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ABSTRACT

This university level course in economic geography emphasizes the need for control of the spatial allocation of our resources, and strives for heightened student awareness of the world as a complex. It may thus be considered an introduction to geocybernetics, the study of man/machine relationships in the control of spatial organization. A systems analytic technique within behavioral and cybernetic contexts is emphasized showing how a geographer can tackle a problem, and presenting a general framework or philosophy. It is a convenient organizing technique because of: 1) the treatment of large complexes as wholes, not as mechanistic parts; 2) the encompassing of concepts of interaction and spacial relationships within socioeconomic systems; and, 3) the inclusion of values, goal-seeking, decision-making, and symbolic cognitive processes important to human behavior and landscape patterns. 1) The course begins with the pure, abstract notion of a general system, and considers why the system concept is operational; 2) then links it with other concepts using interaction models; 3) examines the economic elements in the global system including: agriculture, resources, manufacturing, service systems, transportation; and, 4) finally produces the concrete concept of the terrestrial spatial system. Interwoven are concepts of order and regularity, the theories to explain order, and the analytical procedures used to test them. An appendix describes the mathematical models. (Author/SBE)

A SYSTEMS ANALYTIC APPROACH TO ECONOMIC GEOGRAPHY

ASSOCIATION OF AMERICAN GEOGRAPHERS

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PREFACE

We wish to gratefully acknowledge the constructive comments by the following persons on earlier drafts of this outline: Professor R.H.T. Smith, Professor E.J. Taaffe, Professor R.C. Brown, Professor J.W. Simmons, Mrs. E.W. Eliot Hurst, Mr. George E. Bushell, the students in Geography 221, Fall 1967, at Simon Fraser University, and the students in Geography 39/339, Summer, 1968, at the University of Western Ontario.

Mrs. E.W. Eliot Hurst (a social anthropologist) and Professor E.M. Gibson (a cultural geographer) deserve special mention for their stimulus and encouragement in developing a behavioral economic geography.

We hope that no one will associate these reviewers with any flaws, pedagogical or otherwise, which may remain in this work. We have not always been wise enough to heed their advice!

We are especially grateful to the Commission on College Geography for the opportunity to present our views for critical evaluation.

Robert McDaniel
University
of
Western Ontario

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Simon Fraser
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October, 1968

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A SYSTEMS ANALYTIC APPROACH TO ECONOMIC GEOGRAPHY

INTRODUCTION

"The rising tempo of contemporary change is perhaps the most bewildering challenge facing man today. He must either exercise intelligent control over his own destiny or be swept away by blind and run-away forces beyond his reach."[1]

This course in economic geography emphasizes the need for control of the spatial allocation of our resources. It may thus be considered an introduction to geocybernetics, the study of man/machine relationships in the control of spatial organization. The approach is concerned not simply with describing how geographers tackle problems, but attempts to present a Weltanschauung which will assist the student to recognize and to frame his problems.

An earlier course outlined by K. W. Rumage and L. P. Cummings[2] emphasized the view of the Iowa School which stresses that geography is a problem-solving discipline and emphasizes statistical analysis and significance testing. This course outlined below differs from that earlier one in emphasizing a systems analytic technique within behavioral and cybernetic contexts. Thus this approach is more comprehensive than the earlier view, containing the latter as a technique. It is concerned with more than showing how a geographer can tackle a problem, in also attempting to present a general framework or "philosophy."

There have been four or five types of change within economic geography in the last 20 years, that are of particular importance to teaching at the university or school level. These are quantitative methods, systems analysis, probability or chance processes, the use of models, and a convergence with other subdisciplines and disciplines.[3] This course emphasizes the second and last of these, but it is obvious that these types are not mutually exclusive.

It should also be explicitly noted that, although the authors recognize the behaviorist trend in the field and indeed support and encourage it, an alternative development is human disengagement through automation.

Systems Analysis

"Control is an attribute of a system. This word is not used in the way in which either an office manager or a gambler might use it: it is used as a name for connectiveness."[4]

Thus system can be described as a number of parts making a complex whole, and systems analysis means consideration of that complex interrelated whole, as opposed to the study of the individual parts separately.

1. Harold Sackman. "Computers, System Science. and Evolving Society," Wiley. 1967. p. 4.

2. K. W. Rumage and L. P. Cummings, "Introduction to Geography: a spatial approach," in 'New Approaches in Introductory College Geography Courses'. Commission on College Geography, Pub. No. 4, 1967, pp. 113-166.

3. These are covered in greater detail in R. C. Brown and M. E. Eliot Hurst, "Recent changes in economic geography." *Journal of Geography* forthcoming, October, 1968.

4. Stafford Beer, "Cybernetics and Management," Wiley. Science Edition, 1959, p. 9.

A systems analytic approach to decision-making about spatial allocations frequently implies viewing the space-economy as points and lines (or sites and routes).[9] "The lines depicting the network of our system are in fact its communications. The state of the lines at any given moment reflects the amount of information in the system. The structure of the communications and the nature of the information which flows through them to one of the elements of the system will determine, at any given moment, whether this element is in a given state or not. If we liken the system to an electric circuit, then the existence of power in some portions of the communication network is a form of information reaching the elements concerned, and will switch it on or off. This is fundamentally a decision-making process."[10]

The point here is that the flows, of various kinds which characterize the space-economy, are usually initiated by a human decision. Increasingly, however, routine decisions are being delegated to an electronic computer. We must learn how these two forms of decision-making affect the spatial pattern of economic activity.

Thus the systems analytic approach is a convenient organizing technique for the economic geographer because:

(a) it has a common vocabulary for all behavioral and non-behavioral subjects;

(b) it is a technique for treating large complexes as wholes, not as mechanistic parts. Thus all parts receive equal weight;

(c) it encompasses a number of concepts crucial to geography, such as interaction and spatial relationships, which can be viewed as the result of information and circulation nets within socio-economic systems, and

(d) it can also encompass values, goal-seeking, decision-making and symbolic cognitive processes which are themselves recognized as of increasing importance to human behavior and landscape patterns.[11]

The Behavioral Context

Economic geographers have tended until recently to consider problems either descriptively or from the point of view of optimal solutions and 'economic' man. By themselves neither approach is sufficient; the boundaries of disciplines are artificial and there has been an increasing contact and overlap with other parts of geography and other social sciences. Optimal solutions make both implicit and explicit assumptions about behavior, that man is all knowing, all seeing, and always rational. In fact, economic geographers are interested in all forces, particularly those spatially identifiable, that influence economic activities as they are carried on within the milieu of the earth's varied cultural and physical settings. These forces may be physical, social, cultural or political, as well as economic.

From without Geography, the subdiscipline has been influenced by recent work in sociology, anthropology, and psychology. From these come our present concern with behavior and the forces that influence that behavior, whether it be economic or social. Man's economic behavior is seen as the result of his perception of the total environment, but his perception

9. Philip Wagner, "The Human Use of the Earth," Free Press, 1960, pp. 119-125.

10. Beer, op. cit., p. 11.

11. See, for example, W. Buckley, 'Sociology and modern systems theory,' Prentice-Hall, Englewood Cliffs, 1967.

is moulded by his individual and group values, and his learning processes. Any actions finally taken contain some degree of uncertainty as to results. This uncertainty arises through the imperfectness of human decisions, through the multiplicity of equal choice, and through the multiplicity of small causes and counter causes. This viewpoint obviously rejects rational man, that certain, all knowing, optimising, economically rational concept. One social scientist, Simon, calls this rational man, the optimiser, and suggests that we replace him with the satisficer.[12] The satisficer within his perceptual bounds chooses a course of action which is "good enough" and not necessarily the best in economically rational terms. To be the optimiser requires a more deterministic world, more information, and decision processes at levels higher than we normally operate.

A number of recent studies have adopted these perceptual, uncertainty, and satisficer concepts. A study of location behavior by Pred has set decision-making in agriculture, manufacturing industry, and retailing within a behavioral matrix; he compares results obtained from economically optimal models within the behavioral framework.[13] McNee has suggested we view the spatial patterns of the production process within the context of the values system held by a particular society,[14] and Gould sees the growth of crops and animals as set in part by the views of the farmer of the world around him—his 'mental image' of his environmental setting.[15] Besides these attempts several other papers examine the behavioral approach as to agriculture decisions,[16] flood plain occupance,[17] traffic and individual movement,[18] and uncertainty principles;[19] and there is a new textbook in preparation which emphasizes the behavioral approach to the analysis of all economic activities.[20]

The Cybernetic Context

The linking of the techniques of operations research with information technology has influenced decision-making in three ways:

(a) the location of a given decision-type is shifting (centralizing?),

12. H. A. Simon, "A Behavioral Model of Rational Choice," *Quarterly Journal of Economics*. Vol. 69, 1952, pp. 99-118.

13. A. Prod, 'Behavior and location,' Part I, (Lund, C. W. K. Gleerup, 1967) Lund Studies in Human Geography, Series B, No. 27.

14. R. B. McNee, "Toward stressing structure in geographic instruction, or goodbye to Hevea braziliensis and all that," in 'Introductory Geography: viewpoints and themes,' Commission on College Geography 1967, Pub. No. 5, pp. 31-44.

15. P. R. Gould, "On mental maps," Michigan Inter-university community of mathematical geographers, discussion paper No. 9, 1966.

16. J. Wolpert, "The decision process in spatial context," *Annals* Assoc. Am. Geogrs., Vol. 54, No. 4, 1964, pp. 537-558, or P. Gould, "Man against his environment: a gametheorotic framework," *Annals* Assoc. Am. Geogrs., Vol. 53, No. 2, 1963, pp. 290-297.

17. R. W. Kates, 'Hazard and choice perception in flood plain management,' Chicago Press, Paper 78, 1962.

18. Marble, "Simple Markovian model of trip structure in a metropolitan region," *Procs.*, Western Section Regional Science Assoc., Tempe, Arizona, 1964; and M. E. Eliot Hurst, "Household behavior and individual movement structure," *Urban Studies*, forthcoming.

19. L. Curry, "Regional variation in the seasonal programming of livestock farms in New Zealand," *Economic Geography*, Vol. 39, No. 2, 1963, pp. 95-118.

20. M. E. Eliot Hurst, 'A geography of economic behavior,' Belmont, Wadsworths, forthcoming, April 1969.

(b) the quality of the decision is improved (more rational?),

(c) the fact that the decision-maker knows that he can do so much more with increasing data is leading to a shift in attitude toward research possibilities (control of human evolution?).

Automation can be most successfully applied where the phenomenon being processed is characterized by continuous flow. Thus oil refineries, power generating stations and telephone systems are examples of highly automated processes.

The flow of information can be made continuous. Indeed this is what makes automation possible. The continuous transmission of electronic data, automatically analyzed by a computer which is programmed to issue instructions (again electronically) is the sine qua non of space travel and the SAGE defence system.

There seems to be developing a conscious effort to disengage man from routine procedures, such as operating machine tools, flying aircraft and driving automobiles. We can even observe how a bank trust officer makes decisions to buy and sell stocks and bonds, and then program a computer to do the job more efficiently.

The gradual extension of the automated factory to the cybernated space-economy will have considerable impact upon economic geography. Speculation and research in this area is in a barely embryonic form as yet.

It is fitting, however, that we consider both the behavioral and the cybernetic contexts in this course, since both are important in the obvious developmental trend toward joint man/machine decisions.[21]

Topic Sequence

Having introduced the conceptual background of the course, we now turn to its substantive content. We shall adhere to the following list of topics:

PART 1 - Basic Concepts
- general systems theory
- cybernetics
- information technology
- concepts of spatial patterns
- behavioral analysis
- an economic system

PART 2 - Models of Interaction (systems)
- input-output system
- linear programming
- gravity model
- graph theory

PART 3 - The Agricultural System
- elements
- location theory
- technology
- behavior

PART 4 - The Resource System
- elements

21. Sackman, op. cit., and Howard Thompson,' Joint man/machine decisions,' Systems and Procedures Assn., Cleveland, Ohio, 1965.

- Barnett/Morse vs. traditionalists
- The "information resource," – resource management
- perception

PART 5 - The Manufacturing System
- elements
- location theory
- technology
- behavior

PART 6 - The Tertiary System
- elements, urban systems
- central place theory
- technology
- behavior

PART 7 - The Transportation System
- elements
- theory
- macrogeography, the link between transport and the analysis of spatial distribution and space relations
- technology
- behavior

PART 8 - The Total Spatial System
- stages and levels of economic organization
- determinants of structure
- sites and routes
- regional organization; customs unions, free trade areas, preferential areas, economic communities, intranational economic regions
- optimization of sites and flows

PART 9 - Problems of Economic Organization and Location (malfunctions of the system)
- levels of development, organization, productivity, and wealth
- demographic influences
- theories of economic growth and change
- behavioral variants
- problems encountered by newly developing and rapidly industrializing countries

Conclusion: the world economy as systems

Thus the course begins with the pure, abstract notion of a general system, considers why the "system" concept is operational, links it with other concepts, examines the economic elements in the global system, and finally produces the concrete concept of the terrestrial spatial system. The normative global system is compared with actual real world deviations.

Interwoven throughout are concepts of order and regularity, the theories developed to explain order, and the analytical procedures used to test them. Herein lie the behavioral and empirical aspects of the course.

On the successful completion of the course the student has a heightened awareness of his world as a complex, interdependent array of elements, which are his to control ar ould according to his perception. Such a conclusion seems to be quite .. ping with the spirit of an age of operations research, management sc. ce, operation "Plowshare," and Marshall McLuhan.[22]

PART 1 - BASIC CONCEPTS

General Systems Theory (GST)

"Recent decades have brought increasing frustration as it is found that no one or two specialities are capable of dealing satisfactorily with any one problem. The problem of smog in some urban areas, for example, involves many kinds of contributing factors. A complete understanding of the problem involves knowledge of climate, the molecular behavior of gases, the chemistry of the automobile engine whose exhaust helps create smong, the number of automobiles, the geographic layout of the city, including the location of its homes, work places, and highway arteries, the availability of alternate means of transportation, the speed of traffic and the timing of traffic lights, the incomes of the population, the chemistry and biology of the lungs and blood stream, problems of microbe and virus growth under the chemical, light, and temperature conditions produced by smog—among many other problems. A problem of this sort can be dealt with only by a combination of specialists, and the "interdisciplimary" approach to problems in recent years has been rampant.

"To group specialists from various disciplines around a single problem is probably a technique which the human race will have to use from here on out. Simultaneously, however, a movement is underway to combine, synthesize, and simplify some of the related fields of knowledge so that there will be fewer specialties, or at least a greater amount of common knowledge and technique which will permit a person to move more easily among different specialties, and make greater use of their special contributions. This movement is going on in many places, the Society of General Systems Research. . . being among the more conspicuous examples."[23]

General systems theorists hope to develop a common language and viewpoint which will facilitate a greater exchange of ideas among the diverse fields of knowledge. This general systems language will complement the traditional lingua franca of science—mathematics.

GST thus has certain basic concepts and methods applicable in all fields. One of the most useful and fundamental concepts is the principle of feedback.

In feedback, information about one stage of a process is returned, or fed back (recycled) to a controlling device of an earlier stage to influence its action and to continue to maintain equilibrium. Thus consider an automatic traffic control system. The flow of cars is detected by a remote-sensing device which transmits the information to a central computer; the information is analyzed, a decision made and new instructions (feedback) sent out to the affected traffic lights. Feedback occurs within all systems in order to achieve homeostasis or maintenance of balance within the system.

22. M. McLuhan, 'Understanding Media: The Extensions of Man,' McGraw-Hill, 1964.
23. Alfred Kuhn, 'The Study of Society,' Irwin-Dorsey, 1963, pp. 4 and 5.

The concept of information plays an important role in GST and will be discussed below. To receive information and to act on the basis of such information is the essential function of every system. Related to information is the concept of entropy which may loosely be described as a tendency toward disorder or randomness. The randomness of entropy is in contrast to the different·ation of parts in an ordered system. Negative entropy (usually equated to information) is movement in the direction of increased order.

Two further concepts are those of open and closed systems. Closed systems are "those which possess clearly defined closed boundaries across which no import or export of materials or energy occurs."[24] Closed systems tend toward a state of maximum entropy, change only occurs through innate or given differences within the system. Given the initial elements, one therefore knows how the system will interact and develop. For any model, this is a useful concept since we frequently deal with static conceptions, though in the real world closed systems are rare, if they occur at all.

An open system is quite different in that it needs an energy supply for its maintenance and preservation. Such systems may attain a steady state in which the import and export of energy and material are equated by means of an adjustment of the form of the system itself.[25]

In general, for any one system, the larger system to which it belongs is its environment, and the small systems (subsystems) within it are its components. Any system must contain at least two interacting components,[26] or it is not a system.

The concept of system has made its most explicit appearance in geography as ecosystem. Stoddart has summarized his views on this concept in a recent paper.[27]

Suggested Reading

1. L. von Bertalanffy, "General systems theory," General Systems Yearbook, Vol. 1, 1956.
2. *G. Burck, 'The Computer Age,' (Harper and Row, 1965).
3. K. E. Boulding, "General systems theory—the skeleton of science," Management Science, Vol. 2, 1956.
4. B. J. L. Berry, "Approaches to regional analysis: a synthesis," Annals of the Association of American Geographers, Vol. 54, 1964, No. 1.
5. *M. Chisholm, "General systems theory and geography." Transactions, Inst. of British Geographers, No. 24, December 1957, pp. 45-52.
6. *J. Diebold, 'Beyond automation,' (McGraw-Hill, 1964), Chapter 3, "High promise of information technology."
7. D. P. Eckman, 'Systems: Research and Design,' (Wiley, 1961).
8. *S. D. Popell, 'Computer time sharing,' (Prentice-Hall, 1966).

24. R. J. Chorley, 'Geomorphology and General Systems Theory,' U.S. Geological Survey, Prof. Paper 500-B, 1962.

25. Both the concepts of *entropy* and *homostasis* have come under attack; see, for example, Beattie, *op. cit.*

26. Blalock and Blalock, "Toward a clarification of System Analysis in the Social Sciences," *Philosophy of Science*, April, 1959.

27. R. D. Stoddart, "Organism and Ecosystem as geographic models" in R. J. Chorley and P. Haggett, 'Models in Geography,' Methuen, 1967.

9. *D. R. Stoddart, "Geography and the ecological approach," Geography 50, 1965, pp. 242-251.
10. *J. W. Thompson, "Meteorological models in the Social Sciences," General Systems, Vol. 8, 1963.
11. O. R. Young, "A survey of general systems theory," General Systems, Vol. 9, 1964.
*—most suitable for undergraduate reading at this level.

Cybernetics

Many writers would consider general systems theory and cybernetics as synonymous terms. For example, the Soviet scientist Kolman[28] describes cybernetics as a scientific theory which studies processes of totally different nature, but which are similar in their quantitative (i.e. mathematical model) form and which therefore lend themselves to a unified treatment. He uses oscillations as an example noting that they may be qualitatively different, but that their quantitative form will be general. He argues that "scientific analogy" is not only permissible but is indispensable in science. The similarity between this view and that of the West's general systems theorists is striking.

In this course, we view cybernetics as the application of GST to real world problems. Following Wiener,[29] we would define cybernetics as the scientific analysis and control of animate or inanimate systems, based upon their methods of communication. It emphasizes the essential unity of all systems, human or nonhuman, stressing such functional parallels as neural networks and electronic circuits, and is therefore a natural follow-up of general systems theory. Comparisons are made between the very similar structures of man, machine, and society, which can be best understood and controlled through the study of their control and communication facilities. The messages of control between man and machine, machine and man, and machine and machine are seen to play increasing roles in society. The newer computation machines with their ability to calculate, compute, retain in memory, react to environment, and select free alternatives on the basis of experience, that is to duplicate to a high degree the human system, provide the background and basis for all current cybernetic activity.

As mentioned in the introduction, a special emphasis is placed on the concept of control in this course. The authors hold the opinion that man must very soon begin to consciously plan his own evolution.[30] We must become more future-oriented,[31] hence the need for rigorous speculation about societal and technological developments[32] which may influence spatial organization.

Suggested Reading

1. W. R. Ashby, 'An introduction to cybernetics,' (Wiley, 1963).

28. Translation of E. Kolman's "What is cybernetics?" (1956) by A. Rappaport in '*Behavioral Science*,' Vol. 4, 1959.
29. N. Weiner, 'Cybernetics,' M.I.T., 1961.
30. See Sackman, *op. cit.*, for a full exposition of this view.
31. P. F. Drucker, 'Landmarks of Tomorrow,' Harper, 1959.
32. H. Kahn and A. J. Wiener, 'The year 2000,' Macmillan, 1967.

2. *C. Cherry, 'On human communications,' (Wiley, 1961).
3. C. T. Guilbaud, 'What is cybernetics'? (Grove Press, 1959).
4. *V. M. Glushkov, "Thinking and cybernetics," Soviet Studies in Philosophy, Vol. 11, No. 4, 1964.
5. *L. Kerschner, "Cybernetics: key to the future"? Problems of Communism, Nov-Dec., 1965.
6. I. Malyshev, "Cybernetics, economic planning, and the social system," Soviet Union Today, September, 1964.
7. C. E. Shannon and W. Weaver, 'The mathematical theory of communication,' (University of Illinois Press, 1963).
8. *N. Weiner, 'Cybernetics,' (M.I.T. Press, 1961), Chapter 8.
9. *N. Weiner, 'The human use of human beings,' (Doubleday, Anchor, 1954).
10. *C. R. Dechert, Ed., 'The Social impact of Cybernetics,' (Simon and Schuster, 1967).

Information Technology

A key feature of present technology is the increasing use of energy to augment human brain power, via electronic computers. Automation and space technology are ramifications of this new development. Concurrently there is a great increase in the use of mathematics and statistics in the solution of spatial problems, as we try to grasp the nature of whole systems. Up to now, though we were conscious of the many interrelationships among the things we studied in geography, we necessarily had to ignore many of these factors because of our physical inability to take them into account. Some of these problems would have taken a lifetime to solve simply because of the time-comsuming arithmetic computations required. But the electronic computer is changing all this, and it can aid the evolution toward a particular optimal spatial pattern of economic activities.

At present, systems exist for the storage of economic flow (input-output) data in a computer data bank. Geographical locations can be coded in such a way as to permit computer mapping and various other computer-based spatial analyses.

But whilst this development is one which will greatly alleviate the problem of data gathering, (as more and more firms resort to management information systems to facilitate and expedite control of production, inventory, and sales), our concept of a data bank is still a pretty primitive one. The second generation of such data banks is already being developed, and this is an on-line real-time (OLRT) information system. On-line is a "term applied to a system in which input data are processed as they are received,"[33] instead of periodic collection and processing. Real-time is the capability to receive data, process them, and return results to the source in a time compatible with the response needed by the generative source. The information system which most strikingly illustrates an on-line real-time capability is the one which controls the various space voyages launched by the U.S. and the U.S.S.R. Real-time in this instance, especially during the launching and landing phases, is measured in nano-seconds.

But OLRT Systems are now contributing to the control of business

33. D. F. Parkhill, 'The challenge of the computer utility,' Addison-Wesley, 1966, p. 196.

organizations. For example, here is a quotation form the Scientific American:

"Probably the most extensive and advanced use of a real-time system in industry today is that of the Westinghouse Electric Corporation. Its tele-computer center in Pittsburgh is becoming the nerve center of the corporation. The center started operating in 1962 as an automatic switchboard for messages in the teletype network that serves all the Westinghouse divisions. Today this system, in continual communication with about 300 plants, field offices, warehouses, distributors and applicance repair centers, is taking over the functions of inventory control and order processing on a vast scale. It has also begun to take a hand in production control and is steadily moving into new fields. The improvements in the company's operations have been dramatic. By directing shipments to customers from the nearest warehouse that has the ordered item in stock the system has speeded up deliveries and reduced transportation costs. It provides salesmen with information about the availability of products and about prices within minutes. It updates sales statistics continuously. (Authors' underlining.) It automatically requisitions replenishments when inventories fall below a given level. The data captured by the computer from the messages it is continually receiving and transmitting give the management a growing fund of timely information."[34]

One cannot help wondering whether what is good for Westinghouse is good for the total space-economy.

It does seem clear, however, that if we are to consider data banks at all, then we should seriously evaluate the feasibility and the implications of the OLRT information system on a regional and a national scale.

Such a capability would add significantly to the time-dimension of our spatial studies. We would be enabled to effectively probe the dynamics of our space-economy—the everchanging spatial pattern stemming from continuous variations in the direction, volume and nature of flows.

But, it may be objected, information systems may be fine for giant corporations such as Westinghouse. What about the majority of firms which may not economically aspire to such a system?

Here, again, a new development may be observed which seems to offer a solution to this very real problem. This is the computer utility. This new technology is essentially an OLRT capability plus a time-sharing capability. Time-sharing takes advantage of the speed with which a computer performs its operations. When a person communicates with the machine from a teletype console, his speed of input is vastly inferior to the speed with which the machine obeys his instructions. Thus it spends a great deal of time (relatively!) just waiting for the next instruction. In a time-sharing system, the computer cycles among many users, giving its undivided attention for only a few seconds or often less than a second. But the cycling is so rapid, that each user has the impression that he is the sole user of the machine.

