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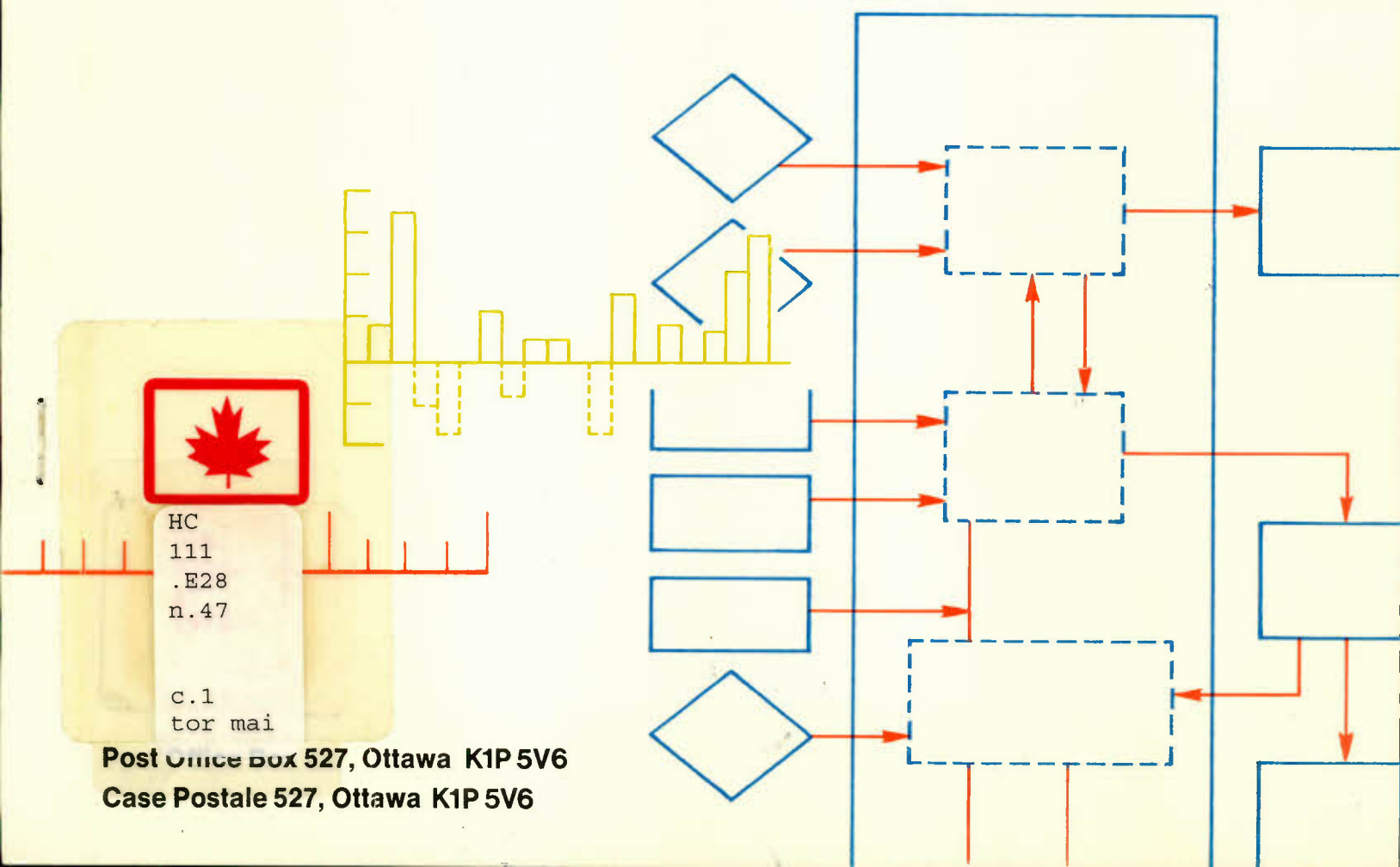

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DISCUSSION PAPER NO. 47

The Regional Factor in the Diffusion of Innovations

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RESUMÉ

Le but de ce travail théorique est de démontrer que les caractéristiques d'une région influenceront plus ou moins la diffusion de l'innovation selon que l'innovation en cause est effectivement diffusée selon l'un ou l'autre des différents modes de diffusion. Il y a quatre modes de diffusion : l'épidémiologique, la hiérarchie urbaine, le processus de diffusion selon l'environnement des firmes, la diffusion selon les caractéristiques internes des entreprises. Aucun de ces modes n'est une explication également valable de la vitesse de diffusion pour toutes les innovations tant en ce qui a trait aux biens et produits nouveaux que pour les techniques de fabrication.

