TWO MODELS OF INNOVATION DIFFUSION

by

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This paper describes two communication models which Simulate INnovation DIffusion (SINDI).* SINDI 1, a stochastic model, simulates diffusion of information to cliques in a small Latin American community. SINDI 2, an expected-value model, simulates the diffusion of the adoption of an innovation among members of a community. Both models are programed in USASI FORTRAN because the language is widely understood and FORTRAN compilers are available on most computers.

SINDI 1

SINDI 1 follows the traditions of Torsten Hägerstrand[1], Georg Karlsson[2], Forest R. Pitts[3], and Paul J. Deutschmann[4], researchers who have simulated spatial and social diffusion phenomena. Part of Deutschmann's model is incorporated in SINDI 1. The simulation was run using data derived from a secondary analysis of data collected in Colombia by Everett M. Rogers[5].

The diffusion of an innovation is the spread over time of a new idea through a social system.[6] The innovation enters the social system, in this case a peasant village, through external channels. In SINDI 1 there are two external channels, one representing an extension agent, the other representing the school teacher who has an urban, rather than local, orientation. Mass media channels are not important in SINDI 1 because the the villagers are illiterate and not exposed to agricultural radio programs. Individuals in a community can be divided into cliques of highly interacting members, with local word-of-mouth messages flowing more frequently within cliques than between cliques. In the model, 67 peasants were divided into four interacting cliques and one group of isolates. There is a small group of individual ("tellers") within the community with a high probability of passing information to others after they have received it; all others have a low probability of passing information. There are nine potential tellers in SINDI 1, each of whom cannot contact others until he has received information about an innovation (become a "knower").

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Prior to each run, SINDI 1 preassigns some individuals as knowers if they were knowers before the start of simulated time.

The following parameters are defined as input to SINDI 1: (1) the number of cliques, the number of members in each clique, and the number of potential tellers in each clique; (2) the number of contacts allowed each external channel source per time period; (3) the number of contacts allowed a teller once he becomes a knower; (4) the probability of a non-knower becoming a knower through any external channel source; (5) probability of a member of a clique becoming a knower through contact with a teller from any clique.

Technically, SINDI 1, consists of a main program and five subroutines (see Figure 1). The main program handles the monitoring tasks for the simulation: it acts as a "clock" by executing the time-varying Do loops and calling the other subroutines. The first subroutine, INPUT, reads in the parameters and initializes arrays for the beginning of a run and a time period. The next routine, EXTMES, is the external message section. In this routine each external channel randomly contacts a specified number of individuals. Associated with each individual (as an input parameter) is an information transfer probability based on his channel orientation and the channel source of the message for a particular contact. A randomly generated probability is compared with the information transfer probability: if the former is less than or equal to the latter, the person will become a knower; if not, he remains a non-knower. Subroutine TELCON is the teller contact section. It functions like the external message section except that the information transfer probability depends on the individual's clique membership and the clique membership of a contacting teller. Subroutine OUTPUT prints out a summary of the information transfer events for the simulation. Subroutine RANDOM is random number generator which provides random integer subject numbers and random probabilities based on an extension of Lehmer's rule.

Results of three different runs of SINDI 1 are shown in Figure 2. The runs simulated diffusion of information about a weed spray to Colombian peasants. The results have so far failed to replicate both the slow initial curve rise and the high number of knowers at the top of the "S" curve of the original data.

SINDI 2

SINDI 2 extends the conceptual model of SINDI 1 by modeling not only the diffusion of information but also the influence process which leads people to adopt innovations.

SINDI 2 was designed and tested using survey data collected from approximately 100 dairy farmers living in a progressive farming community in the state of Minas Gerais, Brazil. In the model, information and influence flow to the potential adopters in the community via the print media (agricultural magazines and agricultural pages in newspapers), the electronic media (radio programs on agricultural matters), and word-of-mouth communication with adopters encountered individually and at meetings of community organizations. No provision has yet been made in SINDI 2 for interaction with extension agents or commercial salesmen.

The model makes the following assumption:

1. Each simulated individual manifests a resistance or delay to adopting an innovation following first awareness. This resistance factor is a function of the individual's demographic and attitudinal characteristics as well as the economic characteristics of his enterprise.

2. Each potential adopter is influenced proportionally to his exposure to innovation information carried in the mass media and to his frequency of interaction with adopters in his community.

3. When the magnitude (a continuous, expected-value variable) of an individual's cumulative influence from various sources exceeds the magnitude of his resistance to adoption, he becomes an adopter.

SINDI 2 requires the following input data:

1. real time at the beginning of the simulation run; the number and duration of each time period;
2. "quantity of information" about innovation X carried by each mass media channel for each time period of the simulation (square inches of magazine and newspaper print; minutes of radio and television program time);
3. each individual's probability of exposure to each issue of a magazine and newspaper and to particular programs on radio and television;
4. each individual's list of discussion partners in the community, his frequency of work-related discussion with each partner, and each partner's credibility as an influence source;
5. each individual's probability of attendance at meetings of community organizations; the number of meetings of each organization for each time period;
6. the time periods that each individual entered the community and/or began work enterprise (e.g. dairy farming) if later than first time period of simulation;
7. the individual's resistance to adopting an innovation predicted from a multiple regression of real-world adoption behavior with demographic, attitudinal, and economic independent variables (after partialing out variables related to the communication behavior accounted for by the simulation model);
8. parameters specifying the extent of influence on an individual which results from his exposure to innovation messages in the mass media and from his interaction with another adopters in the community.