Parkhill discusses the computer utility as

"a general purpose public system, simultaneously making available to a multitude of diverse geographically distributed users a wide range of different information processing services and capabilities on an on-line basis. As in any utility, the overhead would be shared among all users,

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34. M. Greenberger, "The Uses of Computers in Organizations," *Scientific American*, Vol. 215, No. 3, 1966, p. 200.

with each user's charges varying with the actual time and facilities used in the solution of his problems. Ideally, such a utility would provide each user, whenever he needed it, with a private computer capability as powerful as the current technology permitted but at a small fraction of the cost of an individually owned system."[35]

Complementary with this development is the tendency for accounting firms, which "keep books" for many small firms, to introduce computer-based information systems. To facilitate their operations, one may anticipate a trend toward standardization of invoicing forms among participating firms in order that they will be computer-compatible.

When our primitive, isolated data bank has evolved into a full-fledged, complex OLRT information system, we may expect a rather different man/computer relationship. It may be argued that this difference is in degree only, but we think that it will be a difference with a special significance. Some geographers might label it the "second revolution" in their discipline.

Let us try to elaborate.[36] At present, we tend to use the computer as an extremely rapid, and extremely efficient, calculating machine, and draftsman But the data we use are periodic, and subject to long delays in updating. The maps, no matter how sophisticated the analytical techniques employed, are static.

Yet another development is a graphic display device, the cathode ray tube (CRT). Given a time-series of spatially defined data (e.g. a series of digitized weather maps), perhaps transformed to a continuous surface, one can run this information sequentially through an appropriately programmed computer and display the results on the CRT. On the screen may be viewed a moving image representing changes in the climatological situation, or in the economic landscape over time. Such a dynamic image (which could be video-taped for repeated viewings) would provide further insight into relationships underlying the observed differential rates and directions of change.

An OLRT capability, in conjunction with the above CRT capability, would enable one to observe spatial changes as they were happening. This, we submit, is a difference in degree, which may lead to a difference in kind insofar as control of the space-economy is concerned. It would seem that such a continuous involvement (requiring as it must virtually continuous man/computer interaction) may lead to a mode of thinking quite different from that evolved in an environment kept at arm's length, so to speak.

But continual up-dating of data is very costly, and is it necessary? What constitutes real-time in one activity may lead to redundancy in another. Should data be reported daily, weekly, monthly, or hourly? The answer will depend upon the process speeds involved. Much research would be required to answer this question, using OLRT systems.

And how does a mere human cope with the problem of interpreting such a continuing flood of information? The solution to this problem may lie in some form of pattern recognition methodology. As we turn more and more detailed analysis over to the machine, we perhaps must devote equally increasing amounts of research effort to the development of modes of information display which the human brain can grasp. As humans, our strength appears to lie in the recognition of form and concept. Perhaps we have much to learn from the artist in this regard.

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35. Parkhill, *op. cit.*, p. 3.

36. Some support for some of the views presented may be found in H. Thompson, *op. cit.*

Much of the forgoing implies control of our space-economy through continuous electronic surveillance. It appears to be directly analogous to NORAD's continuous search for threatening signs via the DEW system and BMEWS. It therefore evokes images of "1984," and all that. And well it might.

Our concern is to ensure that our students not only can make use of this very useful intellectual aid, but that they also recognize explicitly its direct and indirect impact upon that same spatial organization which it helps them to study!

Suggested Reading

1. *Scientific American, Sept. 1966, special issue on information technology, pp. 65 onwards.
2. *J. Diebold, 'Beyond automation' (McGraw-Hill, 1964).
3. *2000: Communicating," Monetary Times, April, 1967.
4. R. Borchardt, "Computer systems: their effects on the organization," Systems and Procedure Journal, May-June, 1967.
5. L. G. Wagner, "Computers, decentralization and corporate control," California Management Review, Winter, 1966.

Concepts of Spatial Pattern

Geographic methodology operates in a spatial context, with particular references to spatial patterns. The term spatial refers to relative location, distance, and extent. One of the fundamental contributions of geography is the analysis of the relations between location and communication—a systems approach, where something is and the links which exist between it and other spatially separated points. To locate an activity means to locate that activity in relation to a spatial context. An economic activity itself is, amongst other things, characterized by its relative location—a reference to the point at which the activity occurs, and its relation to other activities and physical objects distributed in a spatial system.

The distance between the objects or activities represents an obstacle for interaction, and a spatial pattern in fact implies a pattern of distance. The spatial separation then of the activities initiates movement or an interaction between them under certain conditions to be discussed in the section on transportation. We also use the concept of distribution over space to refer to a pattern of activities spread over the earth's surface. Another useful term is spatial impact. Thus one might seek to know the spatial impact of a new highway through an urban area. What is sought is the effect of this highway upon other locationally-identifiable phenomena or activities, such as traffic flow, pattern of consumer travel behavior, and distribution of retail stores.

Distributions over space may be described as random, uniform or clustered. Each of these in turn refers to points, or areas assumed to be points. The spacing of such points results in varying density, which in turn will vary with area. Distributions may also be described by such terms as circular, elliptical, stellar or linear, by noting the shape assumed by the boundary points in the system. Generally, however, interest in distributions and their characteristics arises only insofar as they are symptomatic of some behavioral trait which we are trying to discover.

Nystuen[37] would add to our spatial concepts such others as direction or orientation, and connectiveness and accessibility.

Recent work in economic geography, and in allied fields of study within geography, such as urban and transportation studies, has pushed forward on a number of fronts: quantification, systems, models, stochastic processes, game theory, etc. These changes have strengthened both the abstract formulations of spatial distributions and spatial relations, and the substantive empirical work underlining man's resource changing and space adjusting technique. Four levels of analysis are identified by the Ad Hoc Committee report:[38]

(a) Static aspects of spatial patterns; this first level of studies is concerned with spatial distributions at various scales. Particular patterns (location, density, and the dispersion of phenomena such as population density, land values) are studied within a static framework (cf. nearest neighbour analysis).

(b) Location and geometry of connections; this level is concerned with the interrelationships or links within a system, such as central place theory, which shows not just the components of the system (e.g. retail stores) but how these components and the consumer are interlinked (cf. graph theory).

(c) Temporal dynamics of spatial patterns, the addition of the sometimes neglected time dimension. There are deterministic and stochastic studies of change: the effects of highway change on land use, or the spread of innovations, (cf. Monte Carlo).

(d) Normative models and efficiency solutions: the final level, the most abstract or generalized, which stresses what the solution ought to be, given a number of assumptions. Transport networks, price equilibria and trade flows have been studied this way (cf. linear programming).

Suggested Reading

1. W. Christaller, 'Central places in southern Germany,' trans, by C. W. Baskin, (Prentice-Hall, 1966).
2. M. L. Greenhut, 'Plant location in theory and practice,' (Chapel Hill, 1956).
3. *W. L. Garrison, "The spatial structure of the economy," parts 2 and 3, Annals of the A.A.G., Vol. 49, 1959, and Vol. 50, 1960.
4. P. Haggett, 'Locational analysis in human geography,' (E. Arnold, 1965).
5. A. Losch, 'The economics of location,' trans. by W. H. Woglom, (Yale, 1954).
6. *W. Isard, "Regional Science: the concept of a Region and Regional Structure," Papers and Procs., Regional Science Association, Vol. 2, 1956.
7. W. Isard, 'Location and space economy,' (Wiley, 1956).

37. John D. Nystuen, "Identification of some fundamental spatial concepts," in B. J. L. Berry, and D. F. Marble, Editors, 'Spatial Analysis,' Prentice-Hall, 1968.

38. Ad Hoc Committee on Geography, 'The Science of Geography,' NAS-NRC, 1965, pp. 44-53.

Behavioral Analysis

Up until the 1930's, geographers tended to view the world as static, fixed, and determined. At first, human behavior was seen to be predictable in terms of a given set of environmental factors, determined in fact by the physical environment and its component elements. Later this environmental determinism was replaced by a superficially less certain explanation, but one which still relied on a deterministic notion. The environment was conceived as a set of opportunities to be fashioned by man, sometimes with ease, sometimes with difficulty. However, to these possibilists, man could do most things, because he was all-knowing and everything was eventually certain. A freedom of choice existed, but there was a certainty of action and outcome.

More recently, a third approach has arisen which assumes that man only responds to the environment which he perceives, and that his decisions and behavior with respect (in our case) to economic activities can only have meaning within this perceptual environment. Man's behavior thus is determined neither by his physical environment nor any all encompassing rationality. The behavioral environment can be defined as all stimuli to which a particular individual or group responds, whether those stimuli be internal or external.

In rejecting those earlier deterministic viewpoints, we obviously also reject rational man, as a certain, all knowing, optimizing, economically rational being. Instead we can turn to Simon's concept of the optimiser and satisficer.[39] Since no man can possibly be aware of all alternatives when we come to make one economic decision, and since we do not know the final outcome of our actions, Simon says we do not try to optimize but that we satisfice. Thus we attempt to find a line of action that is satisfactory, and that we adopt it without necessarily being concerned about whether or not there may be a better course of action. In this view, human actions or behavior, are not determined by physical environment, free-will, or economic rationalism, but that decisions are made within the learnt abilities of the individual. That is we learn about possible courses of action, and go on learning until we find one which is satisfactory, not necessarily the best, but sufficiently satisfactory to be acceptable.

In real world terms, an individual does not have complete information, and if he did, he would not have learned how to assess it—this is Simon's notion of "bounded rationality." The satisficer within his perceptual bounds chooses as it were along a preference scale, which would vary from person to person and from group to group. This preference scale might stretch from say the optimal solution to a choice which makes one worse off, although the actual range of choices would be more restricted.[40]

To be the optimiser, or rational economic man, requires a more deterministic world, more information, and decision processes at levels higher than we normally operate. We may use these conditions to set up a model, and most models assume such rationality, against which we can measure the effects of 'imperfect' competition and the actions of men who are quite frequently markedly different from 'economic man.'

"A person is an emergent entity of and in a certain physical, social, and cultural milieu. He cannot be properly represented in isolation from his locale, or from the culture of the group of which he is a member, or

39. H. A. Simon, 'Models of man,' Wiley, 1957, Chapter 14; see pp. 3-4, this outline.

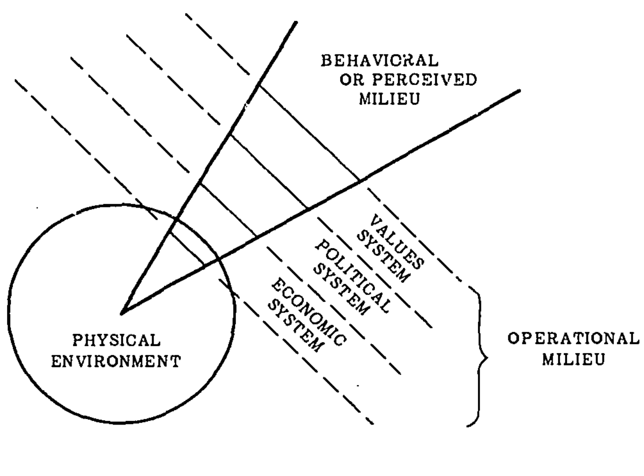
40. Eliot Hurst, *op. cit.*, especially Chapters 1 and 2.

from his status or role in the structure of that group."[41] Economic activities cannot be divorced from those environmental concepts, since they provide the operational milieu within which those economic activities are carried on. One may deny the importance of any part of the milieu for a particular activity, but it is difficult to completely remove one component from such a system. Environmental determinism may no longer be fashionable, but we cannot deny that the physical environment has some effect on say a farming practice. However, the physical environment alone would not explain farming practices, rather other aspects of the operational milieu would also have to be taken into account—perception, values-system, attitudes, and perhaps the market mechanism. To divorce economic geography from this milieu would substitute a mechanistic and simplistic notion divorced from any real world leanings.

Figure 1 outlines the importance of the milieu or environments to economic geography:—(a) there is the physical environment, a storehouse of certain minerals or resources, and a physical or biological realm within and on which man's production, consumption and exchange takes place; (b) an operational milieu, which is interposed between the physical environment and the actor. This milieu consists of interrelated elements representing a values-system, a socio-cultural system, an economic system, political system, etc. These govern the machinery of production, consumption and exchange; (c) a behavioral or perceived environment, the socio-psychological realm of the individual (or group) perceiver.

Implicit in this diagram, though not stated explicitly, is that all such interaction and activities take place in a spatial context.

FIGURE 1
A schematic representation of the milieu in which economic activities occur



SOURCE: Eliot Hurst, op. cit.

41. C. Hall and G. Lindsey, 'Theories of Personality' (New York, John Wiley. 1957). p. 185.

Spatial patterns are the results of course, of many human decisions. The knowledge of these decisions does not move freely or easily. The speed, direction, and effectiveness of the flow depends upon the communications systems available to a society, its values system, learning abilities and experiences, and its social structure. In the real world people making decisions are receiving information, are learners seeking to improve their choice, but perpetually grouping in uncertainty. Instead of an 'economic man' about whom all things are certain, our investigations replace him therefore with a figure who gropes his way towards what is to him a satisfactory solution or activity.

The importance of these concepts to economic geographic reasoning is fairly obvious. Not only is man non-rational in the strict sense, and groping in uncertainty, but he perceives around him only a selection of the alternatives open to him. Thus the economic decision-maker can be envisaged with his scale of preferences and choice set by the values he has, past and present experiences, perceiving in the physical environment and the world of socio-economic facts only what are filtered through highly selective screens of socio-economic values. Thus facts which exist in the physical environment, but do not enter the behavioral milieu of an individual or group, may have no relevance to his behavior.

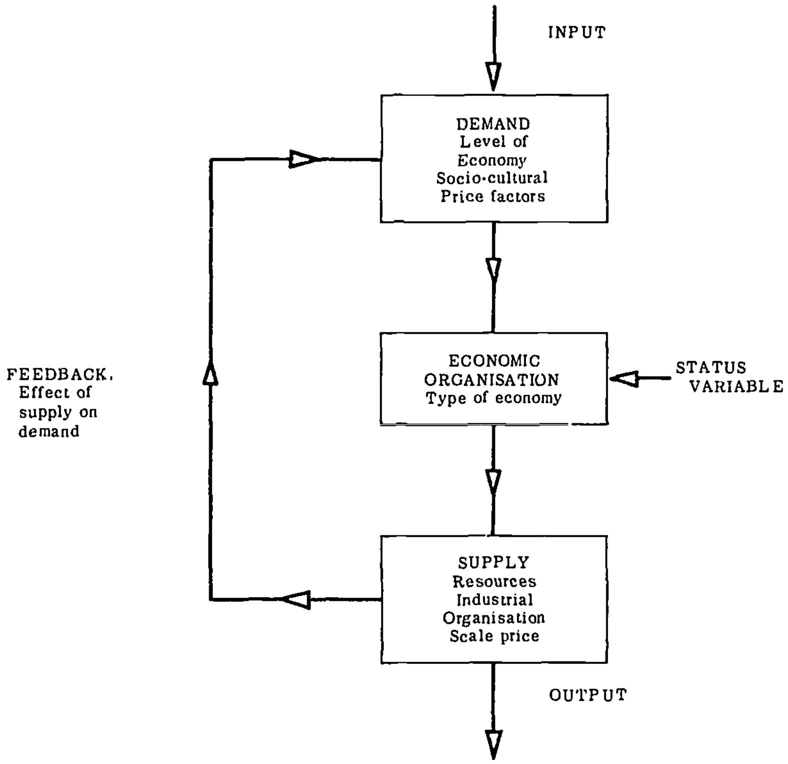
Suggested Reading

1. J. Blaut, et al., "A study of cultural determinants of soil erosion and conservation in the Blue Mountains of Jamaica," Social and Economic Studies, Vol. 8, 1959, pp. 402-420.
2. R. W. Kates and J. Wohwill (eds.), "Man's response to the physical environment," Journal of Social Issues, Vol. 22, No. 4, Oct. 1966, special issue.
3. W. Kirk, "Historical geography and the concept of the behavioral environment," Indian Geographical Journal, 1952, pp. 152-160.
4. *W. Kirk, "Problems of Geography," Geography, Vol. VLVII, Part 4, 1963, pp. 357-371.
5. *D. Lowenthal (ed.), 'Environmental perception and behavior,' University of Chicago, Department of Geography, Research Paper No. 109, 1967.
6. *D. Lowenthal, "Geography, experience, and imagination: towards a geographic epistemology," Annals of the A.A.G., 51, No. 3, 1961, pp. 241-260.
7. P. W. Porter, "Environmental potentials and economic opportunities – a background for cultural adaptation," American Anthropologist, LXVII, No. 2, 1965, pp. 409-420.
8. *H. A. Simon, 'Models of man,' (Wiley, 1957), Chapter 14, "A behavioral model of rational choice."
9. *H. and M. Sprout, 'The ecological perspective on human affairs,' (Princeton, Princeton University Press, 1965) Chapters 6 and 7.
10. *Yi Fu Tuan, "Topophila, or sudden encounter with the landscape," Landscape XI, Autumn 1961, pp. 29-32.

A Simple Economic System

Figure 2 shows a very simple model of an economic system. The input in the demand or need for goods and service in an area; the input variables are independent of the model itself, since they are determined by the operator of the model, but in systems terms they indicate the 'open' nature of the systems. The output is the supply of the services, which are entirely dependent upon what goes into the model, and will vary with the character of the input. A third type of variable can occur within the structure of the model, the status variable which specifies particular conditions, in this case the specific type of economic organization. These latter we can specify as subsistence (production and consumption by one independent family or extended family group) or exchange (goods and service exchanged, for money, barter, or some ceremonial value; consuming and production units separate). The latter can be divided into peasant (some exchange, but primary reliance on self-produced food), market-commercial (exchange regulated by an informal or formal monetary market) and redistributive (exchange regulated by a central social agency).[42]

FIGURE 2
A model of a simple economic system



SOURCE: Eliot Hurst, op. cit.

42. cf. Wagner, op. cit.

The operating characteristics or functions of the model set the internal relationships of the three variables to one another, in this case the function shows the link between demand and supply as modified by economic organization. More usually, demand, supply, and economic type are further specified. There is also a feedback effect, from the output (supply) back to the input (demand), as demand is further modified by increasing satisfaction or nonsatisfaction with the supply.

Such a system, considerably more refined, may be programmed and simulated on a computer, thus providing a method to aid the evolution toward a more socially desirable system.[43]

PART 2 – MODELS OF INTERACTION (SYSTEMS)

We have discussed the abstract concept of a general system. Such a concept would not be so important, perhaps, were it not also very useful. We must now consider how to make our verbal concept fulfill an operational, or analytical, role in the control of spatial organization.

The concept of system is of practical significance insofar as many real-world systems, such as economies, traffic flows and transportation networks, may be represented by mathematical models. Such models are symbolic abstractions, too, but do have the virtue of being deductively manipulable in a rigorous way, usually with the aid of a computer.

We shall demonstrate the operational character of systems analysis using the following models:

a. input-output analysis
b. linear programming
c. gravity model
d. graph theory

These models are introduced to the student at this time because they are viewed as straightforward extensions of the earlier discussion of systems. We want, also, to be able to refer to these models as we consider real-world problems during the course. There is an explicit attempt made to enable the student to see that, in many ways at least, real-world systems and their formal representations (models) are operationally synonomous. That is not to say, of course, that models are the real-world. But we wish to encourage the student to think analytically, hence suggest that he consciously translate his real-world perceptions into their relevant models.

Thus as the student observes the space-economy, it may be pointed out to him that there are two major problems to be solved:

1. internal consistency
2. efficiency

With respect to the first, the goals of the economy must be consistent with the level of resources available with particular group values, etc. to hand. There is little point in planning to build 100,000 cars if there are only resources available to produce 50,000. Input-output analysis can be applied to ensure internal consistency.

With respect to the second problem, efficiency, we note that there are two approaches: given a fixed stock of resources, we can attempt to maximize the number of cars produced; or given that we wish to produce

43. See, for example, G. H. Orcutt, et al., 'Microanalysis of socio-economic systems: a simulation study,' Harper and Row, 1961, and E. P. Holland, et al., 'Experiments on a simulated underdeveloped economy,' M.I.T. Press, 1963.

a fixed number of cars, we can attempt to minimize the resources consumed. This problem can be handled by linear programming.

Thus we find that two very practical problems facing a space-economy may be interpreted pro tem as synonomous with two appropriate mathematical models. Since we can manipulate (i.e. control) the models, this is perhaps indicative of an ability to control the space-economy within certain constraints.

The detailed development of these models of interaction has been placed in Appendix A in order not to disrupt the narrative of the course.

It is anticipated that, as probabilistic simulation models become available, these may supplement (or perhaps serve in lieu of) the deterministic models presented here. However, our main concern in this outline is to present an approach to economic geography, and not to argue the strengths and weaknesses of the various models.

In this part (and in Appendix A) we have tried to demonstrate that the systems analytic approach is more than esoteric jargon. It has been shown that the concept has operational power, and can result in a more effective control of human spatial organization.

We must now turn from technique to substance. During the next few parts of this report, we shall break the global system down into sites and routes. In turn, we shall discuss agricultural, resource, manufacturing and tertiary sites, and then the transportation and communication routes linking the sites. We finally re-integrate the components as a total spatial system.

Each part on sites and routes is intended to provide the conceptual framework which influences the location decision and subsequent fortunes of the activity in question. Though perhaps not made explicit at every point in this outline, it is expected that, as each concept or model is presented, its real-world counterpart is discussed. Methods of testing the validity of the model are explored. Through actual statistical testing, reading of the relevant literature or simple observation of such materials as may be available, the model is evaluated and modifications suggested.

Also throughout the course much emphasis is on the effects of new and developing technology, especially, as noted earlier, information technology. Our concern is to imbue the student with a feeling of mastery over his technology for fear that the alternative may be that he will be overwhelmed by it.

While we are naturally reluctant to "push" any specific textbooks, no fewer than four very relevant texts have been published this year. This is a coincidence which we feel obliged to act upon.

The books are:

1. R. J. Chorley and P. Haggett, 'Socio-economic models in geography,' (Methuen University Paperbacks, 1968).
2. H. O. Nourse, 'Regional economics,' (McGraw-Hill, 1968).
3. R. H. T. Smith, E. J. Taaffe and Leslie J. King, 'Readings in economic geography,' (Rand McNally, 1968).
4. M. H. Yeates, 'An introduction to quantitative analysis in economic geography,' (McGraw-Hill, 1968).

PART 3 – THE AGRICULTURAL SYSTEM

An agricultural system consists of a set of interrelated elements, which include the farm or farm area, which have certain attributes or characteristics like ploughing, planting, harvesting a range of crops and/or animals, functionally related through interrelationships with money, labor, attitudes, magico-religious systems, and so on; the basic inputs to the system are the social and biological needs of the society.

This agricultural system contains subsystems, like subsistence farming, commercial farming, collective farming—all with different land use and geographic responses, and some of these subsystems can be further broken down into forms like plantation, dairying, or mixed farming systems. In the case of the commercial subsystem, each unit or farmer is competing within a 'market context,' and is also competing for available labour, transportation and storage facilities. Each of these is associated with an interregional flow, whose proper scheduling could maximize the farmers' incomes. Thus, in this systems approach, we can see that through competition, farms in such an exchange or commercial economy are interlinked. And because of the economic interdependence of farms, in such a situation the operation of each is a function not only of its own climate, but indirectly of the climate of other farms and other areas.

This latter statement can lead us to an important distinguishing criterion of agricultural systems, commercial or subsistence, and that is a close dependence on the natural environment. This relationship could be put forward in terms of the farmer being in conflict with nature, so that the farmer's problem is what should be his strategy (i.e. his farming practice) in order to maximize his gain or minimize his loss (in food or monetary terms, according to the system). However, for other than the subsistence farmers, the farmer must take into account the market or demand conditions for his produce when he devises a strategy or practice.

Whilst man is limited in his agricultural practices by his relationship to the phenomenal environment, increasingly he is trying various ways to overcome certain of the limitations. To control climate, or rather to offset climatic extremes, the technological systems of certain socio-economic levels have given rise to irrigation, greenhouses, smudge pots, aforestation, and cloud-seeding. Methods have been developed to increase soil productivity by using fertilizers, improved ploughing and harrowing techniques, and through a development like <u>hydroponics</u> to eliminate dependence on soil entirely. Other sectors of the socio-economic system have aided the control of the life processes of plants and animals through improved breeding, through the development of hybrids, by continued research into basic processes like photosynthesis, and finally through efforts to control pests and weeds through the development and manufacture of pesticides and herbicides.

The use of these methods of surmounting environmental hazards ultimately depends, however, on the <u>attitudes</u> of a given farmer; we will come across this matter of attitudes in resource evaluation. Two basic attitudes can be delimited here:

(a) if the farmer takes a long term view, such as an owner mindful of his family might, then he may practice <u>genetic</u> agriculture, whereby he seeks to maintain the fertility of his land, or

(b) if he takes a short-term view, such as a tenant farmer who is anxious to maximize his annual return on a year by year basis might, then he may well 'mine' the soil through neglect to replace the elements removed by cropping, thus practicing <u>extractive</u> agriculture.