Le mode épidémiologique privilégie la variable distance; tandis que pour le mode hiérarchie urbaine, c'est la taille des villes; pour la diffusion selon l'environnement, c'est la variable structure de marché qui prime; pour la diffusion selon les caractéristiques des entreprises, ce sont les anticipations du personnel de gestion qui est la variable prépondérante.

Le facteur régional est important surtout dans les cas de diffusion selon les modes épidémiologique ou de hiérarchie urbaine. Il l'est aussi dans le cas où les ressources naturelles et les politiques gouvernementales sont prépondérantes.

SUMMARY

This paper aims at providing the theoretical background for the identification of the regional factor in the process of diffusion of innovations. It is shown that this factor operates through a number of modes of diffusion giving rise to different conceptual models. These models are classified according to the dominant determinant which prevails in each particular situation.

1. Nature of the Diffusion Process

Empricially the variables that influence the diffusion of innovations (in terms of either new products or new production processes), are numerous. Representative examples are: proximity of possible adopters, geographical features and obstacles, profitability of the innovation, size of markets, size of firms, size of cities, management attitudes, age of equipment, type of ownership, concentration of the industry, access to information and financial capital, cost of labour, international connections, index of technological opportunity, Research and Development (R&D) activities by firms, government policy, etc.[1]

The profusion of variables presents a bewildering picture of the diffusion process. This would be less of a problem if it were possible to construct a model that could "conceive the diffusion of new technology to be the resultant (vector sum) in a multi-dimensional space where the various influencing factors operate, the impact of these factors on the resulting diffusion [being] illustrated by the force and direction of the various impulses in this space. However, an attempt to apply this model-like image numerically in a practical context meets virtually unsurmountable difficulties." (Nabseth and Ray, opt. cit., p. 28.)

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1 No less than 40 different variables are used by different researchers in a recent study of diffusion of new industrial processes. See: L. Nabseth and G. F. Ray, The Diffusion of New Industrial Processes (Cambridge, Mass.: Cambridge University Press, 1974).

Actually, the use of a large number of variables chosen exclusively because they increase the value of the R^2 of a regression has a few disadvantages:

(1) In such an approach no list can claim to be complete. It is consequently not guaranteed that the most important variables (operationally for policy purposes), are included.[2]

(2) Models involving a large number of variables, besides being costly, sooner or later run into problems of insufficiency of data.

(3) Lack of homogeneity in the variables, in terms of level of abstraction and causal relationships,[3] render the comparison of results rather difficult,[4] and, the formulation of policies puzzling.

(4) Similarly, variables are sometimes defined in such a vague way that the studies which use them end up "proving" a tautology. The variable "profitability" has been used in this way. If precautions are not taken studies can end up "proving" that if an innovation is profitable firms will eventually adopt it.

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2 Ibid., p. 54.

3 For instance, one study collects information about both the age of the president and the age of machines.

4 See Nabseth and Ray, op. cit., p. 15.

On the other hand, simplicity, unity and causality can be achieved in the study of diffusion of innovations by relving on a priori models. This approach, which gives rise to many empirical works, enables us also to reintroduce, on the basis of theory, variables rejected for all sorts of reasons by statistical analysis. It differs from factor analysis in the sense that it is not the result of inductive reasoning but of deductive reasoning.

Until now, economists and geographers[5] have asked three main questions:

(1) How fast has been the spatial diffusion of innovations?

(2) How fast has been the diffusion of a particular innovation within an industry or among a set of industries?

(3) What makes an individual firm adopt a particular innovation?

Most of the variables that shed light on these questions are associated with four main a priori models of diffusion. The modes of diffusion which underlie our conceptual "boxes" are:

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5 The literature on the subject is so enormous that we are now at the stage where publications consist of bibliographies or survey articles. See, for instance: L. A. Brown, Diffusion Processes and Location, A Conceptual Framework and Bibliography, 1968; "Technical Progress: A Survey" by C. Kennedy and A. P. Thirwall, The Economic Journal, March 1972, pp. 11-73; M. I. Kamien and N. L. Schwartz, "Market Structure and Innovation: A Survey," Journal of Economic Literature, March 1975. Yet the reader should not confuse the vast literature on the relationship between market or urban structures and the generation of innovations or even the intensity of R&D efforts, with what we are attempting in this paper -- the study of diffusion processes.

