are commodities; necessary but conferring no advantage.

Technology maturity and strategic impact tend to go together. Emerging technologies are likely to be of the bottom of the 'S' curve. Pacing or key technologies tend to be moving up the 'S' curve, and those that are base tend to be mature and at the top of the 'S' curve (Figure B.1). But the correlation is not always perfect. Since it is direly related to competitive advantage, the strategic impact of a technology is industry specific. In contrast, technology maturity is not industry specific, as it is a measure of the evolution of a technology regardless of application. In practice, specific technologies are not readily transferable from the originating industry. So, although maturity is theoretically a measure independent of industry sector, it is normally determined by the sector that uses it most. Maturity can therefore be regarded as synonymous with strategic impact.

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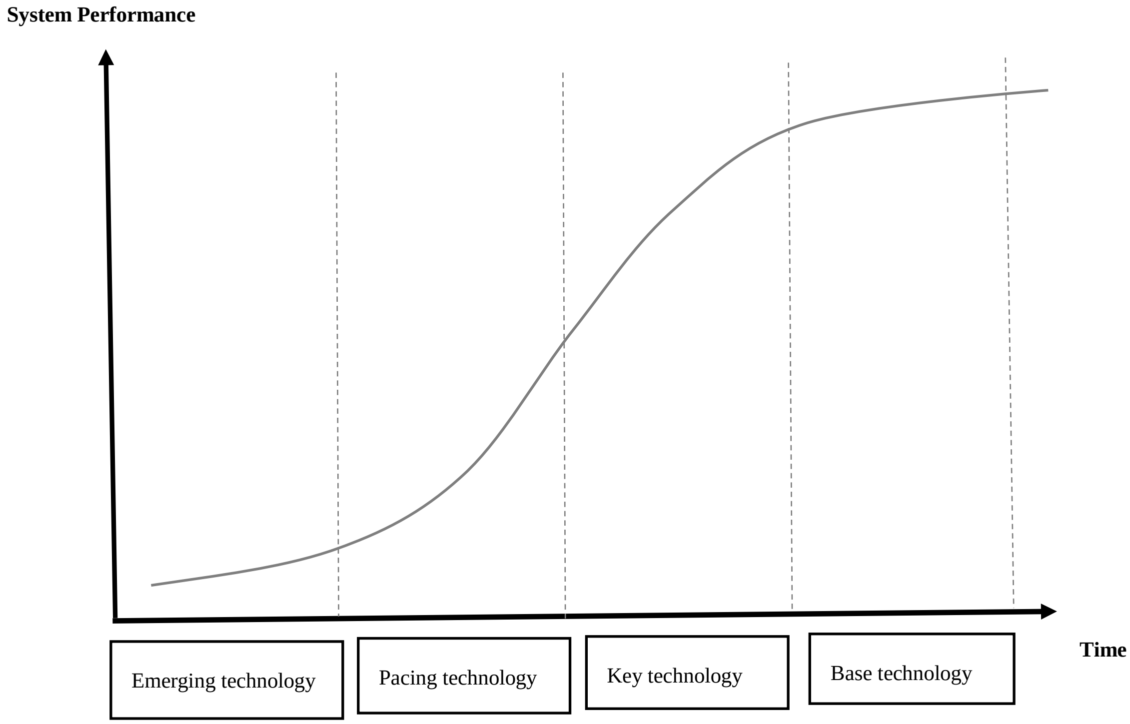
4 Floyd, Chris. 1997. Managing Technology for Corporate Success. Gower Publishing, Ltd. https://books.google.com/books?id=fSvcNJZ8nT4C.

5 Arthur D. Little, Inc., philip A Roussel, Kamal N Saad, and Tamara J Erickson. 1991. Third Generation R & D: Managing the Link to Corporate Strategy. Massachusetts: Harvard Business School Press. https://archive.org/details/thirdgenerationr00rous.

FIGURE B.1- THE TECHNOLOGY 'S' CURVE

SOURCE: ARTHUR D. LITTLE, INC. 1991.