These are by no means universal attitudes, or the only attitudes, since various values-systems may not identify the value of genetic agriculture. However, even the most conscientious genetic agriculturalist must operate within the limits or constraints set by his own knowledge.

The distinguishing features of the agricultural system can be listed as:

(a) environmental constraints. Agricultural production is subject to the vagaries of weather and climate, despite the advance noted above. The magnitude or size of harvest is never certain until the crop is to be harvested. Biological characteristics also carry with them an inflexibility, so that agriculture is relatively inelastic in response to changes in demand.

(b) attitudinal variations. The farmer has to have the motivative knowledge, and ability, to perceive the various tools or strategies which are provided within the economic system. These farmer or farmer attitudinal variations are important in landscape terms, since as Wolpert[44] points out, unlike manufacturing, decision-making in agriculture is dispersed spatially amongst many farmers or producers. Thus even the diffusion of inventions and other technical information will show great spatial variability because of the dispersed pattern of decisions compared to the more concentrated patterns of manufacturers.

(c) farm size. Type of farming practised is often closely associated with the size of holding. Farms under five acres, for example, have little place for animals other than, say, poultry. In advanced economies, a farm under 100 acres will tend to specialize in dairying or truck farming, and yet many often tend to have a margin of economic insecurity.

(d) tenure is another structural attribute of considerable significance to the agricultural system. Tenure is a system or individual agreement under which land is held or occupied, e.g. commercial, freehold, tenancies, etc. They are important because they can affect the operation of the farm — planning over the long term, reliance on other resources, investment in cropping, or animals, and so on.

(e) marketing. Sales to the consumer directly from the farm are rare; quite frequently the farmers are dealing with markets too distant or too impersonal for direct contact. Small production quantities also lead to the use of middlemen, but in some instances farmers have organized their own cooperative marketing systems.

The existence of these marketing systems are of considerable importance to the continuance of many agricultural systems, since without such agencies a crop's production may be seriously curtailed, with its obvious effects on the landscape. Insecurity for the farmer via high costs from middlemen, uncertainty of markets, and fluctuating prices, could force a farmer to abandon a particular crop or crops, with obvious results.

(f) general economics of agriculture. Land is not generally economically productive of its own accord. For land to become productive, at least one other factor of production, labor, has to be available. At higher socio-economic levels, technological developments have increased yields without necessarily increasing land/labor inputs. In this way, capital has been substituted for land and labor. Also of concern here is the notion that an agricultural region or area tends to produce those products for which it has a special ability or physical advantage compared with other areas, or the least disadvantage. This factor is called the principle of comparative advantage.[45]

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44. Wolpert. op. cit., p. 10.

45. See, for example, R. L. Mighell and J. D. Black, 'Interregional competition in agriculture,' Cambridge, Harvard University Press, Chapter 2.

Heady[46] has noted that systems of farming derive ratios of advantaged or disadvantage as the result of the interaction of two broad economic relationships; firstly, the relations between various physical inputs like land, labor, and capital, and the ultimate output; and secondly, the relations between prices and costs. Price-cost relations can affect the rate of technological change, and can affect the farmer's final choice of what to grow and how to grow it.

Having examined some of the structural attributes of the agricultural system, one can identify a general framework within which agricultural practices may be placed. A fundamental distinction is between subsistence and exchange agriculture; the locational decisions involved are very different and will lead to differences in the landscape pattern. In subsistence agriculture the operating unit, as producer and consumer, is the household or extended family unit. Choices and decisions are made within that context, and even in dealing with the same crop as, say, a commercial exchange farmer, allowing for differences of technology and values-systems, the producing decisions would differ.

Exchange farming can be subdivided into peasant,[47] market-commercial and redistributive (state-directed) components. Some of the distinctive attributes of these types are summarized in Table 1.

Although agricultural systems are in reality complex, a number of theoretical conceptualizations exist. These are based upon a number of simplifying assumptions in order to help the disentanglement of the complex variables which affect the location of agricultural activities. Such conceptualizations involve economic rent (von Thunen), input-output analysis and linear programming, comparative advantage, game theory, information diffusion and hazard perception.[48]

Most of such models include unrealistic assumptions about behavior. There is also a tendency to assume that all land use patterns and practices which are now part of the landscape are optimal systems, only the best surviving. Many areas have suboptimal land uses, since the optimal solution is not perceived, because of current technologies, culture and perceptual abilities.

Thus models of agricultural location perhaps ought to incorporate some of the elements of learning and communication theory, as well as decision-making. But in an age of decreasing numbers of farmers, and automation, whose learning and decision-making characteristics ought we to be studying? How relevant are time and motion studies of a worker at a machine about to be converted to numerical control via a computer?

Computer-based information systems are being introduced into agriculture slowly. In dairying, for example, in Denmark and Canada, cooperating farmers may submit data on their operations to a data centre, where these data are analyzed by agricultural experts aided by a computer. The results are returned to the farmer with an interpretation and recommended action.

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46. E. O. Heady, 'Economics of agricultural production and resource use,' Englewood Cliffs, Prentice-Hall, 1960, Chapter 22.

47. "...I take the peasant to be the self-employed farmer (as distinct from the non-operating land owner) who is largely dependent on the labor of his family; and we may expect the contribution of this labor to be more important than the contribution of capital." E. Estyn Evans, "The ecology of peasant life in Western Europe," in 'Man's role in changing the face of the earth.' (ed. W. I. Thomas), Chicago, 1956, p. 220.

48. For a review of these, see Harvey and Henshall as indicated in readings at the end of this part.

TABLE 1
Summary of systems of agricultural production
in four basic organization types

ATTRIBUTE	SUBSISTENCE	PEASANT	COMMERCIAL	REDIS-TRIBUTIVE
Values	Magico-religious PRODUCTIVE LEISURE		Receptive Economic and Social Optimizers	Economic Optimizer
Goals	Family Consumption & Survival	Family Consumption	Income and Net Profit	Planned Production
Decision-making	Arational Traditional	Traditional, Satisficer	'Rational' and Choice Making	Intendedly Rational, Managerial, Planned
Agricultural Regulator	Labor Supply	Labor Supply/ Market	Market	State
Farm Input	Family Labor	Family Labor -	Family - Hired	Combine
Technology	Static, Traditional, Little Innovation	Static Traditional, Some Mech-anization	Dynamic and Rapid Innovations Mechanized	
Factor Proportions and Rates of Return	High Labor/Capital Ratio Low Labor Return	Medium Labor Return	Low Labor/ Capital Ratio High Labor Return	Medium Labor/ Capital Ratio Medium-High Labour Return
Distribution	Deficient and Imperfect	Barter-Market	Efficient and well-developed market	Market (Planned and Prescribed)
Proportion of Agricultural Sector in Total Economy	Very large	Large	Small	Medium-small

SOURCE: M. E. Eliot Hurst, 'A geography of economic behavior,' Wadsworth, forthcoming; S. H. Franklin, "Systems of production: Systems of appropriation," Pacific Viewpoint, Vol. 6, No. 2, 1965, pp. 145-166; and C. R. Wharton, "Research on agricultural development in Southeast Asia," Journal of Farm Economics, Vol. 45, 1963.

Remote-sensing by satellite of soil, vegetation and moisture characteristics may be undertaken in the future at the request of a farmer, and the results returned to him without his stepping outside of his house.

These technological developments may be expected to hasten the trend toward human disengagement from productive activity of a physical sort.

However, at present, each farmer is not only competing in the market place, or devising a strategy against nature, but he is competing for labor, transport, storage conditions, and so on. Each of these competitive situations is linked to the farmer's perceptual abilities. These, in turn, are linked to his learning, education, values system, etc., which in their turn are affected by the socio-economic milieu in which they occur. Because of the interdependence of anyone acting within the world scene, the operation of each farmer is a function not only of his own abilities, but indirectly of the abilities of others. Thus, once again a return is made to the systems approach, which stresses the interdependence of phenomena.

In the following sections, a few of the above concepts are developed in some detail. It is considered that these may provide the basis for student exercises which may provide a "feel" for the interdependence which we emphasize.

Economic Rent

Chisholm discusses economic rent based upon fertility (Ricardo) and upon distance (von Thunen). This concept is important in agricultural location theory and is one of the more important factors underlying this activity.

Fertility of soil varies from place to place. This simple, but crucial, fact means that for a given application of labour and capital, there will be a greater yield (and thus a greater profit) as fertility increases. Thus, if we imagine a large-sized piece of land being under the control of a single landlord, then this individual (if he is rational) will assign rents in accordance with fertility, the highest rents being associated with the most fertile soil. This situation, in turn, will encourage the tenant to grow that crop for which he will get the greatest return, thus enabling him both to pay his rent and enjoy a margin of profit. This situation will give rise to regional differences in the kinds of crops introduced.

Now let us consider the factor of distance. Further, let us consider only one commodity.

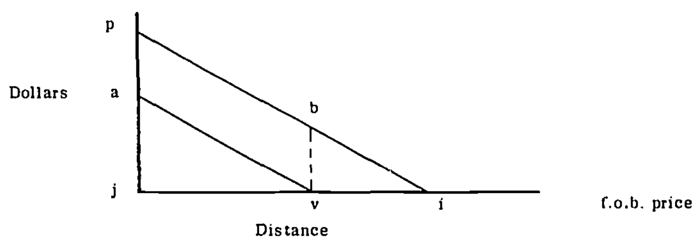


FIGURE 3

Look at the above diagram. The market is at j. Let us assume that the demand at j is such that all farmers along the line ji, including the farmer at i, must produce the commodity, say wheat, if the demand is to be satisfied.

Thus the people at j must be willing to pay a price for wheat which will enable the farmer at i (the most distant from j) to grow wheat, ship it to j, and yet be able at least to break even. So the farmer at i, in fact, sets the price of wheat at j, since it is not possible to distinguish among the various producers.

If each farmer along ji has the same costs of production, then we may designate this base line as the f.o.b. price. The line ip is the transport gradient, and jp (graduated, say, in cents) is the cost of shipping a unit of wheat from i to j. Thus the delivered price, p, is made up of the cost of production of the unit of wheat (the f.o.b. price) plus the transport cost from i to j. The farmer at i, then, is the marginal producer (the last farmer brought into production in order to just satisfy the demand) and he sets the price!

Next consider a farmer between i and j, at v. This farmer is also producing wheat to ship to j. His costs of production and transport cost are the same as for the farmer at i. Thus the transport gradient va is parallel to ip, but note that the cost of shipping a unit of wheat from v to j is only ja. However, the price which this farmer can get for his wheat is still p (see above). The farmer at v, therefore, gets a profit represented by ap (equals vb) which we call economic rent.

In order to see how economic rent results in a varying pattern of agricultural production, we shall consider an example using three commodities.

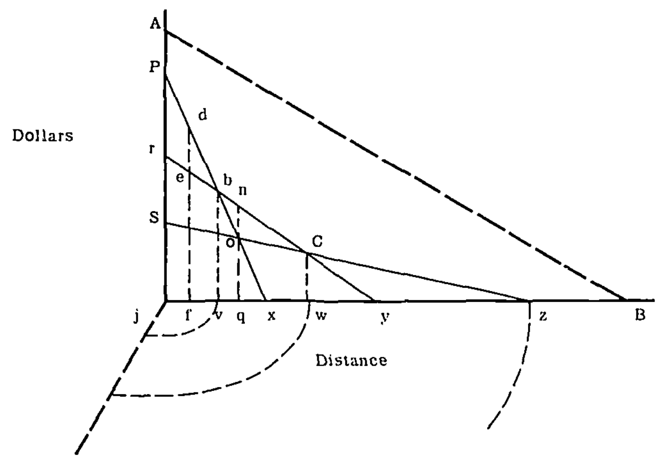


FIGURE 4

Once again, we shall consider production along a line, jz, with the market at j. The transport gradients and their associated commodities are px (garden produce), ry (wheat) and sz (forest products), with p, r, and s being their respective delivered prices at j.

Now if you look again at Figure 3, you will observe that economic rent is represented by any line from pi perpendicular to ji. Similarly, in

Figure 4, economic rents for garden produce, wheat and forest products may be determined from lines drawn respectively from px, ry and sz perpendicular to jz.

However, note what happens at b, where the transport gradients for garden produce and wheat cross. Exactly at point b (or, more correctly, at the point v, where bv is perpendicular to jz) the economic rents for garden produce and wheat (bv) are equal. But if we move slightly to the left, to f, then the economic rent for garden produce (df) is greater than the corresponding economic rent for wheat (ef), and therefore the farmer at f will gain more if he specializes in market gardening. Conversely, if we move to the right of v, then the opposite condition holds, i.e., the economic rent for wheat (nq) is greater than that for garden produce (oq).

A similar argument could be developed to explain the agricultural production around the point w.

If we now rotate our model (Figure 4) about the axis pj, we shall generate a nested set of rings with radii jv, jw and jz within which shall be produced garden produce, wheat and forest products respectively. Thus we have developed von Thunen's rings.

Note that Chisholm[49] refines the concept of economic rent. Thus, using our model, Figure 4, with respect to garden produce and wheat, the economic rent of garden produce at f, is represented by the difference (de) between df and ef, and thus the area prb represents the total economic rent accruing as a result of market gardening. This does not change our basic argument above.

Note, finally, the fundamental factor underlying this process of agriculture differentiation. It is the simple fact that transport costs differ that gives rise to the varying pattern of agricultural production. Of course, this is only one factor. Above, we noted the influence of varying fertility. There would also be the varying factors of climate, soil, tastes, etc. Our problem is to determine that pattern of production which maximizes the return to the farmers, or if you prefer, which minimizes the costs to society in general.

Now suppose a factory which processes soybeans locates at j, and offers the price A per unit of soybeans. Let the transport gradient for the beans by AB. Note that AB runs over all the other gradients in Figure 4, thus implying that a higher economic rent is possible by changing the whole area to soybeans.

How would this changeover take place, if it in fact did? As in Figure 5, we might note that the new pattern could develop over time in a rather spotty fashion. The introduction of the new crop might well be more a function of human attitudes than of the natural environment. The high price might bring more land into production as represented by zB.

We could look upon the gradual spread of soybean cultivation over the landscape as a reflection of the diffusion of information, i.e. of the process by which farmers become aware of, make a decision upon and act to take advantage of the possibility of increased profit. The investigation of this phenomenon is the aim of much current geographic research.

However, the introduction of soybeans has now disturbed the balance of our market system. The forces of supply and demand, conditioned by human tastes, will operate to bring about a new equilibrium which may imply higher prices for garden produce, wheat and forest products—or it

49. M. Chisholm, 'Rural settlement and land use,' Hutchinson, 1962, see his Figure 3, p. 23.

may mean that the market at j will find to its advantage the importation of these commodities from much further afield, thus extending its spatial system of food production and consumption. This situation, in turn, may encourage hitherto subsistence farmers to join the exchange economy, or may result unfortunately in foreign entrepreneurs moving into an area and establishing plantations. This development may then upset the political balance of power—and so goes the chain of events in this complex, interrelated world.

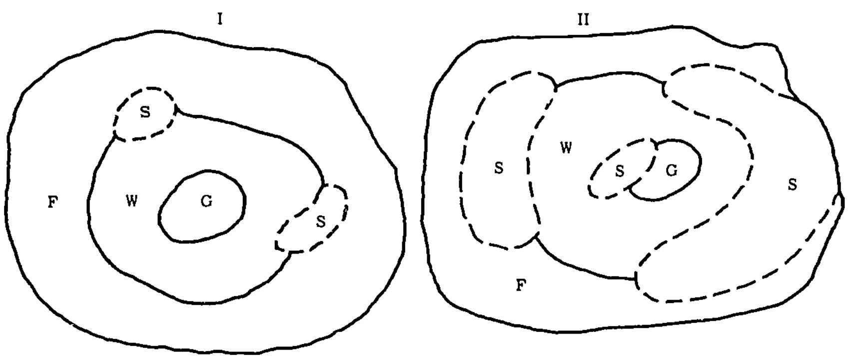


FIGURE 5

Competing Markets

In the last section, we considered the case of one market. Let us now relax this assumption and allow another market to enter and compete with the first. (See Figure 6).

In Figure 6 the competing markets are A and B. Circumscribed about A and B are rings (or isoprofit lines), showing the profit associated with a good as one moves outward from the markets. Two producers are represented by X and Y, and we note that they are equidistant from B. The cost of transporting a unit of the good produced to the market is simply the difference between the profit figure at the market, and the figure at the point of production. This difference is 20 cents between consecutive rings.

Let us consider two cases:

Case I: A and B both offer the same price for the good. The line RS represents a boundary of indifference alongwhich producers enjoy the same profit regardless whether they sell to A or B. Note the producer X is on this boundary.

Producer Y, however, can make an extra 20 cents per unit by selling to market A. Thus this competing market has diverted the production of Y from B to A.

Case II: Suppose B is favoured by industrial growth and increases in population and total income. It is reasonable to assume that the price of the good in B will also rise. We assume a rise in price at B from $3.00 to $3.40.

Note that the boundary of indifference has shifted to position VW, bending back around market A. Producer X is no longer indifferent but will ship to B. Producer Y finds to his advantage to stop shipping to A, and to ship instead to B.

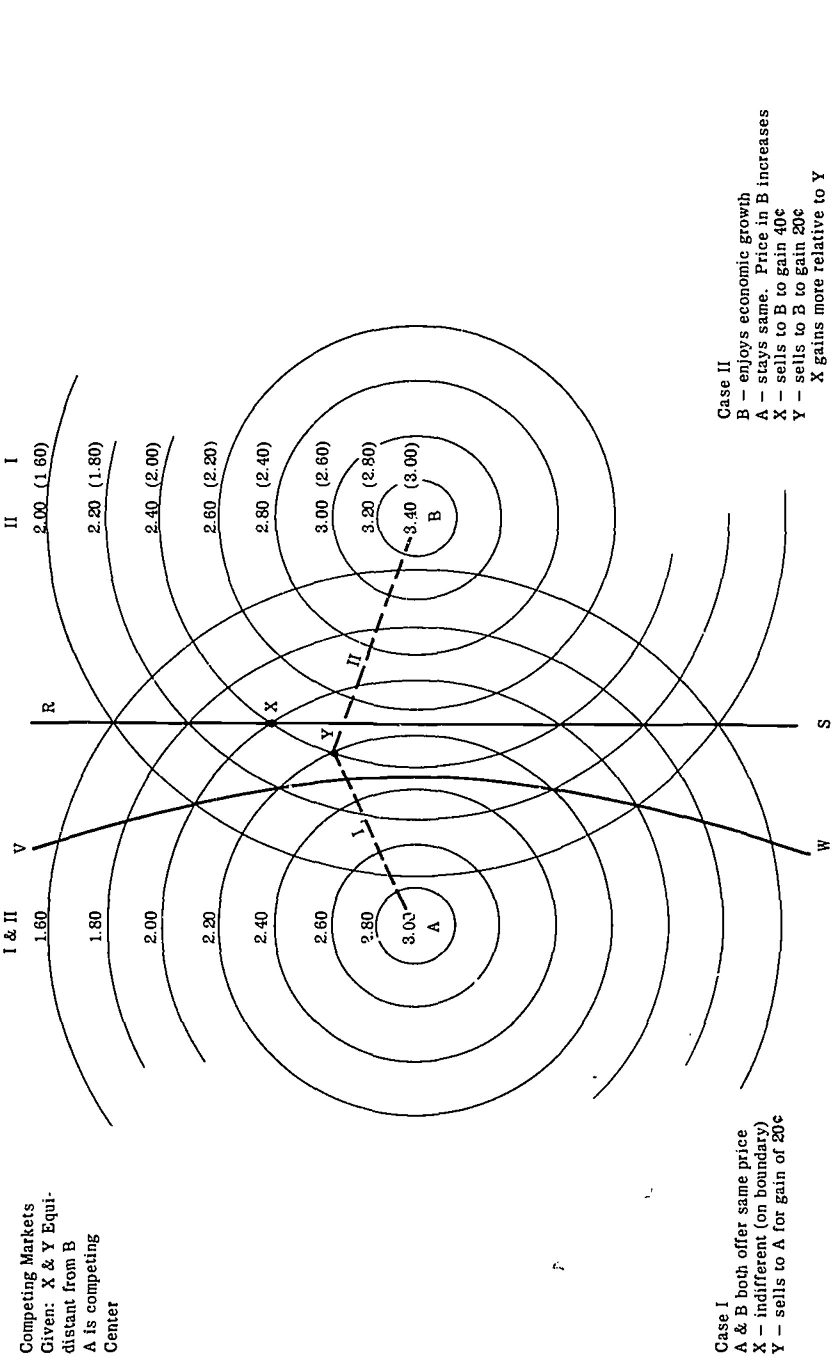

Competing Markets
Given: X & Y Equi-
distant from B
A is competing
Center
I & II
1.60
1.80
2.00
2.20
2.40
2.60
2.80
3.00
A
II I
2.00 (1.60)
2.20 (1.80)
2.40 (2.00)
2.60 (2.20)
2.80 (2.40)
3.00 (2.60)
3.20 (2.80)
3.40 (3.00)
B
R
S
V
W
X
Y
I
II
Case I
A & B both offer same price
X – indifferent (on boundary)
Y – sells to A for gain of 20¢
Case II
B – enjoys economic growth
A – stays same. Price in B increases
X – sells to B to gain 40¢
Y – sells to B to gain 20¢
X gains more relative to Y

FIGURE 6

The student will realize that shifts in shipping patterns can result, too, from changes in the transport rate structure. Indeed, our economy is so sensitive to changes in freight rates that it should be no surprise that governments step in to regulate them.

The Principle of Comparative Advantage

A region tends to produce those products for which it has a special talent or physical advantage, or the least disadvantage compared with other regions. Let us explore the conditions which may or may not result in an advantage from trade.

Case I: We shall in every case consider two regions A and B, producing crops of wheat and garden produce. We shall discuss production in terms of arbitrary units of yield resulting from an application of a composite unit of labour and capital.

	A	B		
Wheat	40	40	50	$\frac{2}{3} = \frac{2}{3}$
Garden	60	75	75	

In this case, we note that the domestic ratios between yields is the same in both A and B, i.e. 2/3. This still holds even when yields in B rise to 50 and 75. Under these conditions, there can be no advantage from trade, or specialization.

To see why this is so, suppose B specialized in garden produce; then two composite units of labor and capital results in the production of 150 garden (using the second ratio) produce units; A would specialize in wheat and, applying also two composite units, would produce 80 units of wheat. Now suppose trade takes place: in order to replace the lost production of garden produce, A will import 60 units from B, thus leaving B with a surplus of 15 units, after its own demand for 75 is met.

On the other hand, we find that B will take 50 units of A's wheat, but after B meets its own demand for 40 units, there are left only 40 units; thus B has a deficit of ten units of wheat.

How do we resolve this disequilibrium? Well, we note that in A ten units of wheat is the equivalent (in terms of composite units of labor and capital) of 15 units of garden produce. But this is also true in B. Therefore, either A produces another ten units of wheat and trades this to B for 15 units of garden produce, or B transfers the appropriate amount of labor and capital into wheat and produces its own wheat instead of the 15 units of garden produce.

But when we are all through this, we find that neither A nor B is any better off than before. Therefore, there is no advantage to specialization and trade.

Case II:

	A	B	
Wheat	40	50	$\frac{2}{3} < \frac{5}{4}$
Garden	60	40	

In this case, the domestic ratios differ; therefore, we would like to conclude that there is an advantage in the two regions specializing and trading.

A has an absolute advantage in garden produce and B an absolute advantage in wheat, and should therefore specialize in these commodities.

Thus: for 12 garden produce units, A will trade eight units of wheat (being the equivalent to the garden produce in terms of labor and capital) and similarly, for 12 garden produce units, B will trade 15 units of wheat. There is, then, a basis for trading 12 garden produce units for from eight to 15 units of wheat. The determination of the actual trading ratio will depend upon the terms of trade, that is, the conditions of demand within each region and their relative powers of bargaining.

Suppose, however, that trading equilibrium is established at the rate of 12 garden for ten wheat. Then A, which is producing garden produce, will gain two units of wheat over and above what it could produce itself for an equivalent amount of labor and capital. B, on the other hand, will save five units of wheat in that it may have produced 15 units but has only to trade ten for its desired amount of garden produce.

Both A and B therefore profit through specialization and trade, when each has an absolute advantage in different commodities desired by both.

Case III:

	A	B	
Wheat	40	70	$\frac{2}{3} < \frac{14}{13}$
Garden	60	65	

Once again, the domestic ratios differ. However, in this instance, B has an absolute advantage in both wheat and garden produce. But A has a least comparative disadvantage in the production of garden produce.

It can be shown that there is a mutual advantage in A's specializing in garden produce and B's specializing in wheat.