(i) The Epidemiology[6] diffusion process;

(ii) The Urban Hierarchy diffusion process;

(iii) Diffusion according to the economic and institutional environment of the firms;

(iv) Diffusion according to the firm's characteristics.

Each model of diffusion incorporates or is a proxy for a set of many variables explaining the mode of diffusion of a particular innovation. Some, but not all, of the variables may be common to two or more models. What distinguishes them is that each emphasizes a different dominant variable theoretically identified. Epidemiology emphasizes "distance"; for urban hierarchy it is "size of cities"; for diffusion according to the "environment" it is either market structure or labour costs; and for diffusion according to the firm's characteristics it is "management attitudes" as reflected by the firm's internal structure and behaviour.

Four models seem necessary because none of them, alone, seems sufficiently complete to give a satisfactory explanation of the diffusion of different types of new goods or production

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6 Our understanding of this term is wider than that which is sometimes used by geographers, e.g., Brown (1968). We incorporate the so-called distance-biased model with the strictly defined epidemiology model under the generic name of epidemiology.

techniques. Each of them has been successful in certain categories only. Epidemiology seems satisfactory in explaining the diffusion of agricultural production techniques, some household goods, and, in general, other goods or techniques over a small area. Urban hierarchy can cover a much wider area, the classic example being the diffusion of T.V. stations.[7] Similarly the environment of the firm has been a good explanation for manufacturing industries, e.g., coal, steel, railroad, brewing industries,[8] and float glass,[9] while in studying the phenomenon of the diffusion of production processes, such as shuttleless looms, and tunnel kilns,[10] certain firm's characteristics were found to be important.

The fact that any one of the models does not constitute a general theory of diffusion is not too much of a drawback. First, even in the multi-variant approach across-the-board generalizations have failed. Second, complete explanations are not always necessary. Although not a paragon, take, for example, location theory. For a long time it wrestled with the problem of determining "the" dominant location factor. It finally settled for the use of a collection of factors, each dominant with respect to a particular industry. The end result is today's custom of labeling industries

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7 B. L. Berry, "Hierarchical Diffusion: The Basis of Developmental Filtering and Spread in a System of Growth Centers" in N. Hansen, Growth Centers in Regional Economic Development, 1972.

8 See E. Mansfield, The Economics of Technological Change, Norton, 1968, "Empirical studies substantiate the hypothesis that large firms are quicker, on the average, than small ones to begin using new techniques," p. 192.

9 Nabseth and Ray, op. cit.

10 Ibid.

as either market-oriented, transport-oriented, labour-oriented, energy-oriented, resource-oriented, footloose industries, etc. A similar approach could be used in the study of the diffusion of innovations using the predominant mode appropriate for each industry. There would then be epidemiology-oriented industries, urban hierarchy-oriented industries, market structure-oriented industries, management-oriented industries, ownership-oriented industries, etc.

2. Variables Common to Different Modes of Diffusion

It is possible to make "profitability" the main explanation of diffusion whatever the mode of diffusion. However, it amounts to saying that only profitable innovations will be adopted.[11] That's almost tautological since it is compatible with all the postulates of the main theories of the firm: profit maximization, or profit optimization or even "satisficing."[12]

"Profitability" is nontautological and thus an outright determinant in a particular model of diffusion when the hypotheses of pure competition and perfect knowledge are removed.

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11 When profitability is easy to determine as in the case of agriculture and some small machinery, it can explain ceteris paribus the speed of adoption, i.e., other things being equal, the easier the computation of the expected profitability of an innovation the more rapid its adoption.

12 This is what Griliches found while studying the diffusion of hybrid corn: "farmers behaved in a fashion consistent with the idea of profit maximization." See Svi Griliches "Hybrid Corn: An Exploration in the Economics of Technological Change," Econometrica, no. 4, vol. 25, 1957, p. 522.

However, in such a case profit expectations are difficult, if not impossible, to measure ex ante.[13]

Actually the ability to recognize and separate cases of profitable innovation from those that are not is the basic explanation of the differences in the performance of entrepreneurs; the successful entrepreneur is precisely the one who sees profitability where others do not, and vice-versa. Because most real-life situations are cases of imperfect knowledge and imperfect competition, the analyses of "causes" of diffusion should then concentrate on the factors that influence the formation of expectations about the profitability of prospective innovations.