Appendix C [For Online Publication]

Horizontal Merger Guidelines[6]

"These Guidelines outline the principal analytical techniques, practices, and the enforcement policy of the Department of Justice and the Federal Trade Commission (the "Agencies") with respect to mergers and acquisitions involving actual or potential competitors ("horizontal mergers") under the federal antitrust laws." (U.S. Department of Justice; the Federal Trade Commission, 2010, p1)

Market Concentration

"Market concentration is often one useful indicator of likely competitive effects of a merger. In evaluating market concentration, the Agencies consider both the post-merger level of market concentration and the change in concentration resulting from a merger. Market shares may not fully reflect the competitive significance of firms in the market or the impact of a merger. They are used in conjunction with other evidence of competitive effects.

In analyzing mergers between an incumbent and a recent or potential entrant, to the extent the Agencies use the change in concentration to evaluate competitive effects, they will do so using

[6] U.S. Department of Justice, and the Federal Trade Commission. 2010. Horizontal Merger Guidelines. USA. https://www.justice.gov/sites/default/files/atr/legacy/2010/08/19/hmg-2010.pdf.

projected market shares. A merger between an incumbent and a potential entrant can raise significant competitive concerns. The lessening of competition resulting from such a merger is more likely to be substantial, the larger is the market share of the incumbent, the greater is the competitive significance of the potential entrant, and the greater is the competitive threat posed by this potential entrant relative to others.

The Agencies give more weight to market concentration when market shares have been stable over time, especially in the face of historical changes in relative prices or costs. If a firm has retained its market share even after its price has increased relative to those of its rivals, that firm already faces limited competitive constraints, making it less likely that its remaining rivals will replace the competition lost if one of that firm's important rivals is eliminated due to a merger. By contrast, even a highly concentrated market can be very competitive if market shares fluctuate substantially over short periods of time in response to changes in competitive offerings. However, if competition by one of the merging firms has significantly contributed to these fluctuations, perhaps because it has acted as a maverick, the Agencies will consider whether the merger will enhance market power by combining that firm with one of its significant rivals.

The Agencies may measure market concentration using the number of significant competitors in the market. This measure is most useful when there is a gap in market share between significant competitors and smaller rivals or when it is difficult to measure revenues in the relevant market. The Agencies also may consider the combined market share of the merging firms as an indicator of the extent to which others in the market may not be able readily to replace competition between the merging firms that is lost through the merger.

The Agencies often calculate the Herfindahl-Hirschman Index ("HHI") of market concentration. The HHI is calculated by summing the squares of the individual firms' market shares, and thus gives proportionately greater weight to the larger market shares.[7]

$$HHI = \sum_{i=1}^{n} S_i^2 \qquad \text{(C.1)}$$

Where S_i is the market share of firm, and n is the number of firms, and market share of the each firm expressed as a whole number, not a decimal.

When using the HHI, the Agencies consider both the post-merger level of the HHI and the increase in the HHI resulting from the merger. The increase in the HHI is equal to twice the product of the market shares of the merging firms.[8]

Based on their experience, the Agencies generally classify markets into three types:

Unconcentrated Markets: HHI below 1500

Moderately Concentrated Markets: HHI between 1500 and 2500

Highly Concentrated Markets: HHI above 2500

The Agencies employ the following general standards for the relevant markets they have defined:

Small Change in Concentration: Mergers involving an increase in the HHI of less than 100 points are unlikely to have adverse competitive effects and ordinarily require no further analysis.

Unconcentrated Markets: Mergers resulting in unconcentrated markets are unlikely to have adverse competitive effects and ordinarily require no further analysis.

Moderately Concentrated Markets: Mergers resulting in moderately concentrated markets that involve an increase in the HHI of more than 100 points potentially raise significant competitive concerns and often warrant scrutiny.

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[7] For example, a market consisting of four firms with market shares of thirty percent, thirty percent, twenty percent, and twenty percent has an HHI of 2600 ($30^2 + 30^2 + 20^2 + 20^2 = 2600$). The HHI ranges from 10,000 (in the case of a pure monopoly) to a number approaching zero (in the case of an atomistic market). Although it is desirable to include all firms in the calculation, lack of information about firms with small shares is not critical because such firms do not affect the HHI significantly.