Case IV:

	A	B		
Wheat	40	45	$\frac{2}{3}$	$\frac{1}{2}$
Garden	60	90		

Here again the domestic ratios differ, and as in Case III, B has an absolute advantage in both commodities. This time, however, A has a least comparative disadvantage in wheat (that is, only five units less than in B, as opposed to the case with garden produce where A's figure is 30 less than B's) but note that, unlike in the earlier cases, wheat (at 40 units) is not the most productive in terms of yield units when compared with garden produce (60 units).

Nevertheless, as in Case IV, it can be shown that both A and B will profit if A specializes in wheat production and B specializes in garden produce.

It is left to the student as an exercise to sketch out proofs for Cases III and IV.

Thus, in grossly oversimplified language and illustrations, we have presented the argument in favour of free trade. Unfortunately, in the real-world, there are always vested interests which stand to lose if free trade were to run its course, and whole segments of society may suffer unduly if a whole industry is doomed through economic competition. Thus, there are many legitimate instances when regional industries should be protected from competition from more advantageously situated regions, while the terms of trade are worked out carefully, and the people affected are retrained for new jobs, or relocated in other regions where they are needed for their old ones.

The Development Unit and Agricultural Spatial Organization[50]

Spatial relations of economic activities are bound up with time relations. We should like to spatially organize our agricultural activities in order that our products are reaching the market when the price is high (i.e., when competing products are not yet ready for market). We should also like to avoid harvesting at peak demand periods for labor, transportation and storage facilities.

A useful tool for planning agricultural activities is the development unit.

In order to understand this concept, we must first distinguish between growth and development of a plant. Growth results from the accumulation of dry matter, i.e. refers to increase in size of a plant and is associated with yield. Development refers to plant's process toward reproduction by externally recognizable or invisible stages, i.e. from germination to maturation. Little is known about the biological activities involved in either of these vital phenomena, but it is known that development rate is a function of temperature and sunlight.

It has been discovered by Dr. C. W. Thornthwaite that the development of many domestic plants can be measured in terms of potential evapotranspiration. This concept is defined as the amount of water that would be lost by evaporation and transpiration from a surface completely covered by vegetation if there were sufficient water in the soil at all times for use of the vegetation. This loss of water by a plant may be directly related to its development, and it has been established that in the period of time during which 10mm. of P.E. occurs at a locality, a plant will progress toward maturity by 100 development units (or one dev. unit equals 1/10 mm. P.E.).

Most plants take a definite number of development units to reach maturity from germination regardless of time or place. Thus a variety of garden pea, known as the Alaska Pea, requires exactly 1,680 development units. Now the rate at which development units accumulate depends only upon mean temperature and the length of day. It is, therefore, to be expected that the more development units which accumulate in an area over a year, obviously the greater is the flexibility afforded a farmer in selecting his dates of planting or harvesting. Ideally he would like to plant and harvest his various crops at different times in order to minimize his labor required through avoidance of peak workload periods. This would also ensure labor a longer and more steady work period.

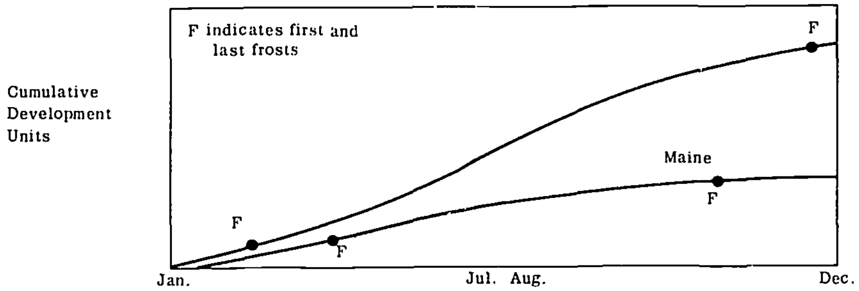
Note the tabular example below for Alaska peas at Seabrook, N.J.:

Planting Date	Harvest Date	Days to Maturity
March 1	June 5	96
April 15	June 15	61
June 15	July 19	34

Here you will see that, as the warm summer weather approaches and the development units accumulate at a faster rate, the days to maturity decrease. You should be aware, however, that dates given are only averages, and may differ from year to year as a result of variations in temperature.

50. L. Curry, "Climate and economic life," *Geographical Review*, 1952.

FIGURE 7



As we noted earlier, each farmer is not only competing in the market place, but is also competing for the available labor, transportation and storage facilities. Each of these is associated with an interregional flow and we wish to schedule these flows in order to maximize income. Thus, once again, we are led into a systems approach, because, through competition, the farms in an exchange economy are linked. And because of the economic interdependence of farms, the operation of each is a function not only of its own climate, but indirectly of the climate of other farms and other areas.

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PART 4 – THE RESOURCE SYSTEM

In this part, we include discussion of energy resources, minerals, lumbering, fishing, and an introduction to resource management. Our concern is not to catalogue the global occurrence of these phenomena, but rather to develop useful generalizations concerning production, consumption and technological trends, and their optimal spatial organization.

Resource is a concept which presupposes some human evaluation or appraisal. Resource is not just the physical fact of having coal, iron ore or a fertile soil, but it is something which is a subjective evaluation of that physical thing. Resources in themselves are quite passive: the understanding of their possibilities, the will to use them, the application of capital and technology, are the means by which that passive factor becomes important to man. The possession of resources is permissive rather than deterministic.

Resources are nothing by themselves. They exist as physical facts, and physical factors may control the presence or absence of a potential resource at any point in earth space. But this is largely irrelevant compared to man's evaluation or non-evaluation of that physical thing. Man must be aware of their existence. Man's awareness is a function of the particular values-system, technological system and socio-economic system of which he is part. In any one area an inventory of resources as physical facts must be governed or constrained by the motivations of man in that area, and whether they perceive the resources, and hence have a conception of their particular usages. A list of resources is deterministic, in the physical sense, but again, evaluation is really permissive; it permits man under certain cultural and economic circumstances to recognize and use resources.

Thus, once more, there is a system, a resource system. The basic elements are values, an educated, achievement-oriented society, technological attributes, and the existence in the surrounding environment of certain physical factors (climate, good soils, minerals) perceived or non-perceived. The term resource system implies that a socio-cultural and economic frame of reference is necessary so that the physical environment acquires a function as a medium for economic production and the satisfaction of human needs in general. Firey's conception of a resource system clearly illustrates the interrelation of socio-cultural, economic, and physical components of such a system[51]—a resource system is "a generic designation of any set of resource processes.... Thus, a particular resource system might be viewed as consisting of the tools which are customarily employed, the combinations and sequences in which they are used; the animals employed, their equipment, care, habits and seasonal characteristics; the crops grown, their growth patterns, soil tolerances, planting, cultivation and harvesting sequences; the soils cultivated, their structure, chemistry, and micro-organismic activity; the productive organization of the population, its market forms, specialization of labor and land division, the relevant conceptual categories, empirical knowledge, and magical beliefs possessed by a people; and, finally, a particular nexus of organic and physical processes such as photo-synthesis, symbiosis, evaporation, etc." It is typical, however, that Firey ignores the spatial aspects of such a system, and one has to be conscious of the fact that all other activities relevant to human existence in its socio-spatial context

51. W. Firey, 'Man, mind and land: a theory of resource use,' Free Press, 1960.

are left outside. Vidal de la Blache's concept of the "genre de vie," in fact, represents an earlier "classical" conception of a resource system.

A resource results from an interaction between man, searching for a means to attain given ends, and something outside of man, the physical environment. Varying views of this systematic relationship exist, some taking a purely cultural view and others a more economic viewpoint. Most of the alternative approaches do stress the human relationship since in the last resort everything depends upon the people themselves, their number, age and structure, their enterprise and initiative, their inventiveness, their perception of the environment, their level of technical knowledge, their desire for material betterment, and their willingness to make necessary sacrifices to attain it. Reference should be made to some of the alternative views – Zimmermann's functional view of resources, a dynamic conception of resources as a function of the cultural and economic beliefs of a people in an area; the ecological viewpoint, the use of the stable or balanced ecosystem, the conservationist view of nature as a system in ecological balance; the "classical" economic views of scarcity; the reformulation of the economic view by Barnett and Morse which allows for a dynamic world with socio-economic changes; cultural view of resources as cultural appraisals, defined in terms meaningful and significant to that culture; and the perceptual viewpoint, an extension of the latter, where practical choices may be due to various restraints or a lack of awareness on the part of the resource manager. These five viewpoints are not exclusive; no one can be drawn out as the working hypothesis. Elements from all probably exist in the resource system, and the limits to resources are cultural, perceptual and economic, as well as natural.

Resources, therefore, are part of a social/technical/economic system. Their exploitation is governed by the cultural evaluation of materials, by the technical means at hand, by the organization of the economy, by the volume and rhythm of production in the society, and by the use made of the resource. What is a resource to one human group may be of no conceivable use to another. The amount of a resource that is used may differ, too, according to the level of organization. Three basic factors, then, to resource use are:

1. A human group that knows how to utilize the physical material.
2. A suitable concentration of that physical material, and
3. A means of access.

As we know from our knowledge of systems analysis, the resource system is only a part of a larger system. To gain an appreciation of the extent of the system, consider the interrelated factors which lead to a decision to mine nickel in Manitoba (see Figure 8). Thus other factors come into play, i.e. the specific spatial arrangement of the system, and its character, capacity and connections. The usefulness of a substance does not depend simply upon knowledge of its potentiality and the desire to have it. It must be possible for the resource finally to appear, transformed, in some product or products which are desired and used. For these, there must be outlets from producers to consumers – either supermarkets, fairs, government allotments, or handouts, i.e. exchange, or household subsistence unit. There must be facilities to transport and store; there must be means to convert the resources, means which themselves need a whole range of pre-conditions. That is, the whole evaluation is under the influence of a host of factors connected with the structure and economic management of the artificial complex, as it is operated by society. No <u>one</u> factor can be drawn out as the most important.

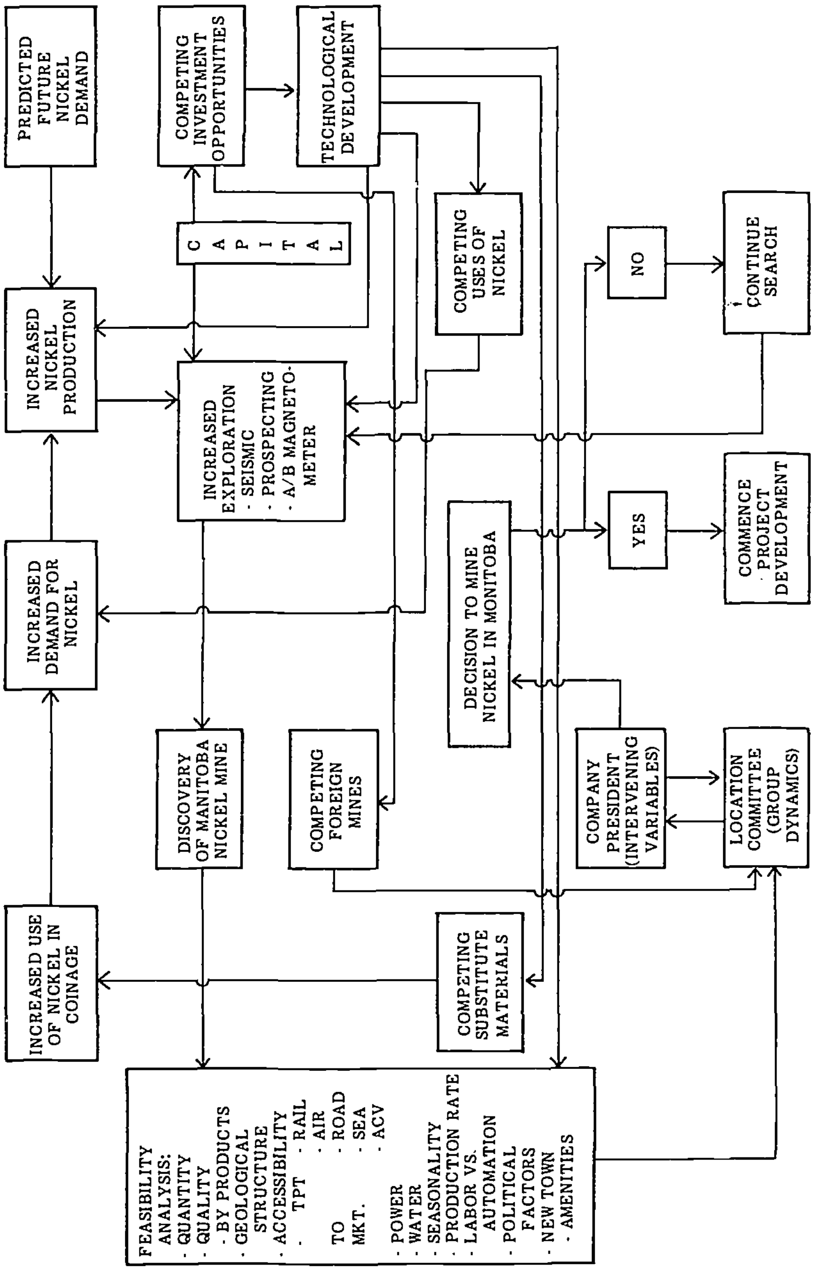
PREDICTED FUTURE NICKEL DEMAND
COMPETING INVESTMENT OPPORTUNITIES
TECHNOLOGICAL DEVELOPMENT
INCREASED NICKEL PRODUCTION
C A P I T A L
COMPETING USES OF NICKEL
NO
CONTINUE SEARCH
INCREASED EXPLORATION · SEISMIC · PROSPECTING · A/B MAGNETO-METER
INCREASED DEMAND FOR NICKEL
DECISION TO MINE NICKEL IN MONITOBA
YES
COMMENCE PROJECT DEVELOPMENT
DISCOVERY OF MANITOBA NICKEL MINE
COMPETING FOREIGN MINES
COMPANY PRESIDENT (INTERVENING VARIABLES)
LOCATION COMMITTEE (GROUP DYNAMICS)
INCREASED USE OF NICKEL IN COINAGE
COMPETING SUBSTITUTE MATERIALS
FEASIBILITY ANALYSIS: · QUANTITY · QUALITY · BY PRODUCTS · GEOLOGICAL STRUCTURE · ACCESSIBILITY · TPT TO MKT. · RAIL · AIR · ROAD · SEA · ACV · POWER · WATER · SEASONALITY · PRODUCTION RATE · LABOR VS. AUTOMATION · POLITICAL FACTORS · NEW TOWN · AMENITIES

FIGURE 8

We might anticipate that expanding information technology may within a few decades enable us to "automate" the information flow and decision-making system.

Related to this concept are the views of Barnett and Morse[52] on self-generating technological change. They argue that "a strong case can be made for the view that the cumulation of knowledge and technological progress is automatic and self-reproductive in modern economies." They also envision a steady state equilibrium in resource use based on advanced ocean technology (see Figure 9).

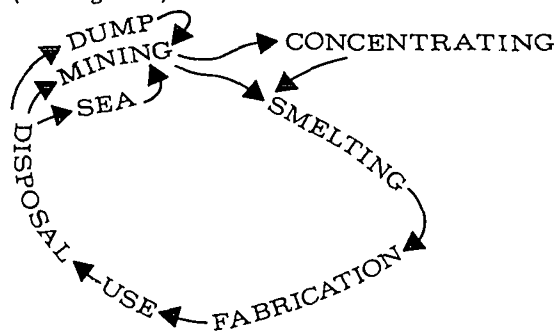

FIGURE 9

No single nation has a full complement of minerals, therefore, world trade in these commodities is important and becoming increasingly so, thus contributing to greater world interdependence. However, as more advanced technology broadens our resources base, it should not be any surprise if a counter-trend develops and we begin to return to a condition of regional self-sufficiency.

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52. Barnett and Morse, 'Scarcity and Growth,' Johns Hopkins, 1963, Chapter II.

PART 5 – THE MANUFACTURING SYSTEM

The main objective of this part is to present an image of unity arising out of seeming chaos and complexity. The main concept is, therefore, that of a global system of manufacturing establishments, linked by continuous flows of people, goods, money and information which are initiated by human and cybernetic decisions. For centuries, industrial transformation was conducted at the home of the consumer, with specialization and supply outside the household growing very slowly. The specialization of large numbers of people in exchange economies carrying out these transformational activities is a phenomenon of the last 200 years. Manufacturing thus covers a wide range of activities, from handicraft and cottage industries producing handcrafter items, to the smelting and refining of ores, and to the assembly of complex electronic equipment. Each type of secondary activity varies in the particular inputs of materials, labor and capital, varies in the particular sources from which it draws these, and provides particular outputs for purchase in particular markets and market areas. The locational pattern and the impact on the landscape varies from industrial group to industrial group with the variations of inputs, sources, and outputs; and within each group the influencing factors vary and multiply in number again. Each branch of a group is liable to be affected by even more diverse variables, as scales of production change and scales of management change from the cottage, to the multiplant industry, to the multi-industry firm, and to the state-managed and planned industry. Other variables that can affect the landscape patterns of manufacturing are time, technological change, change in resource evaluation, quantitative and qualitative economic growth, growth in scale of regions, nations and international groupings, and market changes. Figure 10 is an attempt to dissect the system, isolate and define its components and establish their interrelationships in order to understand its totality. The diagram conceptualizes some of the factors which influence the decision to begin an industry at a particular location, or "explains" its existence as part of a particular geographic pattern or system. Following Milstein[53], we can group the components of this system as follows:

Decision Units

(a) Natural resources: agriculture, forestry, fisheries, mining and quarrying

(b) Processing: construction, manufacturing–food, tobacco, textiles, furniture, paper, printing, chemicals, rubber and plastics, metals, glass, machinery, transportation equipment

(c) Services: trade–wholesale and retail; finance, insurance and real estate; transportation; communications and public utilities; personal and business services; government

(d) Households.

Considerations

(a) Transport costs: raw materials; finished products; factors affecting transport costs

53. David N. Milstein, "Location Theory and Community Development," in A. E. Levak, (ed.). 'Social Scientists View Poverty as a Social Problem' Inst. for Community Development, Michigan State University, 1967.

THE INDUSTRIAL SYSTEM

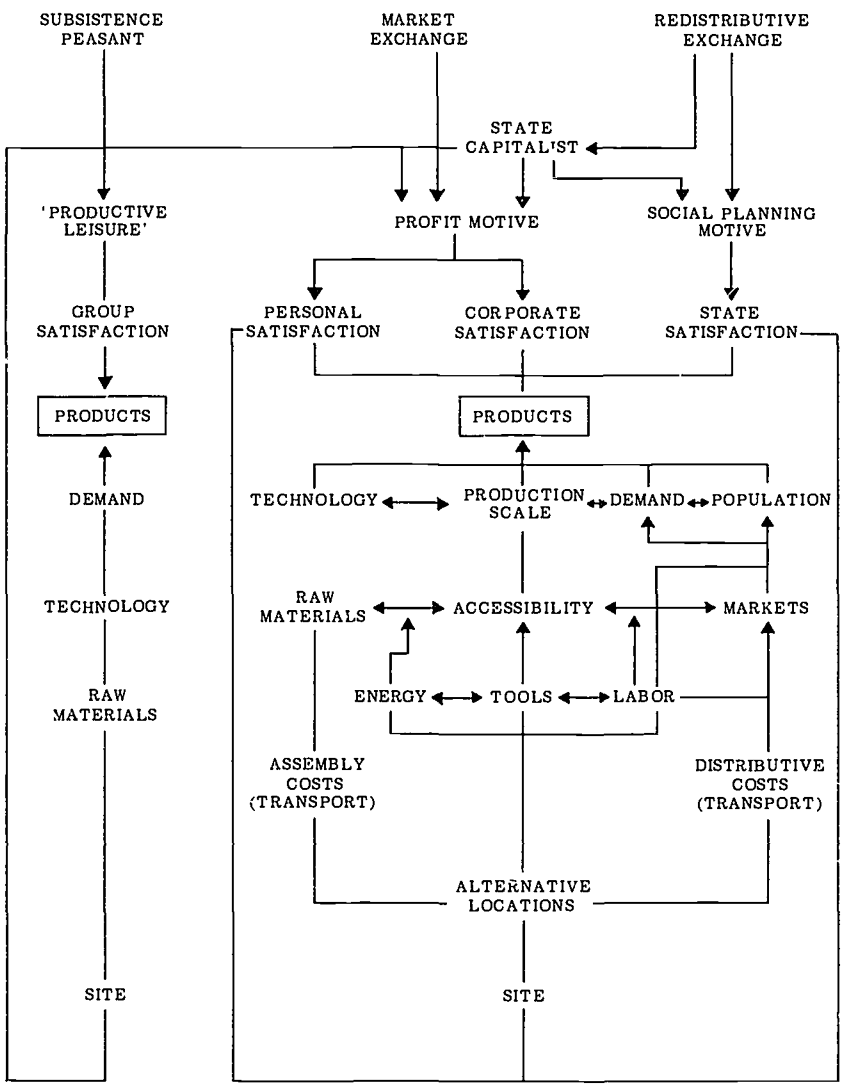

FIGURE 10

SOURCE: (adapted from F.E.I. Hamilton, in Chorley and Haggett, p. 365); and Eliot Hurst, op. cit.

(b) Area cost differentials (per unit of product): natural resources—land, water, fuel, power and light; labor—supervisory, skilled, unskilled; capital; taxes; buildings; local services

(c) Market and supply area differences: size of marketing area; feasible purchasing sources

(d) Clustering effects: scale—economies of large-scale operation; localization—access to industry services, suppliers and customers; urbanization—local environment (shopping, schools, recreation)

(e) Personal factors: achievement orientation; entrepreneurship.

Figure 10 is an attempt to categorize and structure some of the location factors involved. As with the agricultural system, the system is placed in a particular socio-economic context, hence the recognition of subsistence-peasant, market exchange, and redistributive economic organization. Since many market exchange economies are subject to some state planning, and some redistributive economies have a sector of 'private' industry, another category for convenience called 'state capitalism' is introduced. These differences in economic organization are reflected in the locational decisions eventually made, though with the exception of subsistence-peasant, they are essentially dealing with the same set of locational factors, which are therefore shown in the diagram as common to the systems. Even subsistence-peasant economies are rarely without some contact with an exchange economy and thus a link is made to the main system.

Estall and Buchanan[54] provide an exhaustive discussion of these factors, liberally illustrated by examples and case studies.

The system encompasses, then, all activities where man assembles raw materials at an establishment (household, workshop, or factory), where their usefulness is increased, and these products are shipped to the consumer. The focal point of this activity is the place of transformation, the factory, which serves as a link among areas of raw materials and consumption. The interaction of this system, as in Figure 10, focuses on the site or location of the factory. A review of location theory and selected empirical studies indicates the nature of the interrelationships among the factors. Hamilton[55] and Smith, Taaffe and King[56] respectively provide useful material for this section of the course.

The dissection of the locational procedures followed by entrepreneurs is difficult, as noted already for agriculture. The economic needs of factories differ from industry to industry, and vary with the size of the individual firm. Managerial attitudes to location also differ widely; in some cases managers have taken an intendedly rational view and have estimated carefully within the limits of their locational abilities, whilst others have given very little thought to the problem. Existing locations are also not necessarily the most favorable in terms of present-day 'western' strategy; in older industrial areas the original reasons for location may be lost in the past, and a new set of ties may have arisen. Irrespective of the reason why these locations were chosen and the decisions made, over time it has led to a similarity of result, a concentration of manufacturing in areas, belts or agglomeration in many 'advanced' nations.

In most theoretical discussions, it is assumed, as in von Thunen's agricultural model, that entrepreneurs strive to maximize their profits by

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54. R. C. Estall and R. O. Buchanan, 'Industrial activity and economic activity,' Hutchinson, 1961.

55. F. E. I. Hamilton, "Models of industrial location," in Chorley and Haggett, op. cit.

56. R. H. T. Smith, E. J. Taaffe and L. J. King, op. cit.

making thoroughly rational locational decisions. This assumption, of course, is openly questioned, and applied and empirical research has shown that non-economic or personal motives of entrepreneurs have exerted a considerable influence on location decision-making. Some of these motives, as with agricultural motivations and attitudes, are difficult to systematize.

The notion of 'productive leisure' refers to motivation in a non-economic way (Figure 10). Profit of some degree motivates decisions in market-exchange economies, whereas social benefits and costs influence the decisions under a centralized government agency. The divergences among individual enterpreneurs (individual, corporate, or state) are accounted for by different levels of satisfaction. Thus given the same business or plant to locate, no two entrepreneurs would judge alternative locations by the same maximizing criteria of profit or social benefit.[57]

Despite the lack of rational decision-making, some order appears to exist, as the long-term pressures of the economic systems have exerted powerful influences on the seemingly non-economic motives of individuals, so that the factors listed above and those in Figure 10 do seem to play some role in the location pattern of industry.

The two major 'classical' schools of location theory, contrast least cost, or cost minimization (Weber), with those of profit maximization (Losch) both utilizing spatial variations. Both hold that an optimal location is determinable for every manufacturing production unit whether it be run by a single entrepreneur or a coalition of individuals.