"Size" is another ubiquitous variable, especially in the firms' environment and in the characteristics of the firm modes. In this study, we will classify "size" as a component of market structure and thus the environment of firms, when it is perceived as resulting from the technology presently available. Conversely we will classify it as a component of the mode corresponding to the firm's characteristics when it

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13 Mansfield notes, "unfortunately, only partial data can be obtained regarding firms' profit expectations," Mansfield (1968), p. 124. Other researchers also have found that this "is not an easy concept to define, let alone measure." (Nabseth and Ray (1974), p. 13.)

is perceived as the result of the managers' motivation. In this last case company size is a proxy for many variables internal to the firm.[14]

3. The Logistic Curve

As noted a long time ago by Griliches (1957), the phenomenon of diffusion can be represented by "points on an adjustment path." Trend functions are thus the easiest way to represent the phenomenon. Among the many available algebraic forms of such functions, the logistic curve has often been chosen because of its simplicity.

The logistic curve can be seen as a mere description of a diffusion process, or it can also be seen as an embryo of a general theory of diffusion because it makes some vague predictions: diffusion processes go through three phases (1) initial adoption, (2) contagion, and (3) saturation. The schema predicts that the rate of diffusion varies according to the stage. In

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14 For instance for the innovations called "special presses" it was found that:

> "The impact of company size on the adoption of special presses is not through size itself as an independent variable, but because several other variables, for instance, the pay-off period and the company variables expressing resources, appear to be related to size (Nabseth and Ray, op. cit., p. 82).

this aspect, it has an epidemiology flavour. However the vagueness of its predictions, that is the lack of statements about the exact slopes of the diffusion curves of different innovations, shows that it is in need of being supplemented.[15] Now that the existence of stages of diffusion has been established in empirical terms for a large number of innovations, the subject of research is not to determine whether or not the diffusion of products or production processes goes through stages, but how this is done. That is, what are the differences in rates of diffusion, i.e., slopes of the various logistic curves and the values of their other parameters, and, what are the factors accounting for these differences? Because it is suspected that special characteristics of new products or of new production processes lead to different rates of diffusion, there is, then, a relationship of complementarity between the logistic curve and the diffusion modes we consider in this paper. The models we propose represent the different sets of variables that explain the differences of slopes and other parameters of logistic curves.

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15 One author of the Nabseth and Ray study (op. cit., p. 154), states that the logistic curve "tells us little of the many dimensions of the diffusion process."

4. Epidemiology Diffusion

This mode emphasizes "distance." "Distance" is important in this mode of diffusion. It takes many forms: physical distance, physical distance corrected by geographical factors such as natural characteristics (mountains, rivers, etc.), social and economic distance measured by the probability of concluding social and/or economic transactions.

The main prediction of the model of diffusion is that innovations are propagated according to an orderly wave-like pattern emanating from a centre and moving towards a periphery. In such a case the "farther" an economic agent is from the centre, the later he is likely to adopt an innovation.

The model applies mainly to innovations whose adoption is automatic except for the information factor. This is the case of small innovations used by small firms.[16] In this mode, an innovation is diffused by contagion (as in an epidemic); it relies on imitation, band-wagon effect and demonstration effect. Its spreading results primarily from a learning process,[17] thus the importance of information flows and

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16 That is why in the case of large firms "it is difficult to find definitive evidence that the diffusion of a new technique spreads like an epidemic" Nabseth and Ray, op. cit., p. 207.

17 Brown (1968), p. 40.

personal contacts. The shorter the physical distance, the better the communications system; the higher the population density, the higher the probability of exposure; and thus the probability of learning and adoption, i.e., the greater the spreading of an innovation during a given period of time.

Through isomorphism this approach has adopted the mathematical model of epidemiology as an analytical tool.

3. Urban Hierarchy Diffusion

In this approach, the size of cities is the key to predicting and explaining the diffusion of innovations. The geographical or social "distance" does not intervene explicitly. Innovations are transmitted through a filtering-down process -- from large cities to smaller cities. Inside each urban hierarchy the primary city gets the innovation first, and so on for the other levels of the hierarchy. What is peculiar is that proximity does not confer an advantage. For instance, suppose two hierarchies, A, B, C, D, E, etc., and A', B', C', D', E', etc. (where A is a city of a higher order than B, etc.), separated by a large distance where A' is farther away from A than B is from A; suppose also that A and A' are at the same level. In this case A' will get the innovation at the same time as A, and before B, although B is nearer to A.