[8] For example, the merger of firms with shares of five percent and ten percent of the market would increase the HHI by 100 ($5 \times 10 \times 2 = 100$).

Highly Concentrated Markets: Mergers resulting in highly concentrated markets that involve an increase in the HHI of between 100 points and 200 points potentially raise significant competitive concerns and often warrant scrutiny. Mergers resulting in highly concentrated markets that involve an increase in the HHI of more than 200 points will be presumed to be likely to enhance market power. The presumption may be rebutted by persuasive evidence showing that the merger is unlikely to enhance market power.
The purpose of these thresholds is not to provide a rigid screen to separate competitively benign mergers from anticompetitive ones, although high levels of concentration do raise concerns. Rather, they provide one way to identify some mergers unlikely to raise competitive concerns and some others for which it is particularly important to examine whether other competitive factors confirm, reinforce, or counteract the potentially harmful effects of increased concentration. The higher the post-merger HHI and the increase in the HHI, the greater are the Agencies' potential competitive concerns and the greater is the likelihood that the Agencies will request additional information to conduct their analysis." (U.S. Department of Justice; the Federal Trade Commission, 2010, p18)

Appendix D [For Online Publication]

A tool for analyzing structural change is input-output analysis. Here, the focus is on interindustry transactions. The interindustry transactions or industry by industry flow table provides a summary of the industrial structure of an economy for a given year. It contains information on the values of flows of goods and services between industries and between different sectors of the economy. (Claus, 2009, p134)[9]
"Pioneer researchers in the field include Leontief[10] (1953) and Rasmussen[11] (1956). Leontief's work in this respect involved triangulation on the input-output table for the USA as a mechanism of understanding the internal structure of interindustry transactions. This analytical framework rested upon concepts of dependence, independence, hierarchy and circularity of industries. Rasmussen used an input-output model in measuring changes in the structure of production in Denmark between 1947 and 1949. In this seminal study, he proposed a method for measurement of industrial linkages using the open static input-output model." (Soofi, 1992)[12]

Measurements of Backward and Forward Linkages

Hazari (1970)[13] explain Rasmussen's method: The gross output levels X's required to sustain a given vector of final demand F in the input-output model are determined by the following equation:

$$X = (I - A)^{-1}F \quad . \qquad \text{(D.1)}$$

[9] Claus, Iris. 2009. "New Zealand's Economic Reforms and Changes in Production Structure." Journal of Economic Policy Reform 12 (2): 133–43. https://doi.org/10.1080/17487870902872938.

[10] Leontief, Wassily. 1951. The Structure of American Economy, 1919-1939: An Empirical Application of Equilibrium Analysis. 2, reprint ed. the University of California: Oxford University Press. https://books.google.co.uk/books?id=8pEdAAAAIAAJ.

[11] Rasmussen, Poul Nørregaard. 1956. Studies in Inter-Sectoral Relations. Amsterdam, North-Holland: Einar Harcks Forlag. https://books.google.co.uk/books?id=ta-gAQAACAAJ.

[12] Rasmussen, Poul Nørregaard. 1956. Studies in Inter-Sectoral Relations. Amsterdam, North-Holland: Einar Harcks Forlag. https://books.google.co.uk/books?id=ta-gAQAACAAJ.

[13] Hazari, Bharat R. 1970. "Empirical Identification of Key Sectors in the Indian Economy." The Review of Economics and Statistics 52 (3): 301–5. http://www.jstor.org/stable/1926298.

The analysis of the elements of the (I - A)-1 would reveal the structure of the economy as well as that of the industry. Let us denote the elements of the (I - A)-1 matrix by (bi j)'s. The sum of the column elements of the (I -A)-1

$$\sum_{i=1}^{n} b_{ij} = b_{.j} \qquad \text{(D.2)}$$

indicates the total input requirements for a unit increase in the final demand for the jth sector. In a similar way the sum of the row elements

$$\sum_{j=1}^{n} b_{ij} = b_{i.} \qquad \text{(D.3)}$$

indicates the increase in the output of sector number i needed to cope with a unit increase in the final demand of all the industries. The averages

$$\frac{1}{n}\, b_{.j} \quad (j = 1, \dots, m) \qquad \text{(D.4)}$$

are interpreted by Rasmussen[14] ". . . as an estimate of the direct and indirect increase in output to be supplied by an industry chosen at random if the final demand for the products of industry number j (j = 1, . .. , m) increases by one unit."