Smith's[58] theoretical framework is useful here in enabling one to visualize the spatial changes associated with varying economic conditions. All these approaches simplify the environment and assume that man, the decision-maker, has available to him formidable amounts of knowledge which he sorts and uses in an economically rational way.

A large number of factors influencing manufacturing location has been indicated. It should be apparent that the relative importance of each of these will vary from industry to industry, and indeed from firm to firm. In fact, the concern is with a system, a number of elements (factors) have been listed, and a change in any one of these factors will generate a change in the others. Perhaps we can conceive of these components having some force of attraction (or repulsion) which acts upon an industry or firm. The firm is conceptually being pushed or pulled over space until an equilibrium point is approached.

Is there any single concept which can describe analytically what is happening here? Isard suggests the notion of substitution over space (which was originally suggested by the German economist, Predohl). The concept was developed within the field of economics, and implies that every time a firm is moved over space to effect a savings in some factor, some other factor must increase in cost. Thus when a firm moves from Toronto to Owen Sound to take advantage of lower labor costs at the latter point, it may in effect be substituting increased transport costs to the market, which may still be Toronto. It is presumed, of course, that the savings in labor costs more than offset any increases in other costs.

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57. M. L. Greenhut and M. R. Colberg, 'Factors in location of Florida Industry,' 1962; L. Curry's paper "Chance and Landscape," in 'Essays in Honor of G. H. Daysl,' ed. J. W. House (Newcastle, 1967) is also of interest here and in other sections.

58. D. M. Smith, "A theoretical framework for geographical studies of industrial location," *Economic Geography*, Vol. 42, No. 2, April, 1966.

Let us develop a simple locational model using three types of substitutions: (after Isard)[59]

(a) substitution between transport inputs (ton-miles), and outlays (costs) and revenues associated with various commodities used in the production process.

(b) substitution among sources of materials

(c) substitution among markets

Thus the whole production process may be conceived as a complex substitution problem in space.

Assume two sites, C (market) and M_1 (raw material), and a transport link between them. Where should we locate P (production point)?

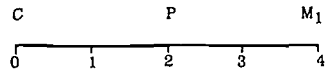

FIGURE 11

We may borrow a concept from production theory in economics, and construct a transformation line (all combinations of inputs along the line giving rise to a given output). We shall assume the same unit ton-mile cost for product and raw material.

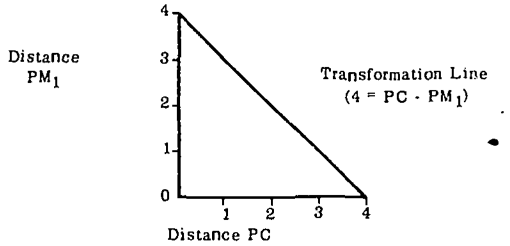

FIGURE 12

Since the transformation line is a straight line, it turns out in this instance that P can locate at any point along CM_1.

Let us now complicate our case. Production now requires a second raw material available at one source, M_2.

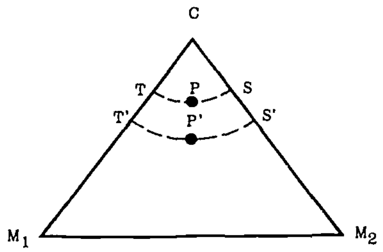

FIGURE 13

59. W. Isard, 'Location and space-economy,' M.I.T., 1956. Chapter 5.

Suppose the distance PC is a constant, i.e. P can locate anywhere along TS.

Again construct a transformation line. This time it turns out to be a curved line.

As above, suppose that the cost of shipping a unit of M_1 is the same as for M_2, and that one ton of each is required in the production process. Suppose also that the transport rate is proportional to distance.

Draw in a series of isocost lines (lines of equal shipping costs).

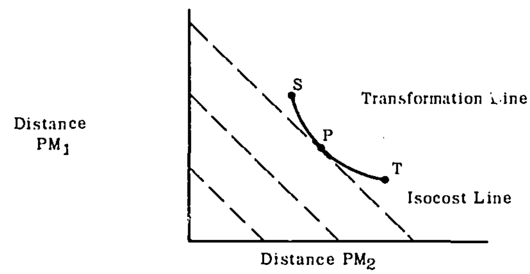

FIGURE 14

Where the isocost line just touches (is tangent to) the transformation line is the least cost transport location. Since the value of the isocost lines increases as one moves away from the origin, then it follows that the minimum transport cost point along TS must be given by the tangent isocost line.

We might try to find a still lower transport cost point by taking a new distance, CP,' as our constant, thus giving us the new locus, T'S'. We might continue in this manner, i.e. holding one distance constant and letting the other two vary, but our attempts to find the least cost point might well be futile. This is so since every time we change one distance we immediately, of necessity, alter the other two.

The solution to this problem, then, really requires the solution of a system of simultaneous differential equations. Isard develops such a system, but discussion of this is considered beyond the scope of this course. Presumably, however, any "real world" locational problem must try at least to approximate the theoretical technique that we have described.

While the Isardian model above is a valuable conceptualization of the industrial system, it is not operational. At this point, the student should be reminded of the models of interaction (e.e., input-output analysis and linear programming), and a discussion of their relevance here should ensue.

It is appropriate also at this point to consider the data requirements of such models, and others, in the light of the developing information technology discussed earlier. It can be anticipated that the provision of timely, accurate and complete data will have a significant impact upon location decision-making. One can envision the possibility of programming a location decision algorithm, though the reality may be rather remote. Of course, we remember that, in its limited way, linear programming is just such a technique. A major consideration is, however, that the human decision-maker is under no obligation to follow the results of this tool. Frequently, in view of the technical and conceptual limitations of the model, he would be foolish to implement such a machine decision without further thought. But perhaps this frequency can be reduced.

Consideration must also be given to the spatial impact of such developments as automation, computer linked national information systems, and remote control of factory production through direct electronic manipulation of numerically-controlled machine tools.[60]

Suggested Reading

1. *Alexandersson, 'Geography of Manufacturing,' (Englewood Cliffs, Prentice-Hall, 1967).
2. G. Alexandersson, "Changes in the location pattern of the Anglo-American steel industry, 1948-1959," Economic Geography, 37, 1961, pp. 95-114.
3. W. Alonso, "Location theory," in J. Friedmann and W. Alonso, 'Regional development and planning,' (M.I.T., 1964), pp. 78-106.
4. *R. C. Estall, "The electronic products industry of New England," Economic Geography, Vol. 39, 1963, pp. 189-216.
5. V. R. Fuchs, "Changes in the location of U.S. manufacturing since 1929," Journal of Regional Science, Vol. 1, No. 2, 1959, pp. 1-18.
6. M. Fulton and L. C. Hoch, "Transportation factors affecting location decisions," Economic Geography, Vol. 35, 1959, pp. 51-59.
7. M. L. Greenhut, 'Plant location in theory and practice,' (University of North Carolina Press), 1956.
8. *E. M. Hoover, 'The location of economic activity,' (McGraw-Hill, 1948).
9. C. W. Boas, "Locational patterns of American automobile assembly plants, 1895-1958," Economic Geography, 37, 1961, pp. 218-230.
10. *G. J. Karaska, "Interindustry relations in the Philadelphia Economy," East Lakes Geographer, 2, 1966.
11. W. F. Luttrell, 'Factory location and industrial movement,' (London, 1962), 2 vols.
12. J. Odhroff, "On the techniques of optimising and satisficing," Swedish Journal of Economics, Vol. 67, No. 1, 1965, pp. 24-39.
13. A. Pred, "The concentration of high value-added manufacturing," Economic Geography XLI, 1965, pp. 108-132.
14. E. A. G. Robinson, 'The structure of competitive industry,' (Chicago, 1958).
15. B. H. Stevens and C. A. Brackett, 'Industrial location,' Bibliography Series, No. 3, Regional Science Research Inst., 1967.

PART 6 – THE TERTIARY SYSTEM

The final group of sites which we study comprises the tertiary (or service) system. Rather than being linked via their inputs and outputs, tertiary activities typically are indirectly interrelated through the behavior of their customers. There are exceptions such as, perhaps, the financial sub-system, where spatial juxtaposition facilitates information flows among the components. McCarty and Lindberg[61] recognize a tripartite division of tertiary activities – services, trade, and finance, some of the characteristics of which are outlined in Table 2. The locational characteristics of

60. "Wider horizons for numerical control," *Electronics*, Vol. 40, No. 13, June 1967, pp. 125 ff.

61. McCarty and Lindberg, 'A preface to Economic Geography,' Englewood Cliffs, Prentice-Hall, 1966, Chapters 6, 7, and 8.

TABLE 2
The tertiary system: characteristics and location of service, trade and financial establishments

	ESTABLISHMENTS	CHARACTERISTICS	LOCATION
SERVICES:			
Recreation	Theatre Movie – Theatre Dance Hall Cabaret Bowling Alley Sports Arena Restaurants	Subject to economic impact of tourism Traffic Located near customers Major centres can support major-league football or hockey, art gallery, symphony orchestra, zoo, etc.	Demand Patterns: (a) frequent, near home; spacing dependent on threshold and range; (b) infrequent use, range considerable Constrained by cultural attributes.
Vacation	Hotels Motels Camps Ski lodge (Restaurants) Souvenirs (Gas Stations)	Natural – Man made Seasonal Spatial relationship of city to recreational area and movement pattern involved. Amount of money spent/visitor Relationship between activity and journey in the recreational experience.	Dependent on resources and barriers. The barriers include cost and inconvenience of travel.
Medical	Offices Medical centres Clinics Hospitals	Economic benefits by agglomeration Some gain by locating in shopping centres to benefit from multi-purpose trips	Threshold of demand for support of a single physician Thresholds increase as degree of specialization of unit of supply increases
Personal Services	Schools Churches Universities	Highly correlated with demand for their services, but ratio of institute to population can be low (e.g. Universities)	Location decisions often obscure – Historical, Political, etc. nearness to demand. Modified by consideration of optimal size (often small). Change in scale associated with transport improvements.

TABLE 2 (Cont'd)

	ESTABLISHMENTS	CHARACTERISTICS	LOCATION
Public Administration	Public Safety	Similar to personal services Some special services dispersed for security or land space usage (e.g. missile sites)	Similar to personal services, often small. But relatively large government offices in State, Provincial, or National centres, to centralize administrative functions.
Business and Repair Services	Advertising Accounting Auditing Bookkeeping Auto Repairs Radio & T.V. repairs Industrial repairs	Special Customer Services	Adjacent to businesses they serv , though threshold varies a great deal. Located with respect to demand (population, income) Located with respect to demand (specialized industry)
TRADE: Retail	Gas stations Grocery stores Drug Liquor stores Used car dealers Speciality stores Department stores Laundries Dry Cleaners Farm equipment, etc.	Subject to varying consumer perception, frequency of use. Needs to be accessible to population, income. Hold inventories at lowest level consistent with consumer demand	Locate by threshold, range, clustering, hierarchies, and conditions of generative, suscipient and shared attraction Low order goods (convenience) Frequent and dispersed; high order goods (shopping, speciality). Less frequent, agglomerated.
Wholesale	Grocery wholesale Bulk gas storage	Most numerous, customer needs Large and frequent	Near to customers, consistent with threshold and range to maintain a positive net income.
	Dry goods wholesale	Less numerous, supply dry goods, furniture, jewelry, etc.	Often confined to medium sized centres and above.

TABLE 2 (Cont'd)

	ESTABLISHMENTS	CHARACTERISTICS	LOCATION
FINANCIAL: Banks	Clearing houses Federal reserve banks Local banks Savings and trust organizations Security and commodity exchanges	Manufacturers of credit. Deal in Services, usually of face-to-face nature, choice near customers. Major item of income: interest on credit.	Regional banks in major cities (threshold and range). Local banks decentralized, (hence subject to threshold entry).
Insurance	Offices Agents	Income via premiums. Much income from agents in the field.	Customer oriented and associated with demand and income of an area; or central & branch offices, more highly centralized since fewer needed.
Real Estate	Offices	Solicit customers and transport them to sales site. Appear wherever demand occurs.	Locate in sales territory. Locate in areas of speculative demand Independent location, no need for regional or national organization. Decentralized, small, correlated to general business activity.

<u>SOURCES</u>: M. E. Eliot Hurst, op. cit.; McCarty and Lindberg, op. cit., Chapters 6, 7, and 8; C. K. Campbell, "An approach to research in recreational geography," in 'The Geographer and the Public Environment,' B. C. Occasional Papers, No. 7, 1966, pp. 85-90; and W. L. Garrison, et al., 'Studies of Highway Development and Geographic Change,' (Seattle, University of Washington Press, 1959), Section V.

the three groups are somewhat similar, since they are consumer-oriented. Thus tertiary activities are spatially distributed, but with a distinct tendency to agglomerate.

These groups or agglomerations are trade centres, service centres, central places or urban areas. As nodal regions, these urban areas or cities perform a variety of economic functions both for the populations within their own boundaries, and for the populations within their hinterland areas. So we can identify two concepts—the internal and the external relationships of cities. The internal relationships include the specific spatial distributions of shops, offices, worksites in general, residences, and the circulation patterns associated with those activities; and the external relationships link the urban centre to areas of surplus production, areas looking for tertiary services, which can be measured by transportation arteries, telephone calls, radio and television, etc. Some of the systems relationships of this latter type can be represented by a model formulated by Christaller; some of the systems interactions and locations in the former by extensions of the Christaller model by, amongst others, Berry and Garrison.

Each tertiary establishment has a minimum size, a minimum amount of sales, below which it cannot operate. Given a sufficient amount of purchasing power, the location is then governed to varying degrees by accessibility to this purchasing power, or by the consumers perception of that accessibility. Retail and services activity is overwhelmingly market oriented, but the important factor is accessibility to a particular set of customers who might be expected to buy at that particular site—location at the place most convenient to those people when they are in the mood to make a purchase. This location might be accessible by foot, car, might be near home, or work, with a group of similar stores or by itself. Thus the tertiary system, its structure, organization, and elements, is subject to analysis, but being an open-ended system, is dynamic and changeable. Table 2 attempts to identify some of the characteristics and location features of the tertiary system.

An important sub-discipline which is introduced at this stage is marketing geography. It is advisable that students be made acquainted with the business field of marketing in order to provide some perspective for what follows. A recommended text would be one that takes a systems approach.[62]

Because of the extensive literature available, we find it fruitful to emphasize retail activities and their factors of location.

The commercial facilities of a city form a sub-system, a set of interrelated elements which interact to create a recognizable structure. There is a consistent pattern or structure of similar business types and commercial aggregations. Knowledge of this system and its elements has been built up over several years of observation, classification and inductive-deductive theorizing.[63] Retail and service establishments are grouped spatially according to the special location needs of the business types

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62. For example, M. L. Bell, 'Marketing: Concepts and Strategy,' Houghton Mifflin, 1966.

63. See, for example, B. J. L. Berry, 'Commercial Structure and commercial blight; Research Paper No. 85, Chicago 1963; B. J. Barner, 'The Internal Structure of Retail Nucleations; Research Paper No. 12, Northwestern, 1966; J. W. Simmons, 'The changing pattern of retail location; Research Paper No. 92, Chicago 1964; and Simmons. 'Toronto's Changing Retail Complex; Research Paper No. 104, 1968.

concerned. Following Nelson[64], we consider next some of the "location needs" of retail activities.

We begin by classifying these activities on the basis of customer characteristics:

(a) Generative: those activities which attract potential customers directly from their residences (e.g. supermarkets)

(b) Suscipient: those activities which rely upon their customers being attracted impulsively or through convenience while away from their residences for reasons other than shopping (e.g. while going to or from work).

(c) Shared: those activities which hope to share in business generated by their neighbours.

The important components of a decision to locate a retail activity, as suggested by Nelson are:

(1) Adequacy of present trading area: from time to time retailers find it useful to assess their current status, especially if sales are dropping off! Depending upon the nature of the commodities being sold, they might wish to investigate the spatial trends in their area associated with population density, sex ratio, age distribution, income per capita, racial and religious factors, and other human attributes. Changing habits of movement, modes of transport, transport routes should also be investigated.

(2) Accessibility of the site to the trading area: here one would first have to delimit a potential trading area (that is the area from which they hope to draw their business), and this would depend upon whether the activity in question could be described as generative, suscipient or shared. It makes a considerable difference whether population is to be attracted from their homes, or to be attracted impulsively as they stroll down the street.

Of course, it probably should be emphasized that any given business will find that their customers come to them for a great variety of reasons, and thus the business will rarely fall wholly into simply one category.

If one were interested in estimating potential generative business, then one might employ the population potential concept, described earlier.

(3) Growth potential: a retailer must not only concern himself with the present trading area, but should also investigate growth trends with a view to long-term advantages. This is a particularly important consideration in view of greatly increased rates of urbanization. At any moment, some locations are declining in attractiveness while others are increasing. Thus, it is particularly important for chain retail organizations such as supermarkets and gasoline companies, to be continually reviewing the adequacy of their outlets, and deciding which ones might better be closed down and where should new replacements be located.

(4) Business interception: a store should locate on a site which can intercept business going to competitors.

(5) Cumulative attraction: particularly where shopping-type goods are concerned, it has been found that stores can sell more when grouped together, than when spatially separated. For example, consider Figure 15A below. Here are five used-car dealers located side-by-side. Now suppose a prospective customer comes along. There would appear to be a rather high probability that, everything else being equal, the customer would visit each lot before making his decision to purchase.

64. R. L. Nelson, 'The selection of retail locations,' F. W. Dodge, 1959.

Consider now the situation represented in Figure 15B. The five dealerships are now widely separated. Thus a visit to one of them considerably reduces the chances of a visit to the others. Indeed a prospective customer might visit four lots then, if he has not made a decision, go home.

Now if this behavior was characteristic of used-car buyers, then in the first case (Figure 15A) each lot could expect to be visited by 100 per cent of the shoppers, while in the second case, each lot would be visited by only 80 per cent of the shoppers, thus severely reducing the sales potential of each lot.

Other stores which can gain by locating together are ones which sell complementary goods, e.g. clothes and shoes, department stores and supermarkets, theatres and restaurants.

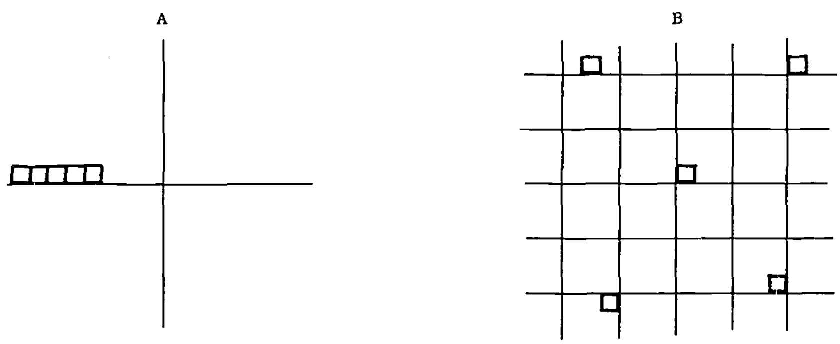

FIGURE 15

(6) Compatibility: retailers must be wary of locating beside activities which are not compatible with their operations, that is, which will tend to repel customers. Some examples are long stretches of "dead frontage" (empty stores or warehouses), busy driveways, parking lots (if between the generative store and the store in question which may be a suscipient or shared type).

Most of us have probably experienced a reluctance to continue our stroll down a row of retail shops, if we come upon a stretch of non-retail activities. We may conclude that there is unlikely to be anything further and so return whence we came, or return along the other side of the street. The point here is that there may have well been a rather interesting store to be seen had we continued on our way past the uninteresting section. By being where it is the store has thus lost a possible sale.

(7) Minimizing of competitive hazard: for many types of retail activities, especially ones not dealing in shopping type-goods, e.g. supermarkets, drug stores, variety stores, there would appear to be an advantage to be located at some distance from possible competition. This might be effected by:

a. siting near a minimum of competitive stores
b. securing control of near-sites, e.g. through options to purchase for a crucial period, say, of one year.
c. ensuring that any competitive sites which exist are in non-intercepting locations.

(8) Site economics: finally a potential site should be checked to ensure the adequacy of street approaches, sidewalks, lighting, building characteristics, area reputation.

These represent a minimum of the factors which should be considered when seeking optimal location. There will invariably be special considerations related to the nature of the retail activity. In addition to these basic structural attributes, the work of Berry and others[65] has identified three complementary structures which appear to exist in most North American cities: (a) nucleations, the Central Business District and a hierarchy of non-central business centers (planned and unplanned) of various sizes: (b) specialized functional areas, groupings of one or more business types which desire mutual benefit through juxtaposition; and (c) ribbons, characterized by a particular spatial form and traffic dependency. These three types of business grouping are not mutually exclusive, and links exist among them.

More recently marketing geography has turned toward the consumer viewpoint. Once again, the infinite number of minor factors which could be operating on the consumer at the point of purchase and which could lead to apparently irrational acts cannot be ignored. A recent paper considers the effects of imagery, transactional psychology, the "honi-phenomenon," and other factors from sociology and psychology.[66] This paper is also a useful review of the present way in which retail research is directed. Bucklin,[67] for instance, detected in his study of the Oakland retailing scene, two basic types of consumer behavior:

(1) Full-search shopping, and

(2) Limited search, which could be subdivided into causal and directed categories. Full search shopping involves considerable search activity, since "the merchandise she (the consumer) wishes to buy possesses a high 'social visibility,' is highly differentiated, and is usually subjected to rapid shifts in style."[68] Price is frequently a secondary consideration to importance of the item itself. Limited, but directed search, involves goods "...less intimately woven into the fabric of the shopper's social life, yet whose prices are of sufficient import to warrant concern over their purchase."[69] Since these goods form a smaller part of the 'social milieu,' the search activity is more limited and may be limited to known stores of a certain perceived image. Limited causal search concerns convenience goods, replaced frequently, and because of their comparatively low price "...the value of extended search for these items is minimal."[70] Bucklin goes on to place these ideas within a 'benefit-cost' framework.

Land values have also traditionally played a strong role in the location of business facilities. Land value theory has been based on the work of Haig and others,[71] and rests on the notion of complementarity between site costs and transport costs, the two forming the cost of 'friction of space.' This land value 'surface' varies spatially, so that different locations

65. See literature referred to in reference 63 above.

66. D. L. Thompson, "Future directions in retail area research," *Economic Geography*, Vol. 42, 1966, pp. 1-18.

67. L. P. Bucklin, 'Shopping patterns in urban areas,' Univ. of California (Berkeley), Inst. of Business and Economic Research, 1967.

68. Bucklin, op. *cit.*, p. 120.

69. *Ibid.*, p. 121.

70. *Ibid.*, p. 122.

71. See, for example, R. V. Ratcliff, 'Urban land economics,' New York, McGraw-Hill, 1949.

and thus different businesses will vary in the amount of rent they pay.[72] Land values themselves are, in fact, influenced by many elements of the urban system, and in particular by the spatial location with reference to the overall spatial distribution of land uses, and with respect to the other sites within one particular land use type. Thus, Ratcliff points out that "...each parcel of land occupies a unique physical relationship with every other parcel of land. Because in every community, there exists a variety of land uses, each parcel is the focus of a complex but singular set of space relationships with the social and economic activities that are centred on all other parcels."[73] The relationship to commercial structure of these land values is therefore obvious. The long ridges of high land values along major easily accessible thoroughfares are associated with the various types of ribbon development, as the levels of values and the intensity of business depend on the intensity of traffic along these arteries. The peaks of high values at the important intersections are associated with the centres and some specialized areas, comprising the hierarchy of functions. The variations in land value are, in part, due to the variation of land parcels, size, topography, and services, but essentially they are created by the location of the land site in terms of relative accessibility, with respect to nearby land use, existing traffic patterns, and potential customers. Garner has placed retail distributions into a more formal land values framework.[74]

The major organizing concept in this section is central place theory.[75] A discussion of the theory, of some interesting empirical regularities over space, and of some implications for marketing and planning practise may be found in Berry.[76]

The basic factors are:

(a) threshold of a good or service

(b) range of a good or service

The threshold of a good or service is that minimum population, or level of business, necessary to just sustain it. The range of a good or service is that distance which a prospective customer is willing to travel to obtain it (or that distance over which the customer is willing to pay the transport cost). Thus associated with each good or service is a threshold and a range.

These concepts of threshold and range imply a certain <u>market area</u> from which customers are drawn. They further imply that once a market area has been captured then it remains the purview of the captor until a competitor forces the first firm out of business. In fact, because of conditions of imperfect knowledge and human perversity, market areas for the same good or service usually overlap.

These concepts also give rise to the concept of <u>hierarchy</u>. Thus, at the bottom of the hierarchy, we will find low threshold, low range goods and services, such as those associated with bakery and dairy products. These are most numerous, and thus here market areas (for a given region) are also most numerous. As we move up the hierarchy, we will encounter goods

72. See Berry, et *al.*, and Garner (References 2 and 8 respectively in readings at end of this part).

73. Ratcliff, op. cit., pp.

74. Garner, op. cit.

75. W. Christaller, 'Central places in southern Germany,' translated by C. W. Baskin, Prentice-Hall, 1966.

76. B. J. L. Berry, 'Geography of market centers and retail distribution,' Prentice-Hall, 1967.

and services with ever-increasing threshold and range values, and therefore with larger market areas, and being less numerous.