The logic of this mode of diffusion is as follows: innovations are risky, often exploiting returns to scale,[18] or are uneconomical below a threshold of population, or require special inputs. Thus innovators prefer to introduce their innovations first in large cities which constitute large markets for outputs and/or assure the lowest cost of supply of some special inputs. Later if the experiment is successful (in the large city), and if the process can be miniaturized without too much loss of efficiency, the innovation is then brought to smaller centres and so on.

Other "reasons for 'hierarchical filtering' can be posited, among them a 'market-searching' process in which expanding industry exploits market opportunities in a larger-to-smaller sequence; a 'trickle-down' process in which an activity faced with rising wage rates in larger cities moves to smaller cities in search of cheaper labour; an 'imitation' process in which entrepreneurs in smaller centres mimic the actions of those in larger cities; or a simple probability mechanism in which the probability of adoption depends upon the chance that a potential entrepreneur residing in a given town will learn of the innovations -- a probability which declines with size of town."[19] This approach is, for certain products, the one that minimizes risks.

The main analytical tool here is the rank-size distribution of urban populations. This tool of analysis has been found suitable

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18 Although some innovations work contrarily, they miniaturize a production process without loss of efficiency, making it suitable for small centres.

19 Op. cit., Berry (1972), pp. 112-13.

to study diffusion of T.V. stations,[20] telephone exchanges,[21] self-service stores, etc. With more empirical research on the diffusion of innovations pertaining to the tertiary sector, the field application of this mode of diffusion is expected to grow enormously.

The fact that this approach, in its pure form, does not incorporate distance is an important lacuna, because although, for instance, a small town in the state of New York is not bigger than a similar one in Dakota, it is more likely to adopt, in one form or another, a household innovation, or be the chosen location of a manufacturing plant rather than the town in Dakota. Proximity affects most real life situations. This matter has been partly corrected by fusing it with the epidemiology mode into a variant of the gravity model.[22] Some of the features of the epidemiology model are lost,[23] but it enables the researcher to picture the diffusion of innovations as a simultaneous movement in two dimensions:

(a) horizontally, among cities of the same size; and

(b) vertically, from large to small cities.

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20 Ibid., p. 119.

21 B. T. Robson, Urban Growth: An Approach, Methuen (1973).

22 See a demonstration of that point in Robson (1973), pp. 137-42.

23 Such as the division of the population into "susceptibles" (non-adopters), "removals" (passive adopters), and "infectives" (active adopters).

5. Diffusion According to the Economic and Institutional Environment of the Firms

Although geographers (the main proponents of the epidemiology and urban hierarchy modes of diffusion) imply[24] that their approach covers both households and entrepreneurial innovations, the range of empirical cases which they have successfully studied is noticeably poor in manufacturing activities.

This is especially true in science-based and resource-oriented and/or monopolistic industries where the facts do not strictly agree with predictions of the geographical models. For instance, the diffusion of innovation in the newsprint industry is not a function of geographical distance, nor of the urban hierarchy.[25] Similarly, Boston, which is far from the top of the U.S. urban hierarchy, has not been found to lag behind New York or Chicago, especially in science-based industries. The inadequacy of the earlier models of diffusion for manufacturing innovations stems from the fact that:

(a) The location of natural or energy resources introduces some distortion to the usual relationships established by either the "distance" approach or the urban hierarchy approach; this leads geographers who deal with this type of innovation to talk about hierarchical forms of diffusion related, for instance, to the river system.[26] Consequently, besides the use of the word "hierarchy" their model of diffusion has little to do with the urban-hierarchy mode described above.

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24 Robson (1973), p. 136.

25 See F. Martin, The Diffusion of Technology, The Case of the Canadian Newsprint Industry (working paper), Economic Council of Canada, August 1975; Mansfield (1968), in his study of steel, petroleum, coal, and railroad industries does not use distance as an explanatory variable.

26 R. A. Roberge, D. M. Ray, and P. Y. Villeneuve, Invention, Diffusion and Allometry: A Study of the Growth and Form of the Pulp and Paper Industry in Central Canada, Ministry of State For Urban Affairs, Canada, Discussion Paper B, 73.20, p. 19.