A similar interpretation has been given by Rasmussen to the set of averages

$$\frac{1}{n}\, b_{i.} \quad (i = 1, \dots, m) \qquad \text{(D.5)}$$

These indices are not suitable for making inter-industrial comparisons and for this purpose the set of averages in (4) and (5) are normalized by the overall average defined as

$$\frac{1}{n^2} \sum_{j=1}^{n} \sum_{i=1}^{n} b_{ij} = \frac{1}{n^2} \sum_{j=1}^{n} b_{.j} = \frac{1}{n^2} \sum_{i=1}^{n} b_{i.} \qquad \text{(D.6)}$$

and thus we consider the indices

$$U_j = \frac{\frac{1}{n} b_{.j}}{\frac{1}{n^2} \sum_{j=1}^{n} b_{.j}} \qquad \text{(D.7)}$$

and

$$U_i = \frac{\frac{1}{n} b_{i.}}{\frac{1}{n^2} \sum_{i=1}^{n} b_{i.}} \qquad \text{(D.8)}$$

The indices Uj and Ui are termed by Rasmussen as the "Index of Power of Dispersion and Index of Sensitivity of Dispersion." Uj and Ui can also be interpreted as measures of Hirschman[15]'s backward and forward linkages.

Since the averages 1/n b.j have been interpreted earlier showing the requirements of inputs if the final demand of industry number j increases by 1 unit, Uj > 1 then indicates that the industry draws heavily on the rest of the system, and vice versa, in case of Uj < 1. Similarly Ui > 1 indicates that the industry number i will have to increase its output more than others for a unit increase in final demand from the whole system.

The indices in equations (D.7) and (D.8) are based on the method of averaging. It is, how-ever, well known from the theory of statistics that averages are sensitive to extreme values and may give misleading results. Consequently -the indices in (7) and (D.8) do not fully describe the structure of a particular industry. To illustrate this it is possible that an increase in the final demand for the product of a particular industry characterized by a high index of power of dispersion may not affect other industries. Such a situation would arise if a particular industry draws heavily on one or a few industries only.

In order to overcome this difficulty a measure of variability must be defined and the indices of coefficient of variation are defined as

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14 Rasmussen, 1956. Studies in Inter-Sectoral Relations, chap. 8, page 133.

15 Hirschman, Albert O. 1958. The Strategy of Economic Development. The Strategy of Economic Development: V. 10. Yale University Press. https://books.google.com/books?id=wls-AAAAYAAJ.

$$V_j = \frac{\sqrt{\frac{1}{n-1}\sum_{i=1}^{n}(b_{ij}-\frac{1}{n}\sum_{i=1}^{n} b_{ij})^2}}{\frac{1}{n}\sum_{i=1}^{n} b_{ij}} \qquad (D.9)$$

and

$$V_i = \frac{\sqrt{\frac{1}{n-1}\sum_{j=1}^{n}(b_{ij}-\frac{1}{n}\sum_{j=1}^{n} b_{ij})^2}}{\frac{1}{n}\sum_{j=1}^{n} b_{ij}} \qquad (D.10)$$

A high Vj can be interpreted as showing that a particular industry draws heavily on one or a few sectors and a low Vj as an industry drawing evenly from the other sectors. The Vi's can be interpreted similarly.

A key sector can be defined as one in which (a) both Ui and Uj are greater than unity (Uj > 1, Ui> 1), and (b) both Vj and Vi are relatively low. One can easily interpret these in terms of Hirschman's terminology. Hirschman defines a key sector as one, which has a high forward as well as backward linkage. Since Uj and Ui have already been defined as backward and forward linkages it follows that any industry in which both Uj and Ui are greater than unity, can be defined as a key sector under Hirschman's definition. It should be noted that no restriction is stipulated in Hirschman's definition of the key sectors on the values of Vj and Vi and he thus disregards the "spread effects" of the development of an industry. These spread effects are exceedingly important from the point of view of industrial diversification and economic development.