If we wish, then, to locate a store, we can either take our chances that a given site will place us at an appropriate point in the hierarchy, or we can carry out a sophisticated analysis to ensure that this is so.

In the first instance, we are hoping that the system will adopt the store, i.e. that we will find a benevolent environment. In the second instance, we are consciously adapting the store to the system or environment to ensure that its survival is not a matter of luck! As market areas become increasingly saturated, and economic activities therefore more keenly competitive with consequently reduced profit margins, it is to be expected that the old trial-and-error adoptive approach will be replaced by the more rigorous, calculated adaptive technique.

But we have been talking as though a retail activity sells only one good or service, while we know from experience that the typical store, for example, sells a great variety of goods, and to large numbers of individuals with greatly varying tastes. And only infrequently does an individual make a shopping trip for a single item. Typically, the shopper will tend to go to the one store, or group of stores, where he can make several purchases at one stop. The automobile has enabled the consumer to easily and inexpensively travel long distances to stores and shopping centres where he can "shop around" in comfort. And as technological progress in transportation has increased the consumer's mobility, retail outlets have enjoyed economies of scale through increasing the variety and scope of their wares and services, and thereby drawing customers in larger numbers. Shoppers are also attracted by the recreational and cultural opportunities provided by different retail centres.

Thus the tertiary system is not static and unchanging; in fact, central places at any one time are at various stages of development, particularly when the rate of urban growth is considered. Some centres will be at various stages of maturity, others will be in decline.[77] Thus the open-ended system which represents the urban subsystem and the tertiary subsystem are undergoing the effects of physical, economic, and social changes. The transportation pattern is modified by these changes, and those changes in turn affect the urban and tertiary subsystems, and vice versa. These changes are, of course, reflected in changed patterns of accessibility and changed land values surfaces.[78] Mobility to and within urban areas is reflected in changing patterns of consumer tastes and demands. Changes in the actual technology of retailing may also have an effect on the commercial system.[79] Thus the urban landscape is dynamic and in a constant state of flux.

The major development stemming from technological progress and economies of scale has been, of course, the planned shopping centre. This institution has many of the characteristics of a super-department store. It draws upon a large market area whose residents are attracted by the

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77. J. W. Simmons, 'The changing pattern of retail location,' University of Chicago, Dept. of Geography, Research Paper No. 92, 1964.

78. M. Yeates, "Some factors affecting the spatial distribution of Chicago land values, 1910-1960," Economic Geography, Vol. 41, 1965, pp. 57-70; and R. V. Ratcliff, "The dynamics of efficiency in the locational distribution of urban activities," in 'The metropolis and modern life.' R. Moore Fisher (ed.), Doubleday, N.Y., 1965, pp. 125-148.

79. A. R. Doody and W. R. Davidson, 'Next revolution in retailing," *Harvord Business Review*, May-June, 1967, pp. 4-20 and p. 188.

prospects of one-stop shopping in an area with lots of parking, without battling the traffic congestion of the mid-town area. The planned shopping centre has doomed many small neighbourhood stores, but these had suffered already from the development of the supermarket chain store. Its major competitor is the central business district whose businessmen have considered counteractions, such as the development of malls. However, there is a tendency for the higher quality, more expensive goods and services to remain in the central business district. These goods and services, in other words, have high threshold and range values thus encompassing the whole urban complex in their market area. The shopping centres tend to develop as secondary centres with more reduced market areas. At the bottom of the urban retail hierarchy may well be the typical variety store-barber shop-cleaning establishment complex.

This discussion has probably caused you to think of several rather obvious questions. Just what is an optimal arrangement of retail activities and services within a city? How many food stores, for example, should there be? Where should they be located? What items should each one stock? These are questions to which the marketing and urban geographer must direct himself. Or we must simply rely upon "natural" competition in the urban system to lead to the "adoption" of the best arrangement.

Again we observe, however, that significant technological changes on the horizon may drastically alter the present spatial pattern of tertiary activities. The advent of a chequeless, cashless society, and the substitution of the electronic flow of audio-visual information for physical flows have ramifications of considerable concern to those who would control spatial organization.

One of the principal trends of the last 150 years in nearly all economic systems has been the tendency for economic activities to become areally polarized, and for an increasing proportion of the population to live in cities. These processes have been fairly regular, which is reflected in a fairly regular distribution pattern of urban settlements. Attention has already been drawn to the regular interrelationships that occur within cities, and between cities and their hinterlands, but this can also be extended to relationships between cities and towns of different size groups in areas of varying sizes. This seems to indicate that each town or city is part of an orderly system of urban places, and that the tertiary activities and services each provides are duplicated by other towns and cities of roughly equal size. Thus, there appears to be a logical order in the distribution of cities and towns through the framework of the general economic system, so that the pattern does not arise fortuitously but results from processes which tend to promote regularity.

While the observation of such regularity may be intellectually satisfying, the basic problem remains one of identifying the nature of the process at work. In a teleological vein, what are the implicit goals of the system? Or, alternatively, what is this system supposed to do for us? What are the human aspirations which are satisfied? Can the search for items for consumption, like the production of the items, be delegated to the machine?

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4. L. Curry, "The geography of service centres within towns: an operational approach," Lund Studies in Geo. Series B, No. 24, 1962, pp. 31-53.
5. R. Cox, "Consumer convenience and retail structure of cities," Journal of Marketing, Vo. 23, 1959, pp. 35-62.
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17. D. L. Thompson, "Future directions in retail area research," Economic Geography, Jan. 1966, No. 1, pp. 1-18.
18. *L. G. Wagner, op. cit.

PART 7 – THE TRANSPORTATION SYSTEM

Up to this point in the course, we have emphasized the location of sites. Now we turn to a consideration of the location of routes. In fact, our interest is somewhat wider than this might at first imply. In many senses, transportation is a measure of the relations between areas, and is therefore essentially geographical, being involved with concepts like spatial interaction, areal association, etc. Transport studies are concerned not just with the flow of goods or people, but with the flow of ideas, innovations, money, and credit. Thus we would include communications as part of the transportation system. This concern with all spatial connections and interactions can be summed up by the term circulation (following Wagner).[80] Thus within this very broad view of transportation, all economic activity may be interpreted as a transportation problem, though we tend to arbitrarily terminate it at the door of factory, store and residence. But the drilling, grinding and reaming of an engine block involves "transportation" of the metallic waste in order to increase the utility of the remainder.

80. Wagner, op. cit., pp. 207-216.

Transportation is involved in the movement of paper in and out of an "in" basket.

Circulation and its study is maintained by some geographers to provide deep insight into the meaning of areal differences, and to provide a key for measuring the likenesses and differences amongst places on the earth. A number of geographers view the core of geography as primarily a study of spatial interaction and this concept of circulation; Ullman and Crowe, for instance, see movement as an indicator of the degree of connection and as underlying patterns of interchange.[81] This idea underlies and is implicit in the absolute spatial concepts of Bunge, and in the work of Nystuen.[82]

In all the systems examined so far, stress has been put on interaction and movement, the systems approach, showing the interdependence of an economy, circulation and traffic, and the transport system.

Here we are concerned with routes (the channel of movement, physical or face to face contact), why these routes arise (specialization separating need and fulfillment), their nature (as a minimization of costs), their location (network geometry) and their growth and change.

On the whole, the vastly improved world transportation net has resulted in a lowering of the cost of movement and this has made possible the economic specialization of areas. In effect, we have substituted interdependence for self-sufficiency (or open for closed systems) with an overall gain in human welfare. But at the same time as the world is growing unlike other forms of circulation (the ease of communication of ideas, for instance) are making the world in some senses more alike.

But what are the conditions for interaction and the resultant emergence of a route? The complexities of economic interdependence, the trend toward the growth of one world economic system, show up in the patterns of circulation in the economy. However, circulation patterns are also influenced by the particular modal system, the particular network, flows, and so on. The matching of demand, which is becoming increasingly similar, and of supply, becoming increasingly specialized, is channeled through the communications system. "The spatial structuring of those patterns help to initiate movement; movement becomes the means of correcting any spatial imbalance. The structure of the transport system, the channeling, effects and moulds circulation patterns, limits in some cases the degree and direction of interchange and interaction."[83]

If the systematic relationships are so complex, how can we disaggregate the transportation system? Basically, we can do this by posing six questions concerning the route or channel, and its actual location:

(1) What is meant by a route? A regularly travelled part of some social and economic significance.

(2) Why does a route arise? There must be a desire to travel from one place to another. This desire is conditioned by considerations of least effort and least cost, and subject to certain environmental factors—topography, political boundaries, intervening opportunities and distractions.

81. P. R. Crowe, "On progress in geography," *Scottish Geographical Magazine*, Vol. 54, 1938, pp 1-19; E. L. Ullman, "Human geography and area research," *Annals of the A.A.G.*, 43, 1953, pp.

82. W. Bunge, 'Theoretical Geography,' Lund, C. W. K. Gleerup, 2nd ed., 1966, Chapters 5 and 8; Nystuen, *op. cit.*

83. M. E. Eliot Hurst, "Land use-traffic generation relationships," *Traffic Quarterly* following.

Ullman advances a three factor typology in explanation:[84]

(a) Complementarity. There must be a demand in one area and a supply (surplus) in the other. This factor may arise through natural and cultural areal differentiation based on the operation of economies of scale.

(b) Intervening opportunity. Complementarity generates interchange between two areas only if no intervening source of supply is available.

(c) Transferability. If the distance between market and supply is too great and too costly to overcome, interaction will not take place. Alternate goods will be substituted.

The frictional effect of distance is important. Zipf[85] investigated a wide range of data relating to the exchanges of information, commodities, and people between paired cities. He observed that the number of such occurrences varies directly as the products of the two populations divided by their distance apart (this is the simple Gravity Model considered in an earlier section).

Both Ullman's typology and the gravity model have limitations which should be noted. The former assumes complete information, rational behavior, and a desire to minimize all movements; the latter is a convenient physical analogy (from Newtonian physics) with little explanatory value.

(3) What is the nature of the routes? It is essentially related to the minimization of costs.[86]

(a) Minimum cost path. This is the route location for which the total cost of a certain arrangement is lowest between two points, i.e. it is the least-cost choice among alternative paths.

(b) Minimum cost technique or design. Transport mode, and type of construction, considered in relation to the environment, service required, traffic volume, and commodity type.

(c) Position of minimum cost transfer points. A consideration of the whole system of movement involving transhipment points.

(d) Position of minimum cost base. The location of operating and repair operations, where they could perform most efficiently.

These first three questions discuss transportation in terms of a route or path. But it is obvious that many routes are needed to order to link the various economic activities together smoothly and efficiently. Thus a supplementary question arises, could we well consider what is the optimal set of routes? What is the optimal set of techniques, bases, and transfer positions? What is the optimal time schedule of movements? There are techniques which can help us to solve these problems. One such technique, the consideration of a least cost route through the system, is considered in Appendix B (the transportation problem).

To these three basic questions, three further questions can be added.

(4) What controls actual route location? If a route has to be built between two settlements, then the intuitive answer to route location is to join them by a straight line; however, few routes follow this straight line form. Four kinds of deviations can be recognized:[87]

(a) Positive deviation. A route may be lengthened in order to collect more freight. The relationship between length of route (the shorter the

84. E. L. Ullman (see reference at the end of this section).

85. G. K. Zipf, 'Human behavior and the principle of least effort,' Cambridge, Addison-Wesley Press, 1949, Chapters 9 and 10.

86. E. Troxel, 'Economics of transportation,' New York, Rinehart, 1955.

87. P. Haggett, 'Locational analysis in human geography,' London, E. Arnold, 1965, pp. 61-73.

better) and the amount of traffic (the greater the better) is optimized.

(b) Negative deviation. A route may deviate to avoid certain barriers, or to minimize the distance travelled through high cost areas.

(c) Political distortion. C. H. Cooley (1894) stressed the importance of political factors, particularly boundaries, in distorting route patterns.[88]

(d) Network geometry. Based on certain distance-minimization concepts, where route location may be a compromise between new costs and builder costs.[89] (See also (3) above)

(5) How do routes grow and change? Routes and communications systems are not stable or static, but they change and develop in response to changes elsewhere in the socio-economic system.

A number of geographers have sketched the changes in the communications system through time, by analyzing network and route changes, and relating these to the whole process of socio-economic development.

(a) Underdeveloped areas. Taaffe, Morrill and Gould have developed a simple four phase model:[90]

(i) A scatter of small ports and trading posts along the coast.

(ii) A few major lines of penetration develop in land; coastal ports expand their immediat hinterlands.

(iii) Feeder routes develop, and the beginnings of lateral intercommunication.

(iv) Linkage and concentration, with the emergence of high-priority linkages between the most important centres.

Like all 'stage' models, this one can be criticized, but Taaffe, et al. warn "...it is probably most realistic to think of the entire sequence as a process rather than as a series of discrete historical stages. Thus at a given point in time, a country's total transport pattern may show evidence of all phases."[91]

(b) Developed areas. Here concern is with development where an existing route system already functions. Interest lies in the ways in which networks are adjusted to technological change in transport itself, and the ever-widening circles of interaction, linkages, and communications as socio-economic levels rise and society grows more complex. Such changes may take the form of a new highway, new technology (supersonic transports, air cushion vehicles, jumbo jets), or shifts in the rate structure. As mentioned earlier, there is a growing trend toward substitution of electronic communication for physical transportation. The serious evaluation of the implications of such trends for spatial organization is stressed in this course.

(6) What is the relationship of route structure, etc. to other economic activities? Transport may satisfy human wants directly as in the case of vacation travel, or it may play a vital role in the productive processes, as in the case of bringing raw materials to the factory and then distributing the finished product. That is, transport adds place utility to goods. In particular, transport can be related to trade, prices, and land use.

This 'six question' approach is essentially the systems approach,

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88. C. H. Cooley, "The theory of transportation," Publications of the American Economic Association, May, 1894, Vol. IX, No. 3; see also R. J. Wolfe, 'Transportation and politics,' Princeton, D. Var Nostrand Co. Inc., Searchlight Series, No. 18, 1963.

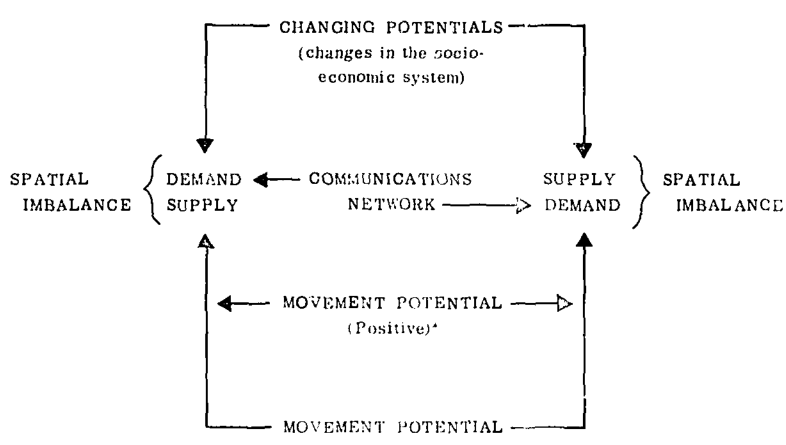
89. See Bunge, *op. cit.*, and Haggett, *op. cit.*

90. E. J. Taaffe, R. L. Morrill, and P. R. Gould, "Transport expansion in underdeveloped countries: a comparative analysis," *Geogr. Review*, Vol. 53, 1963, pp. 503-529.

91. *Ibid.*, p. 505.

showing the mutual interdependence of an economy, circulation and traffic, and the transport system. Circulation results from bringing together spatially separated demands and supplies through trade and interaction (Figure 16). The aim of the economic geographer, when concerned with transportation, is to describe and explain circulation as a component of the world economic system. Circulation is limited, directed and channeled by a composite network system, a conglomerate of many modes and elements acting in unison or competition. Thus movement becomes a function of the nature of demands and supplies and of the character of the available transport systems. Each means of transport has its own technological characteristics and its spatial layout or network. The amount of a flow, the quantity of traffic, is a function of the character of the available transport systems and their 'environments.' "It is obvious that relationships are extremely complex, whether they be of the economy- circulation-transport type which gives rise to goods movement or the livelihood-settlement-circulation-transport type, which describes the movement of persons. Change in any one part of the system is likely to be precipitated throughout the whole. . . ."[92]

FIGURE 16
Simple travel-movement relationships



* forces likely to increase movement (complementarity, intervening opportunity, cultural affinity, political affiliation, etc

** forces which operate to decrease the likelihood of movement (distance, transferability and substitution, movement costs, tariffs, quotas, etc.)

SOURCE: M. E. Eliot Hurst, "A geography of economic behavior," op. cit.

92. B. J. L. Berry, "Recent studies concerning the role of transportation in the space economy," *Annals of the A.A.G.*, Vol. 49, 1958, p. 341.

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PART 8 – TOTAL SPATIAL SYSTEM

We started the course by considering the concept of a general system. We observed that the real world space-economy, to a significant degree, satisfied our definition of a system. We proceeded, then, to illustrate the operational advantages of the concept in the part on models of interaction.

The next step was to decompose the space-economy into the major subsystems of sites (agriculture, resources, manufacturing and tertiary) and routes, and to further analyze their components and associated interrelationships.

Given an improved understanding of the spatial system, we must now consider how to spatially reorganize the systems and their components in order to achieve some human goals.

However, the form of the open space-economy will be influenced by its political and regulatory environment. Explicit consideration must be given to the effect of various politically induced spatial economic organizations, such as the following:

Nation: political philosophy
Nation-colony system
Preferential trade areas: commonwealth of nations
Free trade areas
Customs unions
Economic communities
Intranational economic regions

As an example of the approach suggested here, consider the European Economic Community. By January 1, 1970, it is planned that the six member nations will have:

(a) free movement of persons, services and capital
(b) a common transport policy
(c) common rules of competition
(d) a common social policy on retraining and resettlement
(e) a common external tariff

The goal is, of course, a higher standard of living through more efficient spatial organization. What, then, will be the spatial effects of these measures? These might be considered in such areas as:

(a) Increased spatial interaction leading to changes in behavior and methods of production (more uniformity?)

(b) Government resistance strengthened against political pressure by local groups seeking their own benefit

(c) Adequate market created for an expanded consumer's credit industry

(d) Increased spatial specialization, especially in agriculture

(e) Reallocation of factors of production from less to more efficient producer may result in creation of depressed regions; consider role of European Investment Bank in off-setting socially undesirable capital flows

(f) Effect on relations with outside world: trade creation (within community) vs. trade diversion (outside community).

The discussion leads naturally into a consideration of regional disparities in economic welfare, and the general problem of regional economic development.[93]

In transitional societies, the regional problem arises when, for a variety of reasons, activities come to be concentrated in one or a few centers. These centers grow rapidly and pull in the more dynamic elements from the more static regions. Thus these latter are relegated to an inferior, peripheral position. It should be observed, however, that a center-periphery structure appears to occur at all scales—world, continent, nation and city. Such a phenomenon can be conceptualized as a flow of energy (negative entropy) from the environment (periphery) into an open system (center or "growth-pole") which arrests, and then reverses, the tendency toward disorder (economic depression). Such a development need not be one-way, however, and a counterflow may be generated which produces a "feedback" in the form, perhaps, of increased demand for the periphery's products. Hirschman[94] categorizes these trends as <u>polarization</u> and <u>trickling-down effects</u>, respectively.

93. Excellent reference material may be found in J. Friedmann and W. Alonso. 'Regional development and planning,' M.I.T., 1964, and in H. O. Nourse, op. cit.

94. A. D. Hirschman, 'Strategy of economic development,' Yale, 1958, Chapters 5, 6 and 10.

But peripheral regions or communities are not usually content to fade away, but are motivated to do all in their power to promote their development. How can this be done?

Using Hirschman's terms, we might suggest the stimulation of those economic activities with the most significant backward and forward linkage effects. A backward linkage refers to inputs from a supplier, while forward linkage concerns output to a customer. Thus an economic activity should attempt to get its inputs produced locally and its outputs purchased locally, i.e. where outputs are utilized in a further manufacturing process. Such attempts would lead to a more intensive use of local resources, both human and natural, thus stimulating the establishment of social overhead capital (transport, power, schools) and directly productive activities (factories, mines, farms). This accumulation of capital resources in turn could lead to significant agglomeration economies and increased population, thus contributing to sustained growth through the establishment of services and consumer-oriented industries.

But how are we to discover which activities can generate the large linkage effects desired? One approach would be to study an input-output table of an advanced economy and thus discover those industries which have the kinds of input-output relationships which can maximize use of the resources in out region of interest.[95]

Frequently, however, there may be two or more competing uses for a given resource. The solution of this problem requires a technique termed benefit-cost analysis.[96] This technique is possibly most commonly associated with a government-sponsored water resource development project, where benefits may take the form of hydro-electric power, navigation, flood control, irrigation, recreation and pollution abatement. The calculation of a benefit-cost ratio for each of several competing projects may enable us to decide which confers the largest net benefit on the economy as a whole.

We would summarize a general strategy of economic development as follows (after Leven):[97]

(a) Expand or develop markets for existing or potential local industries and resources. (External focus)

(b) Advertise the region in order to attract new industries and services. (External focus)

(c) Improve efficiency (lower per unit costs) of local public (infrastructure) and private sectors. (Internal focus)

However, it must be borne in mind that, following the center-periphery concept, not all regions can grow at the same rate, and some supra-authority may well be given the responsibility of co-ordinating the diverse (spatially) development programs. Success of one region may lead to depression in another such that there may be an overall system decline in per capita welfare.

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95. This approach is discussed in W. Leontief. "The structure of development," *Scientific American*, Vol. 209, No. 3, 1963, pp. 148-166.

96. W. R. D. Sewell, J. Davis, A. D. Scott and D. W. Ross, 'Guide to benefit-cost analysis.' Queen's Printer, Ottawa, Canada, 1962.

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PART 9 – PROBLEMS OF ECONOMIC ORGANIZATION

Carrying on from Part 8 with its concern for an optimal economic pattern and its suggestions for reaching that, we see in many parts of the world that in reality these optimal patterns are rarely achieved. There are a number of reasons for this malfunctioning of the total system. One of the most notable is the population-resource ratio. In order that human welfare should improve, resources have to become available at rates faster than population growth. Unfortunately, the increase in population in the so-called 'underdeveloped' areas of the world is threatening to outrun all efforts to increase productivity per capita.

The problem of increasing productivity/capita can be tackled in only three basic ways:

(a) by increasing productivity/capita via technological means,
(b) by reducing the rate of natural population increase, and
(c) by a combination of the above.

The ultimate goal is to produce a surplus of goods, over and above that needed for current consumption, which may provide the means of capital formation—as social capital (infrastructure) or instrumental capital (blast furnaces, machine tools, etc.). This new capital can be applied to increasing both goods available for consumption and goods for further capital formation, thus contributing to the upward spiral of economic growth.

However, the malfunction goes much deeper than matters of population/resource ratios, or capital formation. As was suggested in the previous section, political and community groupings interject 'artificial' boundaries into the world economic system. The nation-state, for example, has become the core of political organizations, and with it there are implications for economic geography. The state represents not just an organized piece of territory, but a set of institutions involving a system of relationships, which are the vehicles by which to achieve certain societal goals. These goals, political and ideological, may run contrary to the optimal running of the total economic system described previously.

Within the context of the total spatial system, there are then a number of dominant trends which tend to lead to less than optimal behavior and economic patterns:

(1) the increasing strength and dominance of nationhood, especially since 1940 and the demise of most European 'colonial' empires. This tendency has produced no pattern other than the patchwork of their own existence. The economic effect, whilst having some influence on investment patterns, is to erect more barriers, political, tariff, custom, etc., to economic flows, and to bolster the self-sufficient economic region, which trends are undermining elsewhere. A counter trend, of lesser strength, are the groupings noted in the previous sections.

(2) An ideological struggle between various groups, each representing in their own eyes, the 'optimal' system.

(3) The consequence of these economic-ideologic differences, which are explicable in such terms as, for example, Frank's metropolis-satellite five phase hypothesis of the capitalist system.[98]

Thus we begin with ideas of a virtually undifferentiated space--the homogeneous plain of von Thunen, Christaller, or Weber. Reality, much more complex, leads to a differentiation of space—through transport costs, agglomeration economies, population-resource ratios, capital availability, and through variations in politico-socio-economic organization. Thus we encompass here the causes for spatial differences noted in the previous section—areas of growth or decline, development or depression—but we must now come up against this further differentiating factor, political variations in space. Such political and economic ideologic compartmentalism has a profound effect on the world economic system.

Table 3 summarizes some of the differences between a developing or underdeveloped economy (peasant and subsistence societies as earlier identified), and contemporary western industrial societies (commercial market, and redistributive). It is not suggested that any column is 'optimal,' though a particular type may be perceived as so by people in particular socio-economic or ideologic circumstances.