(b) Competition is far from perfect in the manufacturing sector. However the epidemiology approach requires rationality, i.e., profit maximization. That is, once an innovation has been perceived as profitable, adoption is supposed to follow directly from knowing about it. Any delay is imputable to imperfection of knowledge and/or some uncertainty as to the exact potential of the innovation, imperfection of knowledge being a function of "distance." However, in the case of imperfect competition one must reckon with the possibility of a modification of profit maximizing behaviour, i.e., the possibility of a variety of modes of behaviour. In such a case the actual rate of adoption will be different from the rate predicted by geographical models.

(c) Other environmental variables such as government activities and policies, labour market components such as trade unions' attitudes and labour costs all interfere with the effects of either distance or urban hierarchy on the diffusion of innovations.

If, in many cases "distance" and "urban hierarchy" do not matter very much, what then does explain the diffusion of innovations? Economists,[27] largely abstracting from the above modes, hypothesized that the economic and institutional environment may, in some cases, be the predominant factor, especially in the so-called science-based industries.

Many years ago the main prediction regarding the generation and adoption of innovations was not too difficult to identify. It consisted of Schumpeter's contention that monopoly power and large size of the firm "are prerequisites for economic growth through technical progress."[28] In the words of Galbraith: "most

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27 See Kamien and Schwartz (1975), and Mansfield, "Determinants of the Speed of Application of New Technology" in B. R. Williams, Science and Technology in Economic Growth, Macmillan, 1973.

28 Kamien and Schwartz (1975), p. 15.

technical innovation comes from the highly organized sector of the modern economy -- the sector characterized by the modern large corporation.[29]

It seems then natural to infer that the main components of the firms' environment,[30] i.e., market structure, would be explanatory factors of the rate of diffusion of innovations in the manufacturing sector. This general position has been translated into the following, more testable, propositions:

(1) Large firms would be early adopters;

(2) Monopolistic and oligopolistic firms would be early adopters; and

(3) Diffusion should be faster in imperfect markets than in atomistic markets.

These propositions have been subjected to both theoretical and empirical study, and in each case attempts to generalize yielded results which were inconclusive, if not confusing. For instance, Scherer[31] says on one hand: "Recognition of opportunities may be faster in atomistic industries simply because there are more

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29 J. K. Galbraith, "Technology in the Developed Economy" in Williams (1973), p. 39.

30 Other important components of the economic environment are the government activity and the characteristics of the labour market and natural resources.

31 F. M. Scherer, Industrial Market Structure and Economic Performance, Rand McNally, 1970, p. 375.

independent centers of initiative," and on the other hand he also says "and it may be faster in monopolistic industries if monopolists alone maintain staffs of researchers to keep track of outside scientific advances...."

Furthermore, empirically the inter-firm diffusion of technology has been documented much less than the generation of technology.[32] As in the case of generation of technology, the overall judgments are far from clear-cut. After having studied eight manufacturing innovations, Nasbeth and Ray[33] come to the conclusion that "high concentration, or a monopoly position, may create conditions which can influence innovation or diffusion either way."

The same lack of unique sign of the effect is encountered when the size of firms is investigated as a possible determinant of diffusion: "the pilot study provided no definite evidence that large companies have always been in the forefront of technical progress in the sense of being leaders in innovation and the adoption of new techniques."[34] The only thing which is firmly established is that there is a threshold size which

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32 Recent literature on the subject is found in Nabseth and Ray, op. cit., 1974. J. M. Vernon, Market Structure and Industrial Performance: A Review of Statistical Findings, Allyn & Bacon, 1972; and S. Globerman, Technological Diffusion in Canadian Manufacturing Industry (1974), University Grant Program Research Report, Office of Science and Technology, Industry, Trade and Commerce, Ottawa, p. 4.

33 Nabseth and Ray (1974), p. 13.

34 Ibid., p. 21.

facilitates the diffusion of innovation. It is of no use to try to relate size and diffusion in some kind of monotonic function. "Moreover, this threshold size varies from one aspect of an industry's technology to another, allowing complementarities and interdependencies to exist among large and small firms."[35]

The upshot is that most researchers[36] are convinced that concentration of an industry and the size distribution of firms have an impact on diffusion in many industries, but they are plagued by three problems:

(1) It is not known what these industries are;

(2) They have been unsuccessful in determining the optimum degree of concentration which is advantageous to diffusion; and

(3) Similarly, the threshold size of the firm has yet to be determined for each industry.

There is then a great need for empirical research. In the meantime, any use of this approach has to be "industry-specific."[37]

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35 E. Mansfield, "Determinants of the Speed of Application of New Technology," in B. R. Williams (ed.), Science and Technology in Economic Growth, Macmillan, 1973, p. 204.