All the following text is directly reflecting Soofi’s work in 1992:

Measures of Industry Interconnectedness

Despite some important implications for interindustry economics, many researchers in this field make only passing references to the *V*s as measures of dispersion of interindustry flows. However, a close examination of the concept brings to the fore two important features of interindustry relationships: the significance of the number of direct and indirect industry connections and the importance of the magnitude of interindustry and intra-industry sales (purchases). (Soofi, 1992)

A Measure of Concentration

According to Soofi’s study (1992): from equation (D.1) where $X = [X_1, \ldots, X_n]'$ is the vector of gross output, I is the identity matrix, $A = [a_{ij}]$ is the matrix of technical coefficients, $a_{ij} > 0$, and $F = [F_1, \ldots, F_n]'$ is the vector of final demand. Then for each i_{th} sector,

$$X_i = \sum_{j=1}^{n} a_{ij} X_j + F_i \qquad (D.11)$$

In this analysis, he initially concentrates on the intermediate sector by assuming that the i_{th} sector's final demand delivery F_i is equal to zero. This assumption, to be relaxed later, will allow us to normalize the elements of the matrix A with the corresponding row sums

$$\sum_{j=1}^{n} a_{ij} = a_{i.} \qquad (D.12)$$

and column sums

$$\sum_{i=1}^{n} a_{ij} = a_{.j} \qquad (D.13)$$

for all i and j.

Normalization of the rows of A results in an n x n matrix $C = [c_{ij}]$, with $c_{ij} = a_{ij}/a_{i.}$, $c_{ij} \geq 0$ and $\sum_{j=1}^{n} c_{ij} = 1$.

Complete uniformity of inter-sectoral distribution occurs when-all sectors receive the same quantity of input from the i_{th} sector; hence, $c_{ij} = 1/n$ for all j. We have complete skewness in inter-sectoral distribution when only one sector receives the total output of the ith sector as input; therefore, $c_{ij} = 1$ for some j and $c_{ij}=0$ for all other j. Note that $V_i=0$ if and only if $c_{ij}= 1/n$ for all $j= 1, \ldots, n$, and $V_i=n-1$ if and only if $c_{ij} = 1$ for some j and $c_{ij} = 0$ for all other j. Therefore there is an inverse correspondence between the coefficient of variation and uniformity of inter-sectoral distribution. For example, consider the coefficient of variation of the i_{th} row of A

$$V_i(a_{ij}) = \frac{\sqrt{1/n \sum_{j=1}^{n}(a_{ij}-1/n a_{.j})^2}}{1/n\, a_{.j}} \quad i = 1, \dots, n \qquad \text{(D.14)}$$

Algebraic manipulation of equation (D.14) leads to

$$V_i(a_{ij}) = \sqrt{n}\sqrt{\sum_{j=1}^{n}(c_{ij} - \frac{1}{n})} \qquad \text{(D.15)}$$

which implies

$$V_i^2\,(a_{ij}) = n\sum_{j=1}^{n}(c_{ij}^2 - 1) \qquad \text{(D.16)}$$

Noting from equation (D.16) that max$[V_i^2(\ a_{ij})]\ = n\ -\ 1$, define the following measure of concentration:

$$G_i(a_{ij}) = \sqrt{\max(V_i) - V_i} = \sqrt{n(1 - \sum_{j=1}^{n} c_{ij}^2} \qquad \text{(D.17)}$$

When there is no variation in a sector's sales to (purchases from) other sectors (when $c_{ij}= 1/n$ for all j), i.e. when $G=\sqrt{n-1}$, then the sum of industry sales (purchases) will also determine the number of direct sectoral ties. In this case complete uniformity in inter-sectoral transactions exists. Generally, however, given the sum of the i_{th} industry's sales (purchases), a large value for G implies more direct industry ties. In contrast, a small measure of concentration (a small value for G) implies fewer interindustry sales or purchases. In the extreme case where $G = 0$ ($c_{ij}= 1$, for one j), total skewness in sectoral transactions prevails, which implies maximum concentration. Similarly, $G_j(a_{ij})$, $G_i^{\omega}(b_{ij})$ and $G_j^{\omega}(b_{ij})$ may be calculated.(ω: weighted)

Note that according to the foregoing analysis, in practice the ranking of *G*s should be in descending order of magnitude, which is congruous to the ranking of U^{ω}s.