Suggested Reading

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98. G. Frank, "The development of underdevelopment," Monthly Review, Vol. 18, No. 4, September, 1966, pp. 17-31.

TABLE 3

Variations in economic systems at extremes of development

	Peasant/Subsistent (underdeveloped)	Commercial-Market	Redistributive
INCOME/HEAD	Low; may be declining	High	Medium, increasing
PROP. OF POPULATION DIRECTLY DEPENDENT ON PRIMARY ACTIVITIES	Very high (75% or more)	Very low (25% or less)	Medium to low (10 – 50%)
PROP. OF POPULATION DIRECTLY DEPENDENT ON SECONDARY ACTIVITIES	Very low	High and rising to about 25-30%	High and rising
PROP. OF POPULATION DIRECTLY DEPENDENT ON TERTIARY ACTIVITIES	Low	High, and rising in a sustained fashion, with urbanization	High and rising
POPULATION IN CITIES AND LARGE TOWNS	Small, but some large cities do occur	Very high	High
TECHNOLOGY	Static or traditional	Dynamic, with rapid innovations	Dynamic, with rapid innovations
GOALS OF PRODUCTION	Family consumption and survival	Income and net profit	Net community profit
DECISION-MAKING	A'rational or traditional	Satisficing, intendedly rational	Economic, planned, intendedly rational
INTAKE OF FOOD	Deficient	Superabundant	Sufficient to abundant
PROP. OF DIET FROM STARCHES	High	Low	Medium
DEATH RATE, INFANT DEATH RATE, BIRTH RATE	High	Low	Low
LEVEL OF LITERACY	Low	High	High

SOURCE: M. E. Eliot Hurst, op. cit.; Wharton, op. cit.; N. Ginsburg (ed.), 'Essays on Geography and Economic Development,' Chicago Research Paper No. 62, 1960; and J. Rutherford, M. I. Logan, and G. J. Mission, 'New Viewpoints in Economic Geography: case studies from Australia, New Zealand, Malaysia, and North America,' Sydney, 1966, Chapter 1.

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CONCLUSION – the world economy as systems

We see in the world around us, a complex socio-economic landscape. This complex system describes systems of interrelatedness between the primary, secondary, and tertiary activities that appear in particular places as the overt results of economic behavior. Such arrangements of economic activities are matters of extreme complexity, though through systems analysis these arrangements are more easily conceived and understood.

Any socio-economic landscape when studied in its entirety, reveals the presence of a system, an array of interconnected parts, each of which contributes to the operation of the whole. If the system is a very large one, it can reap the benefits of very specialized divisions of activities, producing this very complex set of interrelationships that characterizes the economic organization of many parts of the present-day world. If, however, because of certain differences in the values system, learned abilities, and culture, a people is not able to achieve these high degrees of specialization, or obtain control of resources that are adequate to support a large-scale economy, its economic system is marked by relative simplicity and its economic landscapes by fewer and less complex relationships. Economic geographers recognize the existence of these interrelationships, because the knowledge of the operation of the system is a prerequisite to understanding the functioning of its parts.[99]

Yet as we move ever farther in the direction of a technological society,[100] and cybernetic decision-making, must we also accept a standardized culture in a standardized spatial organization? Or can advanced technology facilitate an ever-increasing degree of individual expression?

This course is dedicated to the proposition that, given deep awareness of the nature of a man/machine symbiosis, there can continue to be a human geography.

99. H. H. McCarty and J. B. Lindberg, op. cit.

100 For elaboration, see J. Ellul, 'The technological society,' Vintage, 1967; also J. K. Galbraith, 'The new industrial state,' Houghton Mifflin, 1967.

APPENDIX A

Models of Interaction

Input-Output Analysis

Let us suppose that there are three activities in our system or region, each using the output of itself and the others as an input to its process. The activities are agriculture, mining, and manufacturing, whose total outputs are designated as X_1, X_2 and X_3 respectively.

Their technical coefficients (the dollars (cents) worth of input used/ dollar of output) are as follows:

Coefficient Matrix (To)

		Agric.	Mining	Manufac.
	Agric.	0.4	0.1	0.3
(From)	Mining	0.2	0.3	0.1
	Manufac.	0.2	0.3	0.5

Thus the coefficient 0.4 tells us that for every dollar's worth of production (output) of the agricultural activity there is used 40 cents worth agricultural inputs.

Suppose final demands (goods for final consumption, not for further processing and resale), for agriculture, mining, and manufacturing are 5MM (million) dollars, 2 MM dollars and 10 MM dollars respectively. We may then construct a mathematical model of this economy using three linear equations:

$$X_1 - 0.4X_1 - 0.1X_2 - 0.3X_3 = 5 \text{ MM}$$

$$X_2 - 0.2X_1 - 0.3X_2 - 0.1X_3 = 2 \text{ MM}$$

$$X_3 - 0.2X_1 - 0.3X_2 - 0.5X_3 = 10 \text{ MM}$$

The first equation would read—"the total amount of agricultural production (X_1) minus the amount of agricultural production required to produce the demanded level of agricultural production ($0.4X_1$) minus the amount of agricultural production required in mining production ($0.1X_2$) minus the amount of agricultural production required in manufacturing production ($0.3X_3$), leaves as a residual for final consumption, \$5 MM of agricultural production." The other equations would read similarly.

We have thus converted the economic system (real-world) into an analytic system. This latter system may be manipulated (solved) to determine the amounts of X_1, X_2 and X_3 which must be produced in order to satisfy the final demands.

First, we group like terms:

$$(1 - 0.4)X_1 - 0.1\,X_2 - 0.3\,X_3 = 5 \text{ MM}$$

$$-0.2\,X_1 + (1 - 0.3)X_2 - 0.1\,X_3 = 2 \text{ MM}$$

$$-0.2\,X_1 - 0.3\,X_2 + (1 - 0.5)X_3 = 10 \text{ MM}$$

Place in matrix form:

$$\begin{bmatrix} 0.6 & -0.1 & -0.3 \\ -0.2 & 0.7 & -0.1 \\ -0.2 & -0.3 & 0.5 \end{bmatrix} \begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} \begin{matrix} \\ = \\ = \end{matrix} \begin{bmatrix} 5 \\ 2 \\ 10 \end{bmatrix}$$

Convert to symbolic form:

$$(I-A)\ X = Y$$

Multiply both sides of equation by inverse of (I-A):

$$(I-A)^{-1}\ (I-A)X = (I-A)^{-1}\ Y$$

This reduces to:

$$X = (I-A)^{-1}\ Y$$

since $(I-A)^{-1}\ (I-A) = I$, and $IX = X$

Hence we see that to solve for the X's, we must determine $(I-A)^{-1}$ and multiply by Y (final demands).

To find $(I-A)^{-1}$, first augment (I-A) by an "identity matrix" of same size (rows and columns) as (I-A):

	(I-A)			I		
0.6	-0.1	-0.3	1	0	0	
-0.3	0.7	-0.1	0	1	0	(1)
-0.2	-0.3	0.5	0	0	1	

The problem now simply becomes one of converting the (I-A) matrix to an I matrix using "elementary row operations". While we focus our attention in the rows of (I-A), whatever operation we perform on an (I-A) row must also be applied to the corresponding I half of that row.

The elementary row operations which we may employ are:

(a) we may interchange any row with any other (designated by R_{ij}, indicating changing of row i and row j)

(b) we may multiply any row by a constant ($R_i(k)$)

(c) we may multiply any row by a constant and add it to another row, leaving row which is multiplied unchanged ($R_{ij}(k)$) indicating multiplication of row i by k, and addition to row j, leaving row i unchanged).

Let's begin by multiplying each row by 10 in order to eliminate decimal values.

6	-1	-3	10	0	0	
-2	7	-1	0	10	0	(2)
-2	-3	5	0	0	10	

We shall begin the conversion of the left hand matrix to the identity matrix by starting at the upper left corner, moving down to lower left, then across and back up.

$R_1\ (\frac{1}{6})$	1	$-\frac{1}{6}$	$-\frac{1}{2}$	$\frac{10}{6}$	0	0	
	-2	7	-1	0	10	0	(3)
	-2	-3	5	0	0	10	
R_{12} (2)	1	$-\frac{1}{6}$	$-\frac{1}{2}$	$\frac{10}{6}$	0	0	
	0	$\frac{40}{6}$	-2	$\frac{10}{3}$	10	0	(4)
	-2	-3	5	0	0	10	

Note that in this last operation, we multiplied row 1 by the constant 2, and added the computed row to row 2. Row 1, however has remained unchanged in the new matrix. We continue:

R_{13}	(2)	1	$-\frac{1}{6}$	$-\frac{1}{2}$	$\frac{10}{6}$	0	0	
		0	$\frac{40}{6}$	-2	$\frac{10}{3}$	10	0	(5)
		0	$-\frac{20}{6}$	4	$\frac{10}{3}$	0	10	
R_{23}	$(\frac{1}{2})$	1	$-\frac{1}{6}$	$-\frac{1}{2}$	$\frac{10}{6}$	0	0	
		0	$\frac{40}{6}$	-2	$\frac{10}{3}$	10	0	(6)
		0	0	3	5	5	10	

We carry on in like fashion for several more interations and arrive at:

	I			$(I-A)^{-1}$		
1	0	0	$\frac{40}{15}$	$\frac{70}{60}$	$\frac{110}{60}$	
0	1	0	1	2	1	(7)
0	0	1	$\frac{10}{6}$	$\frac{10}{6}$	$\frac{10}{3}$	

We now have $(I-A)^{-1}$ on the right side.

Converting $(I-A)^{-1}$ to decimal form, we solve for X:

$$\begin{bmatrix} X_1 \\ X_2 \\ X_3 \end{bmatrix} = \begin{bmatrix} 2.67 & 1.17 & 1.83 \\ 1.00 & 2.00 & 1.00 \\ 1.67 & 1.67 & 3.33 \end{bmatrix} \begin{bmatrix} 5 \\ 2 \\ 10 \end{bmatrix}$$

or

$$X = (I-A)^{-1} Y$$

Thus

$$\begin{aligned} X_1 &= (2.67 \times 5) + (1.17 \times 2) + (1.83 \times 10) \\ &= 13.35 + 2.34 + 18.3 \\ &= 34 \text{ (rounded up)} \end{aligned}$$

Similarly

$$X_2 = 19$$

$$X_3 = 45$$

You may be surprised at how much total production is required in order to satisfy the given final demands. But we have a completely interdependent system, and a demand upon one sector leads to indirect demands upon all other sectors.

The computation of the inverse, you will have noted, is rather tedious. Fortunately, matrix inversion programs are available for computers, thus one would not solve this problem manually in most real-world cases.

But once the inverse has been computed, then you can proceed to try various final demand vectors, and observe their impact upon the total system. You may also compute a multiplier for each sector, indicating the number of dollars of total production in the system generated by one dollar of final demand in the given sector.

Input-output analysis is often described as an impact-measuring technique since it measures the effect of a change in one or more sectors of an economy upon the total economy.

Thus we have observed that viewing the economy as a system comprised of interrelated sectors or components led us to the empirical determination of the nature of these interrelations. These data enabled us to calculate the technical coefficients, and so to construct our system of equations. These we were able to solve to give us useful further data on which to base possible decisions affecting the control of the economy.

The simple model we have used is non-spatial as are practically all existing input-output models. Isard[101] has described a spatial interregional model which would specify flows of specific location of origin and destination, instead of by non-spatial sectors. Berry[102] discusses an interesting Indian case-study.

Suggested Reading

1. W. Isard, "Methods of regional analysis", (M.I.T. Press, 1960), Chapters 8 and 9.
2. W. W. Leontief, Scientific American, Oct. 1951, April 1961, Sept. 1963 and April 1965, with special wall map, 'The input-output structure of the American Economy', Scientific America Pub. 1966.
3. G. J. Karaska, "Interindustry Relations in the Philadelphia Economy", The East Lakes Geographer, Vol. 2, 1966, pp. 80-95.
4. *W. H. Mierynk, 'The elements of input-output analysis', (Random House, 1966).

Linear Programming

In input-output analysis we were concerned with measuring the effect of a change, given certain assumptions about the character of interrelations in the economy. We were not expressly interested at that point in whether the effect was a desirable one. We simply wanted to know what was going to happen.

The application of linear programming to the economy, however, enables us to state a specific goal (indeed, it forces us!), and to indicate clearly the quantitative aspects of certain conditions which may inhibit our reaching that goal. Linear programming, therefore, is an optimizing technique.

Suppose in our region there are only two manufacturing activities, one producing gizmos and the other producing widgets. Each activity, however, uses the same inputs which we shall simply call land, labour and capital.

101. W. Isard, et *al*., 'Methods of regional analysis,' M.I.T. 1960, Chapter 8.

102. B. J. L. Berry, 'Essays on commodity flows and the spatial structure of the Indian economy.' Chicago Geography Dept., Research Paper No. 111, 1966, Chapter 3.

This time our technical coefficients will be in physical units, and will tell us the amount of input in physical units per unit of output of the activity.

	Technical Coefficient	
	Gizmo	Widget
Land	0.2	0.6
Labour	0.4	0.2
Capital	1.25	2.0

Thus, for example, 0.2 units of land are required per one unit of gizmos. And so on.

But there are limits in our region on the total amounts of land, labour and capital available for our use. The maximum amounts are:

Land	2 MM units
Labour	3 MM units
Capital	10 MM units

Our problem now boils down to this: What is the maximum value of production of gizmos and widgets that we can attain, and yet stay within our resource limitations?

To put it another way: given that gizmos and widgets sell for one dollar each, how many of each should we produce in our region in order to maximize our income from these two activities, subject to the resource constraints?

Let us represent the total outputs of gizmos and widgets as X_1 and X_2 respectively. Since they sell for a dollar apiece, then we can represent total value of production as follows:

$$1\,X_1 + 1\,X_2$$

This then is what we wish to maximize.

But this maximization is subject to resource constraints. These constraints may be represented as follows:

$$0.2X_1 + 0.6X_2 \leqq 2\text{ MM} \qquad (1)$$

$$0.4X_1 + 0.2X_2 \leqq 3\text{ MM} \qquad (2)$$

$$1.25X_1 + 2.0X_2 \leqq 10\text{ MM} \qquad (3)$$

The first inequation is read "the amount of land units used up in the total production of gizmos plus the amount of land units used up in the total production of widgets must be less than or equal to the total amount of land units available."

The remaining equations read similarly.

Now we are ready to solve the problem of the desired levels of production of gizmos and widgets.

We shall do so graphically.

Each constraint inequation may be represented on a graph as a straight line plus the adjoining area below it, as follows:

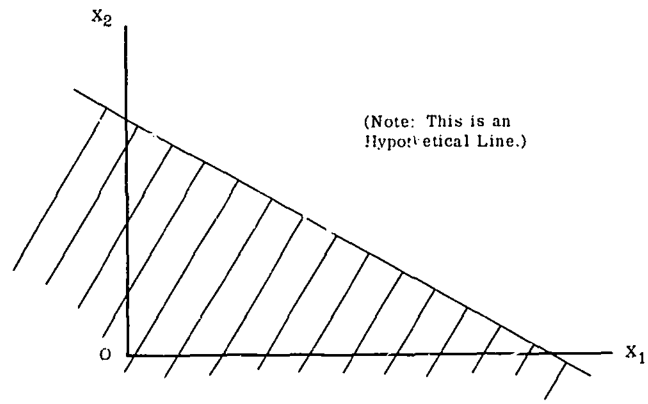

FIGURE 17

A simple procedure for graphing an equation is as follows: Consider $0.2X_1 + 0.6X_2 = 2$

$$\text{Let } X_1 = 0$$
$$0.6X_2 = 2$$
$$6X_2 = \frac{2}{0.6} = \frac{20}{6} = 3.33$$

Thus one point on our line occurs at 3.33 units along the X_2 axis, or at co-ordinate (0, 3.33).

Next, let $X_2 = 0$

$$0.2X_1 = 2$$
$$X_1 = \frac{2}{0.2} = \frac{20}{2} = 10$$

Hence the second point occurs at co-ordinate (10, 0).

Join the two points by a straight line. This line is the graphical representation of your given equation.

Thus, initially, we need only think of the equations and so draw on the graph the three straight lines representing the three equations (Figure 18). We then note that area (convex polygon) OABCD which is common to all inequations, and where X_1 and X_2 are greater than or equal to zero. (These latter constraints are necessary since it is economic nonsense to consider negative outputs!)

Area OABCD, therefore, satisfies our constraints, but since we wish a value of Z as large as possible, then our solution should lie on the segmented line (efficiency frontier) ABCD.

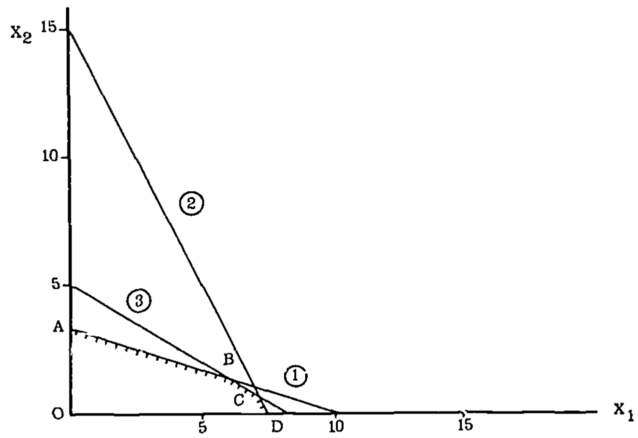

FIGURE 18

But how do we decide which combination of X_1 and X_2 along ABCD is the optimal one? The mathematical "decision-maker" is the equation (objective function) representing the total value of production that we wish to maximize:

$$Z = 1\,X_1 + 1\,X_2$$

Since we have assigned no value to Z (it is, in fact, one of the things that we want to find out), this equation represents a whole family of straight lines, each with a slope of -1. (See Figure 19).

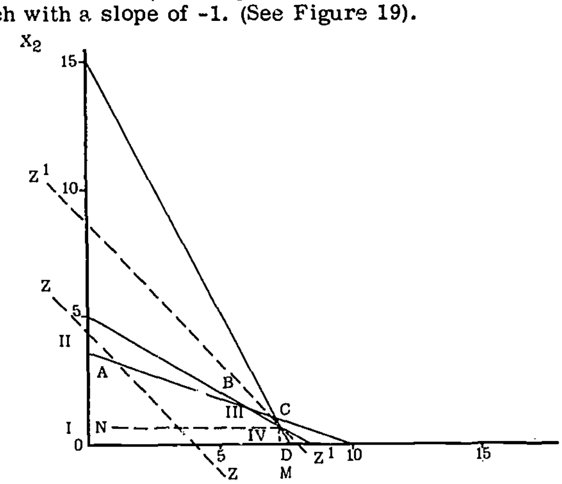

FIGURE 19

One such line of this family of lines is ZZ above. Now consider a line Z^1Z^1, parallel to ZZ, but capable of moving. Move this line away from 0 until it passes through one of the points A, B, C, or D which is furthest from 0.

In the above graph, this point turns out to be C. The values for X_1 and X_2 thus selected can be read off the respective axes as M and N. They are, approximately, $X_1 = 7.2$ and $X_2 = 0.5$. Therefore, $Z = 7.2 + 0.5$
$= 7.7$ MM

Z, then is the maximum income we can get from the production of gizmos and widgets in view of our resource limitations. In other words, we have wrung every last cent from our meager resources!

This model may be made spatial in a way similar to that suggested by Isard above for the input-output system. A suggested approach is explained by Stevens.[103] A variant of linear programming known as the transportation model, which has definite spatial applications, will be discussed later. (See Appendix B).

The graphical method of solving a linear program outlined above is of quite limited practical and conceptual significance. The more general mathematical solution procedure is called the simplex method. We shall describe it, using the above problem again as our example:

$$\text{MAX: } Z = 1\,X_1 + X_2$$
$$\begin{aligned} \text{Subject to: } \quad 0.2\,X_1 + 0.6\,X_2 &\leqq 2 \text{ MM} \\ 0.4\,X_1 + 0.2\,X_2 &\leqq 3 \text{ MM} \\ 1.25\,X_1 + 2.0\,X_2 &\leqq 10 \text{ MM} \\ X_1 \geqq 0; \quad X_2 &\geqq 0 \end{aligned}$$

The procedure which we shall follow (after Vajda)[104] can be used for maximization problems only.

We begin by adding slack variables to each inequation to change them to equations. Thus we get:

$$\text{MAX: } Z = 1X_1 + 1X_2 + 0X_3 + 0X_4 + 0X_5$$
$$\begin{aligned} \text{Subject to: } \quad 0.2X_1 + 0.6X_2 + 1.0X_3 + 0X_4 + 0X_5 &= 2 \text{ MM} \\ 0.4X_1 + 0.2X_2 + 0X_3 + 1.0X_4 + 0X_5 &= 3 \text{ MM} \\ 1.25X_1 + 2.0X_2 + 0X_3 + 0X_4 + 1.0X_5 &= 10 \text{ MM} \end{aligned}$$

These slack variables may be considered fictitious "resource-using-up" activities of zero value.

We then set up the following tableau:

			X_1	X_2
I	X_3	2	.2	.6*
	X_4	3	.4	.2
	X_5	10	1.25	2.0
	Z	0	-1	-1

103. B. H. Stevens, "An Interregional linear programming model," *Journal of Regional Science*, Vol. I, No. I, 1958.

104. Vajda, 'An introduction to linear programming and the theory of games,' Methuen.

The column vector $\begin{bmatrix} 2 \\ 3 \\ 10 \\ 0 \end{bmatrix}$ is called the basis or basic solution. The variables to which it corresponds are on the left of the tableau.

At this point, we note that our objective function (Z) has a value of zero. This is so since our slack variables have "used up" all of the available resources. X_1 and X_2, along the top of the tableau have, therefore, zero values. The slack variables were previously defined to be of no value, hence their large "production" is worthless.

We are now at the origin (indicated by I) on the graph in Figure 19.

Note also that in the tableau the coefficients of the objective function, appearing in the Z row, have each been multiplied by -1, and hence are now negative.

While our value of zero for Z is currently a feasible solution, we presume that we can do better by actually producing some gizmos and widgets.

Look at the Z row. Ordinarily we would choose to produce that variable with the largest negative value, since for every unit we produce we get the most revenue. In this case, however, the values are equal, hence we shall arbitrarily choose to produce X_2.

We shall continue to produce X_2 until we exhaust one of our resources (i.e. force a slack variable to become zero). In order to discover which resource we will run out of first, we divide each of the positive non-zero coefficients of X_2 into its corresponding resource stock figure. (The coefficients, remember, indicate the amount of each resource used to produce one unit of X_2). Thus we get:

$$X_3 \quad \frac{2}{.6} = 3\frac{2}{6}$$

$$X_4 \quad \frac{3}{.2} = 15$$

$$X_5 \quad \frac{10}{2} = 5$$

The smallest of these ratios indicates that $3\frac{2}{6}$ units of X_2 are all that we can produce, because at that level we exhaust our stock of land. Thus X_3 is removed from the basis and replaced by X_2. The number at the intersection of the X_3 row and the X_2 column (.6) is now called the pivot (indicated by an asterisk (*)).

We proceed to set up a second tableau as follows:

(a) Replace the pivot by its reciprocal ($\frac{10}{6}$).

(b) Divide each of the remaining elements in the pivot column by the pivot (.6), and multiply each by -1.

(c) Divide each of the remaining elements in the pivot row by the pivot.

(d) New elements for the remaining positions are determined as follows: Let us call the row, in which is found the element to be replaced, the element row. Similarly, we define an element column. The new element is then defined as:

$$\text{old element } \underline{\text{minus}} \left[\frac{\begin{array}{c}\text{element at inter-}\\\text{section of element}\\\text{row and pivot}\\\text{column}\end{array} \times \begin{array}{c}\text{element at}\\\text{intersection}\\\text{of element}\\\text{column and}\\\text{pivot row}\end{array}}{\text{Pivot}} \right]$$

Example:

To find element to replace 0 in Z row:

$$0 - \frac{-1 \times 2}{.6} = \frac{2}{.6} = \frac{10}{3}$$

The second tableau thus emerges:

			X_1	X_3
II	X_2	$\frac{10}{3}$	$\frac{1}{3}$	$\frac{10}{6}$
	X_4	$\frac{7}{3}$	$\frac{1}{3}$	$\frac{-1}{3}$
	X_5	$\frac{10}{3}$	$\frac{7}{12}$*	$\frac{-10}{3}$
	Z	$\frac{10}{3}$	$\frac{-2}{3}$	$\frac{10}{6}$

Graphically, we are now at position II in Figure 19. We have improved the solution, but the negative element in the Z row indicates that we have not yet reached an optimal solution.

We must construct a third tableau following the above procedure. This time we remove X_5 from the basis, and replace it by X_1. The new pivot is $\frac{7}{12}$.

			X_5	X_3
III	X_2	$\frac{10}{7}$	$\frac{-4}{7}$	$\frac{675}{189}$
	X_4	$\frac{3}{7}$	$\frac{-4}{7}$	$\frac{11}{7}$*
	X_1	$\frac{40}{7}$	$\frac{12}{7}$	$\frac{-40}{7}$
	Z	$\frac{150}{21}$	$\frac{8}{7}$	$\frac{-405}{189}$

We have now progressed to position III on the graph in Figure 19. Our Z value is still better, but we still have a negative value in the Z row, hence the solution is not optimal.