36 See Nabseth and Ray (1974), p. 13; Mansfield (1973), p. 204; and Scherer (1970), p. 376.

37 S. Globerman, "Market Structure and R & D in Canadian Manufacturing Industries," Quarterly Review, Economics and Business, Summer 1973, p. 65.

6. Diffusion According to Certain Firms' Characteristics

In some cases, researchers have found that distance, size of cities, or even market structure were highly similar, but that the diffusion rate varied among countries, regions, or industries. That led them to suspect that some internal characteristics of the firm(s) were probably important in explaining rates of diffusion.

This is not to say that external factors consisting of the economic, geographical, and institutional environments of the firm are not strong influences. But, the environment does not always completely constrain or predetermine the behaviour of management. What has now been realized is that the same objective environment can lead to different decision-making within the firms with respect to the adoption of innovations. This should not be too surprising since it corresponds to the main contribution of the behavioural theory of the firm.[38]

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38 The term "behavioural" corresponds to an approach to the theory of the firm which "investigates effects of variables internal to the firm on price and output decisions. This approach is in sharp contrast to the traditional theory which ignores the internal structure of the firm." See K. J. Cohen and R. M. Cyert, Theory of the Firm (Prentice-Hall, 1963), p. 351.

Obviously different behaviours are possible only in a nonperfectly competitive situation; that is, a situation where the so-called noneconomic factors (but nonetheless real) have an influence of their own. But, on the other hand, this seems to be the usual environment of manufacturing firms, especially those of the innovative type.

Researchers have consequently been led to investigate factors internal to the firms that have an influence on the rate of diffusion. These factors have been grouped into a few variables, mainly: management attitudes, national and international connections, access to financial capital, and internal conditions of the firms with respect to administrative structure and production equipment.[39]

This approach has been taken as both an extension[40] and as a substitute of the environmental approach. It is an extension when it proposes to analyse more deeply some of the variables retained by the environment approach to diffusion. For instance, the size of the firm (a factor in the environment approach) is an aggregate concept that covers many internal aspects of the firm. Size is the result of the presence (absence) of economies

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39 Although not covered specifically in our analysis, this approach incorporates determinants of diffusion of innovations such as age of machines, capacity utilization, the proportion of total costs accounted for by various inputs, information variables, R & D activities, productivity of management, dividend policy, vertical and horizontal integration, etc.

40 For Meyer and Herregat (1974), the two modes (environment and firm's characteristics) "are not necessarily mutually exclusive.... For example, it is entirely possible that all firms respond eventually in a reasonable fashion to objective economic signals, but the rate of response may differ because of managerial or motivational differences" (p. 192). But because our study focuses on differences in rates of adoption and because rates of adoption are a function of managerial attitudes, the study of a variety of managerial attitudes before similar objective situations is consequently crucial to us.

The empirical study of Nabseth and Ray (1974) found that management attitude and other company variables were predominant in the diffusion of a few innovations (tunnel kilns shuttless looms) and more or less important in a host of others.[41] Other researchers such as Layton (who studied different industries) squarely impute international differences in the generation and diffusion of innovations to management skills' differences.[42]

Similarly, the variable "foreign ownership" has proven itself as an explanation of rates of diffusion, both theoretically and empirically. Most people would agree that "multinational companies are unquestionably the dominant institutions transferring industrial technologies across national borders."[43] The international version of the product-cycle theory provides another basis for the above contention:

(i) In the first phase a U.S. innovator acquires a quasi-monopolistic position within the United States;

(ii) In the second phase his competitors imitate it and reduce the extent of his markets; and

(iii) In the third phase "the originating firm has to move to some other innovation. Before or during this phase, however, the originating company may invest outside of the United States to take advantage of the factor cost situation in other countries or to preserve an oligopolistic situation."[44]

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41 For instance in the case of the diffusion of the Basic Oxygen Process, the result was "that some of the differences observed between firms or national industries are attributable to such noneconomic factors as differences in management style and motivations."

42 C. Layton, Ten Innovations, George Allen, 1972, p. 11: "management skills are Britain's scarcest resource."

43 J. B. Quinn, "Technological Transfer by Multinational Companies," Harvard Business Review, November-December 1969, p. 150. That does not mean that multinational firms are restricted to science-based industries.