Along the lines of Diamond's work (1974)[16] we can construct a general index *GI* representing the combined effects of *RU* and *RG*, the ranks of *U* and *G* respectively, as follows[17]:

$$GI = \alpha RG + (1-\alpha)RU \qquad \text{(D.18)}$$

where α is the weight to be attached to the *G* index. The parameter α reflects planners' preference for the sectors with uniform industry sales and purchases. This index generalizes Diamond's approach. It should eliminate the possibility of confusion arising from opposite ranking of the *U*s and *V*s.

Rewriting equation (D.18) as

$$GI = \alpha(RG - RU) + RU \qquad \text{(D.19)}$$

we can observe the following possibilities. First, when $RG = RU$, then the ranking of *U* or *G* alone should suffice in decision-making. Second, for $RG > RU$, the sectors with a lower measure of concentration and high linkages are ranked lower than sectors with the same linkage value but a higher measure of concentration. Third, for $RG<RU$, the *GI* value will lower the *U* ranking of the sector. Accordingly, given two sectors with equal linkage index but different concentration measures, the *GI* index will rank the sector with the larger concentration measure higher.

Note that the *GI* index modifies the ranking of sectors with wide differences in values for *G* and *U*. Also, the *GI* index will have a small effect in the ranking of sectors with small differences between the *G* and *U* rankings.

Entropy as a Measure of Variation

From a review of the literature one can observe two parallel developments in the measurement of industry linkages and interconnectedness. The traditional approach, the multi-sectoral linkage method, emphasizes the quantitative importance (the output multipliers) of each sector in the

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16 DIAMOND, J. 1974. "THE ANALYSIS OF STRUCTURAL CONSTRAINTS IN DEVELOPING ECONOMIES: A CASE STUDY*." Oxford Bulletin of Economics and Statistics 36 (2): 95–108. https://doi.org/10.1111/j.1468-0084.1974.mp36002002.x.

17 I use U as a generic term to include all linkage indices regardless of the data used in their calculation.

economy. The number of direct and indirect industry ties is implicitly accounted for in these indices. The entropy-based and other holistic measures (including the index of diversification and indirect industry relatedness), however, tend to concentrate on measures of interconnectedness in an economy and provide a single scalar, a holistic measure, of the input-output table that summarizes the degree of interconnectedness of the table and is purportedly descriptive of the characteristics of the economy as a whole. (Soofi, 1992)

Soofi (1992) in his paper, instead of calculating a single holistic measure, calculates entropy-based sectoral measures of the dispersion of transactions in an input-output table. He uses the Shannon formula (Shannon, 1949)[18] to calculate the sectoral-holistic measures. These indices are then used to compare the degree of industry in interconnectedness and hence the structure of production of the economies under investigation.

To calculate the sectoral-holistic indices, transform the input coefficient matrix *A* into the matrix of input coefficient proportions, *C*. These proportions are then the counterparts of the probabilities attached to the occurrence of n events. Hence they are subject to the same mathematical manipulations that allow the use of the Shannon formula. (Ibid)

The entropy H_i of the i_{th} sector is given by

$$H_i\left(a_{ij}\right) = \sum_{i=1}^{n} c_{ij} \log\left(\frac{1}{c_{ij}}\right) = -\frac{1}{a_{i.}}\sum_{j=1}^{n} a_{ij} \log a_{ij} + \log\left(\sum_{j=1}^{n} a_{ij}\right) \quad \text{(D.20)}$$