We find that the solution can be further improved by replacing X_4 by X_3 in the basis. The new pivot is $\frac{11}{7}$.

The fourth tableau is:

			X_5	X_4
IV	X_2	.45		
	X_3	.27		
	X_1	7.3		
	Z	7.7	.37	1.36

This time we find that all elements in the Z row are positive. We have an optimal solution, hence shall only complete the basis. This solution brings us to position IV on the graph, which we recognize as our graphical solution location. The difference in the numerical values, of course, arises from rounding errors.

Note that X_3 still has a value of .27. This indicates that the corresponding resource constraint is non-binding, and that .27 MM units of land are left over.

Consider the elements in the Z row. We observe that our maximum Z value is 7.7 MM dollars. The figures .37 and 1.36, associated with capital and labor respectively, are interpreted as <u>marginal products</u>. As such, each marginal product indicates the amount by which Z could be increased if one increased the availability of capital or labor by one unit.

A simple explanation of the other elements in the tableau may be found in Levin and Kirkpatrick.[105]

Upon examining the graph, we may observe that had we chosen to start by producing X_1, we could have converged upon the solution in only two iterations. We could have determined this advantage by dividing both sets of coefficients into the resource totals, and then noting that variable associated with the maximin (maximum of the two minima) ratio.

There is another interesting aspect to linear programming. The problem we have solved above may be considered the <u>primal</u> problem, from which may be derived what is termed the <u>dual</u> problem. The primal goal was maximization, while the dual pursues minimization.

We shall juxtapose the two models and note how the dual may be derived from the primal.

<u>PRIMAL</u>

MAX: $Z = 1X_1 + 1X_2$

Subject to:
$$0.2X_1 + 0.6X_2 \leqq 2$$
$$0.4X_1 + 0.2X_2 \leqq 3$$
$$1.25X_1 + 2.0X_2 \leqq 10$$
$$X_1 \geqq 0; \; X_2 \geqq 0$$

105. R. I. Levin and C. A. Kirkpatrick, 'Quantitative approaches to management,' McGraw-Hill, 1965, pp. 239-247.

DUAL

$$\text{MIN:} \quad Z^1 = 2P_1 + 3P_2 + 10P_3$$

$$\text{Subject to:} \quad 0.2P_1 + 0.4P_2 + 1.25P_3 \geqq 1$$

$$0.6P_1 + 0.2P_2 + 2.0P_3 \geqq 1$$

$$P_1 \geqq 0; \; P_2 \geqq 0; \; P_3 \geqq 0$$

(Note: We dropped the MM for ease of presentation).

Observe what has happened:

(a) The constants (the 1's) in the objective function of the primal have become the constraints in the dual, and vice versa.

(b) A new variable P has been substituted in the dual for X.

(c) The coefficient matrix of the primal is transposed (i.e., rows become columns, and vice versa) when carried over to the dual.

(d) The direction of the inequality signs is reversed.

(e) We retain, however, the non-negativity constraint on the new P variables.

This conversion has been effected by means of a simple, mechanical procedure. But what meaning can be given to the dual?

In beginning our interpretation, it is well to remember that the constants have not been altered in meaning through the conversion. Thus, if we look at the first constraint in the dual, we note that each new variable P is multiplied by a corresponding technical coefficient (the physical amount of a given resource per unit of finished good). These products are summed and must be greater than or equal to the selling price ($1) of finished good 1.

Algebraically, this constraint would be shown as:

$$a_{11}P_1 + a_{21}P_2 + a_{31}P_3 \geqq C_1$$

where a_{11}, for example, would be defined as "the physical amount of resource 1 per unit of finished good 1". The other coefficients would read similarly. C_1 represents the selling price of good 1.

The reason for choosing to represent this constraint algebraically is to make apparent, through observing the subscripts, that the P's are associated with the resources, e.g.

$$a_{21} \quad P_2$$

Since the right hand side of the inequation is in dollar terms, so must be the left hand side. It follows, then that the P variable represents the price per unit of resource. Such prices are termed shadow prices or economic rent.

The constraint states, therefore, that the total cost of resource inputs into one unit of finished good 1 must be greater than or equal to the selling price of good 1. The definitive explanation is given by Dorfman, Samuelson and Solow.[106] But, in general, we could argue that if "greater than" held,

106. R. Dorfman, P. A. Samuelson and R. M. Solow, 'Linear programming and economic analysis;' McGraw-Hill, 1958, Chapters 3 and 7.

then none of good 1 would be produced because it is a losing proposition. On the other hand, if "less than" were the case, then in a world of perfect knowledge, there would be a rush of producers into this field of profit opportunity thus bidding up the price of resources and reducing the price of the good through increased supply.

In the optimal solution the equality holds, thus ensuring that each factor of production receives an imputed price commensurate with its contribution.

In addition to the theoretical insights afforded by the dual, it has other applications. A practical advantage arises from the fact that, in solving via the simplex method, we obtain answers to both primal and dual problems simultaneously. Thus in tableau IV above, it should be noted that X_3, X_4 and X_5 may be considered to be P_1, P_2 and P_3 if considered from the standpoint of the dual. Hence, the solution to the dual is found in the Z row, and P_2 and P_3 have the values 1.36 and .37 respectively. It should also be noted that the final values of the objective functions of both problems is the same, i.e. $Z = Z^1$ (if there is a solution at all). This can be verified by inserting these values into the dual objective function:

$$\text{MIN:} \quad Z^1 = 2\,P_1 + 3P_2 + 10P_3$$

observing that P_1 has zero value (since resource 1 is an excess supply), we get:

$$\begin{aligned} Z^1 &= 2(0) + 3(1.36) + 10(.37) \\ &= 0 + 4.0 + 3.7 \\ &= 7.7 \end{aligned}$$

It is usual, therefore, to solve whichever problem, primal or dual, is the easier. For example, since the simplex method outlined above is applicable to maximization problems only, if one's primal problem involved minimization (as it does in the transportation model to be discussed), then one could convert it to the dual and solve.

Wolpert[107] has used a model similar to the maximization version above to generate an optimal allocation of agricultural production (the "cybernetic decision"). He has then proceeded to test this against agricultural allocation based on the "human decision". We may anticipate such "confrontations" between man and machine on an ever-broadening front.

Suggested Reading

1. *W. J. Baumol, 'Economic theory and operations analysis', (Prentice-Hall, 1961), Chapters 5 and 16.
2. E. Cassetti, "Optimal location of steel mills serving the Quebec and southern Ontario steel market", The Canadian Geographer, Vol. 10, No. 1, 1966.

107. J. Wolpert, "The decision process in spatial context," *Annals of the Assn. of American Geographers*, December, 1964.

3. *K. R. Cox, "The application of linear programming to geographic problems", Tijdschrift voor Economische en Sociale Geographie, November-December, 1965.
4. *W. L. Garrison, "Spatial Structure of the Economy: II. III", Annals of the Assn. of American Geographers, Vol. 49, No. 4, pp. 471-82; No. 3, 1960, pp. 357-73.
5. *M. Yeates, "Hinterland delimitation: a distance-minimizing approach", The Professional Geographer, November, 1963.

The Gravity Model

Another example of an operational system is the gravity model. This model differs from the two discussed above in that it is a measure of latent, not actual, spatial interactions in a system. Isard[108] has presented an interesting derivation of this model from which the following is adapted.

Let us consider an area comprised of five regions. Suppose that the total number of trips generated within and among the regions in a year is T. We shall let the total area population be P, such that $P = P_1 + P_2 + \dots + P_5$ (the latter representing regional populations). The average number of trips (per year) per person is $K = \frac{T}{P}$.

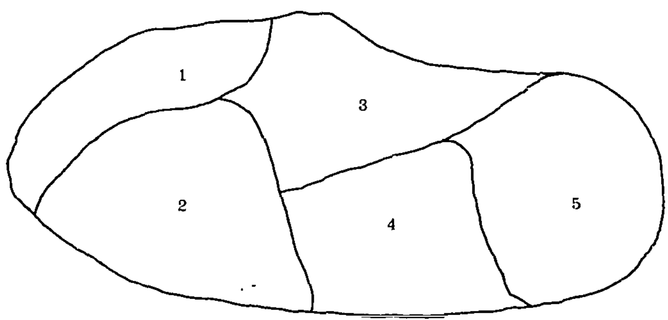

FIGURE 20

Initially, we assume that travel is costless and instantaneous. What, then, is the probability of a person in region 1 taking a trip to visit someone in region 3? Since we know nothing about the purpose of the trip, nor nothing about the people involved, the best we can do is to argue that the greater the number of people in region 3 relative to the total population, the more likely the trip to region 3. Hence, the probability of a person in 1 going to 3 $= \frac{P_3}{P}$.

This may also be construed as the proportion of all trips taken by the person in 1 which terminate in 3.

But we know the average number of trips this person in 1 takes in a year (= K). Therefore, the absolute number of trips a person in 1 makes to

108. W. Isard, 'Methods of Regional Analysis,' M.I.T. Press, 1960, Chapter II.

$3 = K\frac{P_3}{P}$. It follows, then, that the total number of trips to 3 by all persons in $1 = K\frac{P_1P_3}{P} = T_{13}$.

Let us generalize this argument by denoting origins by i, and destinations by j. Therefore, the expected total trips from i to j is given by

$$T_{ij} = K\frac{P_iP_j}{P}$$

But thus far, we have ignored the effect of distance. A number of empirical studies are available indicating intercity flows of bus passengers, telephone calls and commodity flows. We represent such actual flows between i and j by I_{ij}.

In order to observe the effect of distance upon our expected trips, we plot the ratio $\frac{I_{ij}}{T_{ij}}$ against distance (d_{ij}) between i and j, on arithmetic graph paper.

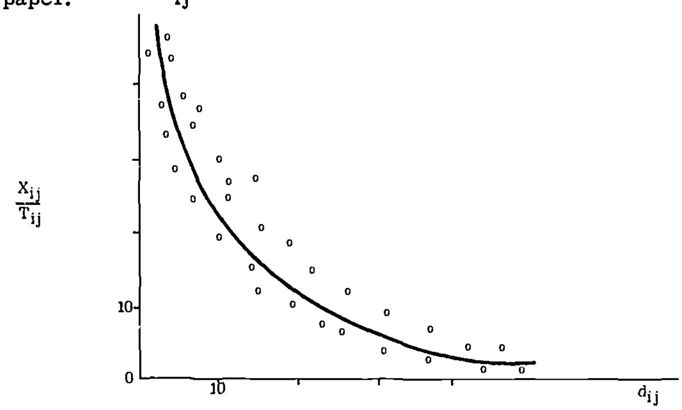

FIGURE 21

We can statistically fit a curve to the distribution of points which emerge. This curve will be of the general form $y = \frac{a}{x^b}$ (an hyperbola). Substituting our variables, we obtain:

$$\frac{I_{ij}}{T_{ij}} = \frac{a}{d_{ij}^b}$$

Replace T_{ij} by its definitional form, and bring to the right hand side:

$$I_{ij} = \frac{a\,K\,\frac{P_iP_j}{p}}{d_{ij}^b}$$

Since a, K and P are constants, we group them so

$$\frac{aK}{P} = G$$

Thus, in final form

$$I_{ij} = G \frac{P_i P_j}{d_{ij}^b}$$

This is the gravity model which purports to predict the level of interaction between centers of population.

Following an earlier study by MacKay,[109] one of the authors has applied this model to estimate the number of long-distance telephone calls between London, Ontario, and a large number of Canadian and United States cities and towns. Data were obtained on telephone calls made during a ten-day period in April 1964. The data[110] on estimated and actual calls made to most of the cities were plotted on double logarithmic paper (Figure 22).

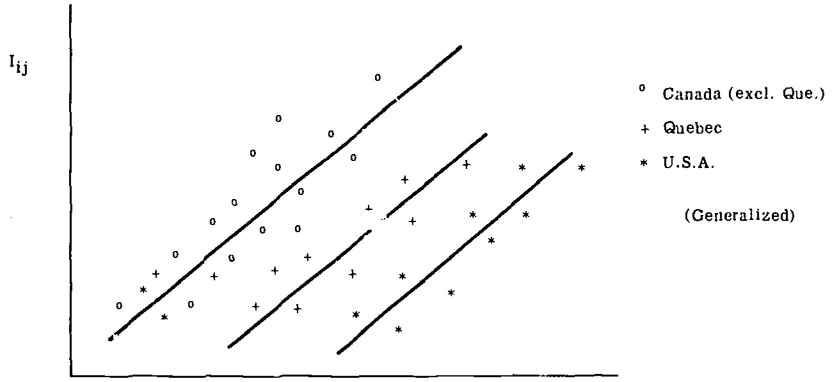

FIGURE 22

Initially no clear linear pattern emerged. However, when the cities were classified according to their location in Quebec, the rest of Canada and the United States, then three distinct groupings were perceived.

Thus Londoners were observed to interact at the expected level with communities in English-speaking Canada, at a lower level than expected with communities in Quebec and at a still lower level with centres in the United States. There were some interesting exceptions. Two Quebec communities, Roxboro and Point Claire, fall among the rest of the Canada group. As you may have guessed, these two centers have large English-speaking populations. U.S. cities which appeared in the Canadian group were Palm Springs, California, and Clearwater, Florida. These are favorite winter holiday areas of Canadians.

As suggested by Isard, one can further develop the gravity model.

109. J. R. MacKay, "The interactance hypothesis and boundaries in Canada: A preliminary study." *The Canadian Geographer*, No. 11, 1958.

110. The data were provided through the courtesy of Bell Canada.

The model

$$I_{ij} = G\frac{P_i P_j}{d_{ij}^b}$$

estimates the level of interaction between i and one other place j. Suppose we sum the interaction between i and all other places (say, n) in the system, including itself. We then get:

$$\sum_{j=1}^{n} I_{ij} = G\sum_{j=1}^{n} \frac{P_i P_j}{d_{ij}^b}$$

This results in a rather large number, so we reduce it to a per capita interaction by dividing through by P_i:

$$\frac{\sum I_{ij}}{P_i} = \frac{G\sum \frac{P_i P_j}{d_{ij}^b}}{P_i} = G\sum \frac{P_j}{d_{ij}^b}$$

This derived measure is termed the potential of population at i, and symbolized as V_i. It is usually interpreted to be a measure of accessibility of i to the system in the sense of closeness to people (or some other phenomena) in general. It may also be considered to reflect the size of the field of influence of the point i.

Potential of population measures for all points in the system may be computed, and, if lines are then drawn through all the points with same potential (at selected intervals) (isopotential lines), a potential surface will be represented. The highest point on this surface (the point with the greatest total potential) would be that point most accessible to all n points in the system.

If distance (d_{ij}^b) is changed, whether measured in miles, cost or time, new potential surfaces can be constructed and altered accessibility patterns noted. The same applies to changes in population size. Like input-output analysis, this aspect could be described as impact-measuring.

With respect to input-output, too, it is interesting to note that Leontief[111] has attempted to incorporate a variant of the gravity model into an interregional input-output model. The intent is to capture the variation in flow intensities over space.

Suggested Reading

1. G. Olsson, 'Distance and human interaction', Regional Science Research Inst., Bibliography Series, No. 2, 1965.
2. W. Warntz, 'Macrogeography and Income Fronts', Regional Science Research Inst., Monograph Series, No. 3, 1965.
3. J. Q. Stewart and W. Warntz, "Macrogeography and Social Science", Geographical Review, Vol. 48, No. 2, 1958.

111. W. Leoutief and A. Strout, "Multi-regional input-output analysis," in 'Structural interdependence and economic development,' (edited by T. Barna), Macmillan, 1963.

4. G. Schwartz, 'Development of marketing theory', (Southwestern, 1963), Chapters 2 and 3.

Graph Theory

In the graph-theoretic approach to systems analysis, we meet the most explicit attempt to treat geography in terms of points and lines. This is also an area where, because of its generality, one can expect to see a flourishing of the general systems concept of interdisciplinary exchange of models. In other words, a system, almost by definition, is a graph, and we may anticipate that the application of graph or network theory to geography may be as all-pervasive as the concept of system.

This section is at the research frontier, and discussions of the applications of graph theory are, not surprisingly, fragmented and exploratory.

Suggested Reading

1. I. Grossman and W. Magnus, 'Groups and their graphs', (Random House, 1964).
2. P. Haggett, "Network Models in Geography", in R. J. Chorley and P. Haggett, Models in Geography, (Methuen, 1967).
3. *W. L. Garrison, "Connectivity of the Interstate Highway System", Papers, Regional Science Assn., Vol. 6, 1960.
4. J. D. Nystuen and M. F. Dacey, "A graph theory interpretation of model regions", Papers, Regional Science Assn., Vol. 7, 1961.
5. G. Avondo-Bodino, 'Economic applications of the theory of graphs', (New York, 1962).

APPENDIX B

The Transportation Problem[112]

A producer of dolomitic limestone for agricultural use has two lime quarries which supply three regional warehouses. The inventory position of each of the quarries this week is as follows:

Quarry	Tons of Lime on Hand
A	100
B	200

Transportation costs per ton from each quarry to each of regional warehouses are shown below:

		Warehouses		
		1	2	3
Quarries	A	3	1	5
	B	2	4	6

The warehouses need lime for next week in the following quantities:

Warehouse	Quantity
1	70 tons
2	60 tons
3	50 tons

We shall proceed to solve this problem as follows:

(a) Set up the primal problem (minimization)
(b) Convert to dual problem (maximization)
(c) Solve the dual via simplex method to determine:
  i. total cost of shipping
  ii. shipping schedule from quarries to warehouses
  iii. location rents of quarries

Primal

Min: $Z = 3X_{A1} + 1X_{A2} + 5X_{A3} + 2X_{B1} + 4X_{B2} + 6X_{B3}$

Subject to:

$$\begin{array}{llllllll}
X_{A1} & & & + X_{B1} & & & \geqq & 70 \\
 & X_{A2} & & & + X_{B2} & & \geqq & 60 \\
 & & X_{A3} & & & + X_{B3} & \geqq & 50 \\
-X_{A1} & - X_{A2} & - X_{A3} & & & & \geqq & -100 \\
 & & & - X_{B1} & - X_{B2} & - X_{B3} & \geqq & -200
\end{array}$$

112. Adapted from Levin and Kirkpatrick, op. cit., pp. 257-261.

Where X_{A3}, for example, represents the tons of line shipped from quarry A to warehouse 3. Note that last two equations have been multiplied through by -1 in order to change the sense of the inequality, which must be ($\geqq$) in a minimization problem.

Following the procedure outlined earlier, we now convert this problem to its dual:

Dual

$$\text{Max: } Z^1 = 70U_1 + 60U_2 + 50U_3 - 100W_A - 200W_B$$

$$\begin{aligned}
\text{Subject to: } U_1 \quad & - W_A \leqq 3 \\
U_2 \quad & - W_A \leqq 1 \\
U_3 \quad & - W_A \leqq 5 \\
U_1 \quad & - W_B \leqq 2 \\
U_2 \quad & - W_B \leqq 4 \\
U_3 \quad & - W_B \leqq 6
\end{aligned}$$

We have substituted new variables U and W for X's. These new variables are associated with the warehouses and quarries respectively. But how do we interpret them?[113]

Looking at the first constraint, we note that

$$U_1 - W_A \leqq 3$$

Since 3 is the unit transport cost from A to 1, we conclude that U_1 and W_A are in monetary units. After due reflection, we define $\underline{U_1}$ as the delivered unit price at 1 (= F.O.B. price at A plus transport cost from A to 1 plus location rent at A). F.O.B. price at both quarries is assumed to be the same, and therefore is equated to zero. Thus, in order for the equation to hold, W_A must be the location rent at A.

Turning to our dual objective function, we note that we are maximizing total transport costs (total delivered costs minus total location rents). Since we were minimizing total transport costs in the primal, this appears rather strange.

However, following Stevens,[114] we introduce the notion of a world trader who buys the lime at the quarries, ships it to the warehouses and resells it to the merchants there. Such a trader would wish to either (or both) minimize his transport costs, or maximize his profits (i.e., maximize the difference between delivered price and F.O.B. price plus transport cost). However, competition among traders will reduce profits to zero as delivered price is forced to equal F.O.B. price (location rent) plus transport costs.

In the solution, of course, $Z = Z^1$ and a just return is apportioned to all.

But we must now proceed to solve this problem by setting up the first tableau as described in Appendix A:

113. B. H. Stevens, "Linear programming and location rent," *Journal of Regional Science*, Vol. 3, No. 2, pp. 15-26.

114. Stevens, op. cit., p. 21.

I.

		U_1	U_2	U_3	W_A	W_B
X_{A1}	3	1	0	0	-1	0
X_{A2}	1	0	1	0	-1	0
X_{A3}	5	0	0	1	-1	0
X_{B1}	2	1*	0	0	0	-1
X_{B2}	4	0	1	0	0	-1
X_{B3}	6	0	0	1	0	-1
Z	0	-70	-60	-50	100	200

Analysis of the first tableau leads to decision to replace X_{B1} by U_1. We shall skip immediately to the fifth and final tableau:

V.

		X_{B1}	X_{A2}	X_{A3}	X_{B3}	W_B
X_{A1}	2	-1	0	-1	1	0
U_2	2	0	1	-1	1	-1
U_3	6	0	0	0	1	-1
U_1	2	1	0	0	0	-1
X_{B2}	2	0	-1	1	-1	0
W_A	1	0	0	-1	1	-1
Z	460	70	60	40	10	120

Now you will recall that we converted our primal to its dual in order to be able to solve it using the simplex method for maximization. Thus we will expect to read our solution in the Z row:

$X_{B1} = 70$

$X_{A2} = 60$ for a total shipping

$X_{A3} = 40$ cost of $460

$X_{B3} = 10$

Note that $W_B = 120$, which indicates a surplus of 120 tons of lime at quarry B. Because of this, quarry B has a location rent of zero.

Turning to the "basis", we note that quarry A has a location rent of 1. This indicates that, for every ton increase in A's capacity, we shall reduce our total transport cost by one dollar. Delivered prices at warehouses 1, 2 and 3 respectively are 2, 2 and 6.

This latter can be confirmed as follows:

Since:
Delivered price = location rent plus transport cost
Therefore:
Delivered price at 1 = 0(B) + 2(B1) = 2
Delivered price at 2 = 1(A) + 1(A2) = 2
Delivered price at 3 = 1(A) + 5(A3) = 6
Delivered price at 3 = 0(B) + 6(B3) = 6

Note that delivered price at 3 is 6, regardless of origin of shipment.
We have solved the problem.

This technique has been used by Cox,[115] Henderson[116] and Miller[117] to derive a theoretical ideal movement pattern against which each then compared an aspect of the real space-economy.

115. K. R. Cox, op. cit.
116. J. M. Henderson, 'The efficiency of the coal industry,' Harvard, 1958.
117. R. E. Miller, 'Domestic airline efficiency,' M.I.T., 1963.

APPENDIX C

SUGGESTED TEMPORAL ORGANIZATION OF THE COURSE

1. Two semester course: 90 Class Periods

Semester 1.

Part 1. Basic concepts	periods 1-12
Part 2. Models of Interaction	periods 13-19
Part 3. Agricultural System	periods 20-32
Part 4. Resource System	periods 33-44
Semester Summary	period 45

Semester 2.

Part 5. Manufacturing System	periods 46-55
Part 6. Tertiary System	periods 56-65
Part 7. Transportation System	periods 66-75
Part 8. Total Spatial System	periods 76-85
Part 9. Problems of economic organization	periods 86-88
Conclusion.	periods 89, 90

2. One semester course: 45 Class Periods

Part 1. Basic concepts	6 periods
Part 2. Models of Interaction	4 periods
Part 3. Agricultural System	5 periods
Part 4. Resource System	5 periods
Part 5. Manufacturing System	5 periods
Part 6. Tertiary System	5 periods
Part 7. Transportation System	5 periods
Part 8. Total Spatial System	5 periods
Part 9. Problems of economic organization	3 periods
Conclusion.	

3. One quarter course: 33 Class Periods

Part 1. Basic concepts	5 periods
Part 2. Models of Interaction	3 periods
Part 3. Agricultural System	4 periods
Part 4. Resource System	4 periods
Part 5. Manufacturing System	4 periods
Part 6. Tertiary System	3 periods
Part 7. Transportation System	3 periods
Part 8. Total Spatial System	4 periods
Part 9. Problems of economic organization	2 periods
Conclusion.	

4. One trimester course: 39 Class Periods

Part 1. Basic concepts	6 periods
Part 2. Models of Interaction	4 periods
Part 3. Agricultural System	5 periods
Part 4. Resource System	5 periods
Part 5. Manufacturing System	5 periods
Part 6. Tertiary System	4 periods
Part 7. Transportation System	4 periods
Part 8. Total Spatial System	4 periods
Part 9. Problem of economic organization	2 periods

Conclusion.