44 Organisation for Economic Co-operation and Development, Gaps in Technology, OECD, Paris, 1970, p. 254.

There are empirical results to support this contention. For instance, Globerman[45] found in the case of the Canadian pulp and paper industry that "domestically-owned firms were slower adopters than foreign subsidiaries, ceteris paribus." Similarly, Nabseth and Ray[46] noted that "foreign involvement (that is, whether or not a firm has foreign subsidiaries or agreements or other special relationships with foreign companies) appears to be important" in the case of the shuttleless looms innovation.

As in the case of environment diffusion, the empirical evidence is small and industry-specific, but the main point is that it exists.

7. The Regional Factor

The regional factor exists if there is a systematic difference in the diffusion processes among regions not attributable to statistical procedures. Furthermore, this difference must be attributable to the influence of some of the basic characteristics of the region on one or many of the key explanatory variables proposed by the various modes of diffusion. These basic characteristics consist of endowments in natural and human resources, a stock of industries, an urban hierarchy, a social infrastructure, a location (near or far away) in relation to the economic and social centre of the country, a set of government policies, activities, incentives, and regulations.

45 S. Globerman, Technological Diffusion in Canadian Manufacturing Industries (1974), University Grant Program Research Report, Office of Science and Technology, Industry, Trade and Commerce, Ottawa, p. 14.

46 Nabseth and Ray (1974), p. 282.

This systematic influence varies with each mode of diffusion. It is theoretically important in the epidemiology and urban hierarchy modes. It is much less significant for the modes involving market structures or management attitudes. For instance, if an innovation originates in an industry where the process of diffusion is governed by the market structure, regional characteristics can largely be ignored. On the other hand, if an innovation is diffused according to the urban hierarchy, the regional factor becomes preponderant.

The effect of the region's characteristics upon the key variables of the various models of diffusion can be illustrated as follows:

The case of "distance" is easy. The region's distance from the heartland of the country is first of all a fact. Second, the other "distances" involved can be influenced by the region's own infrastructure and government policies.

The "urban infrastructure" is also largely an expression of the principal characteristics of the region.

As for the environmental variables, e.g., concentration and size-distribution of firms, the effect of the region's characteristics is much more indirect, if present at all. However, certain favourable cases may be mentioned. For instance, the disappearance of natural resources may be

determinant in the decision of the firm not to introduce innovations. In fact, depending upon the nature of the innovation the phenomenon could either accelerate or stop the introduction of the innovation. Local government policies regarding concentration (or deconcentration) foreign ownership, not to mention fiscal policy, may also have some influence.

Concerning diffusion according to the firms' characteristics, the regional factor also plays a role, but in an even more indirect way. The region through its financial facilities, educational system, government policies (namely, fiscal) may influence the stock, the quality, and the attitudes of management.[47] Similarly, the region's prospects, social attitudes, quality of life, and policies may favour (or not) the establishment of national and international firms.

The above sketchy illustration shows that the regional factor may, in certain cases, play the role of a more fundamental explanation of the varying rates of diffusion of innovations among regions.

8. Policy Implications

All modes of diffusion have regional implications for:

(1) explaining why a particular region has been a leader or a laggard in the diffusion of innovations;

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47 This point has been touched upon by R. E. George, A Leader and a Laggard, University of Toronto Press, 1970, Chapter 10.

(2) assessing the future chances of a region in being successful in attracting a particular innovation; and

(3) determining regional policy changes that may help speed up the diffusion process or correct some lacunae of the region in this respect.

The explanation is achieved by matching the preferred mode of diffusion of a particular progressive industry with the characteristics of a region. Consider an industry where the speed of diffusion of an innovation has been faster:

(1) the smaller the distance from the centre of the country;

(2) the larger the cities;

(3) the better the possibility to associate with other larger firms, or foreign firms; and

(4) the more cosmopolitan the milieu.

In this case, a ranking of the regions of a country can be made, and it may explain the actual distribution of this industry. Similarly the chances of a region being successful in attracting the carrier of an innovation depends upon which mode of diffusion is characteristic of the industry in question and how it compares to the region's characteristics. By extending this analysis to a large sample of representative industries a general forecast could be made about the future relative position of a region with respect to access to modern technology.

Finally, and not independently, the two previous exercises will surely point to strenghts and weaknesses of the region in the fields of urban affairs, urban infrastrcutres, the tertiary sector including transport and communications, industrial structure, local education and research policies, government policy and regulations towards industry, labour, and soon. It is then a matter of imagination to elaborate the feasible remedial policies.