Similarly the entropy of the j_{th} sector is given by

$$H_j\left(a_{ij}\right) = \sum_{j=1}^{n} c_{ij} \log\left(\frac{1}{c_{ij}}\right) = -\frac{1}{a_{.j}}\sum_{i=1}^{n} a_{ij} \log a_{ij} + \log\left(\sum_{i=1}^{n} a_{ij}\right) \quad \text{(D.21)}$$

Note that the c_{ij} in equation (D.21) are defined as $c_{ij}= a_{ij}/a_{.j}$ .Maximizing equation (D.20) subject to $\sum_{j=1}^{n} c_{ij} = 1$ and solving for c_{ij} yields $c_{ij}= 1/n$, implying that the maximum entropy value is equal to $\log n$.

Accordingly, the entropy for each sector (row) is conceptually parallel to the coefficients of variation V_j; and the entropy for each column is a counterpart of the V_i. The row entropy for the i_{th} sector, $H_i(a_{ij})$, is zero when the j_{th} sector is the only sector which purchases additional output from' the i_{th} sector after the i_{th} sector delivers one dollar's worth of its output to the final demand. This is the minimum entropy sector. $H_i(a_{ij}) = \log n$ when all sectors of the, economy purchase an equal amount of output after the i_{th} sector delivers one dollar's worth of its output to the final demand. This is the maximum entropy sector. The higher the variations in the sectoral response to a change in the delivery of the i_{th} sector's output to the final demand, the lower the value of $H_i(a_{ij})$.

Similarly, the column entropy for the j_{th} sector, $H_j(a_{ij})$, will be zero if the j_{th} sector purchases additional output from only one industry in response to the i_{th} sector's delivery of one dollar's worth of output to the final demand. $H_j(a_{ij}) = \log n$ if the j_{th} sector uniformly increases its total intra-industry and interindustry purchases in response to a change in the i_{th} sector's delivery of output to the final demand. The maximum/minimum entropy is used, then, in defining the interval for row/column entropy: $0 \leq H_i(a_{ij}) \leq log^n$ and $0 \leq H_j(a_{ij}) \leq log^n$ respectively.

To prepare a total requirement matrix for use in calculation of sectoral-holistic entropy indices, normalize the matrix by its row and column sums (the elements of the matrix $b_{ij}s$ are divided by the $\sum b_{ij}=b_{i.}$ and $b_{.j}$ respectively).

In addition to large numerous deliveries to the processing sector, and industry may also have economically significant deliveries to the final-demand sector of the economy. Therefore the economic importance of a sector is not exclusively determined by its deliveries to the intermediate sector of the economy. Additionally, one can cite examples of industries that exclusively deal with the final-demand sector of the economy. In such circumstances, however, the entropy measure as

[18] Shannon, Claude Elwood. 1948. "A Mathematical Theory of Communication." The Bell System Technical Journal 27 (3&4): 379-423,623-656. https://doi.org/10.1002/j.1538-7305.1948.tb01338.x.

applied above will misrepresent the sector. To account appropriately for the sectors with strategic important final-demand deliveries, the entropy formula can be applied directly to the flow table.

To measure the impact of deliveries to the processing sectors as well as the final demand sectors, describe the economy by

$$X_i = a_{i1}X_1 + a_{i2}X_2 + \cdots + a_{in}X_n + F_i \quad i = 1, \dots, n \qquad \text{(D.22)}$$

To normalize the system of equations (D.22), divide both sides by X_i and apply the entropy formula (D.20) to the proportions. The calculated entropy values measure interindustry sales as well as sectoral sales to the final demand.

The interpretation of the H_i and H_j that are based on (D.22) is straightforward. $H_i = 0$ when the i_{th} sector sells to one sector only. $H_i = log\ (n + 1)$ when the i_{th} sector sells an equal amount of output to all intermediate sectors as well as the final-demand sector of the economy. Also, when $H\ j = 0$ the j_{th} sector buys from, one sector, and when $H_j = log\ n$ the j_{th} sector purchases uniformly from all other sectors. Therefore, the entropy can measure the degree of industrial interconnectedness by measuring the dispersion of row and column elements in an input-output matrix.