The processing of SINDI 2 proceeds as outlined in Figure 3. (Note: As referred to on the flow chart "innovators" are those individuals who adopted the innovation prior to the simulation starting time; "external adopters" are those individuals who adopted the innovation someplace outside the community and then migrated into the community after the simulation starting time.)

SINDI 2 outputs the simulated adoption time and the relative effect of the various sources of influence for each simulated individual. It also calculates the correlations between the simulated adoption times, the real-world adoption times and the resistance factors (predicted for each individual from multiple regression as indicated in item 7 above). A separate output analysis program7 produces a computer plot of the simulated and the empirical cumulative adoption curves and performs the Kolmogorov-Smirnov two-sample test.

The model parameters have been varied in a series of runs designed to "tune" the model to the real-world data on the diffusion of silos among 88 dairy farmers in the Brazilian community (13 of the original 101 respondents were dropped from the analysis). Each run of the simulation cycled through 36 six-month time periods beginning in 1957. The results of one such run are shown in Figure 4. For this run the correlations (for 72 simulated individuals excluding "innovators" and "external adopters") are as follows:

1. simulated adoption x empirical adoption = 0.666
2. regression resistance x empirical adoption = 0.681
3. regression resistance x simulated adoption = 0.780

The adjusted Kolmogorov-Smirnov probability for N = 72 is equal to 0.795.

The percentages of relative influence (summed over all simulated individuals) from the various sources are as follows:

Magazines and newspapers	15.3%
Radio programs	1.3
Interaction at local meetings	2.3
Interaction with neighbors	81.1
	100.0%

Preliminary Testing of SINDI 2 indicates that the simulation model performs about as well as the straight linear regression model, which has been used in past diffusion research to predict individual innovativeness. However, since SINDI 2 incorporates linear regression to predict resistance to innovating as well as models the dynamic aspects of the diffusion process (in terms of information and influence flows over time), one would expect the simulation model to give better results than the linear regression model. More analysis of the model's behavior and improvements in the data base are required before final conclusions can be reached.

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Further details about SINDI 1 and SINDI 2 may be found in References 8 and 9.

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Figure 1. FLOWCHART FOR SINDI 1

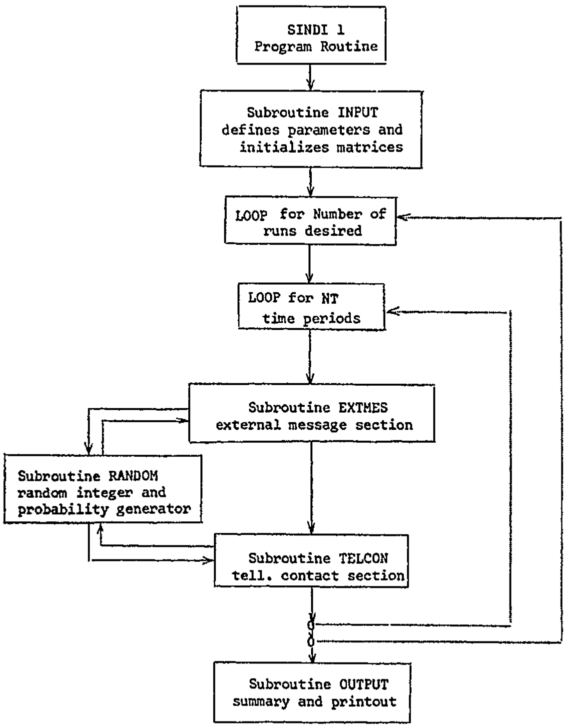

Figure 3. FLOWCHART FOR SINDI 2

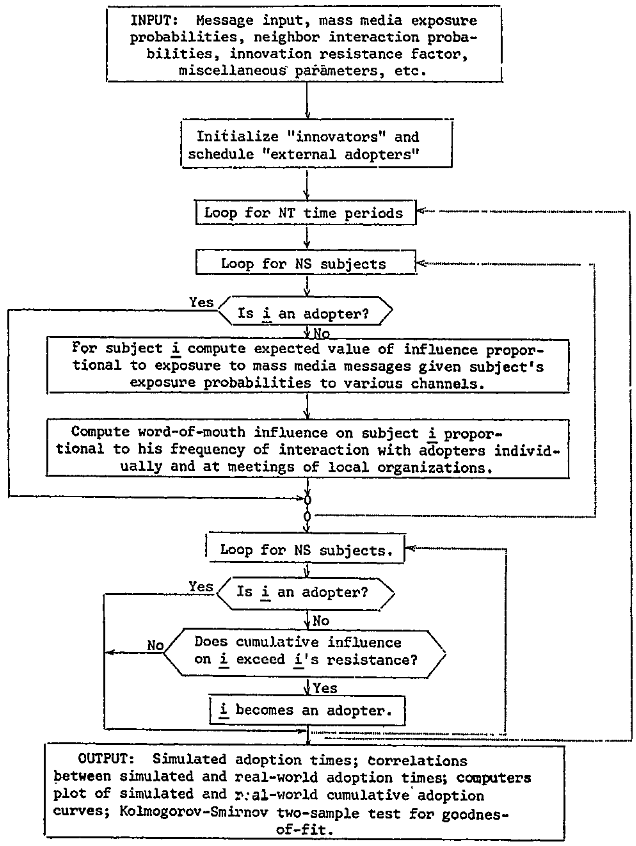

Figure 2. COMPARISON OF SINDI 1 RESULTS

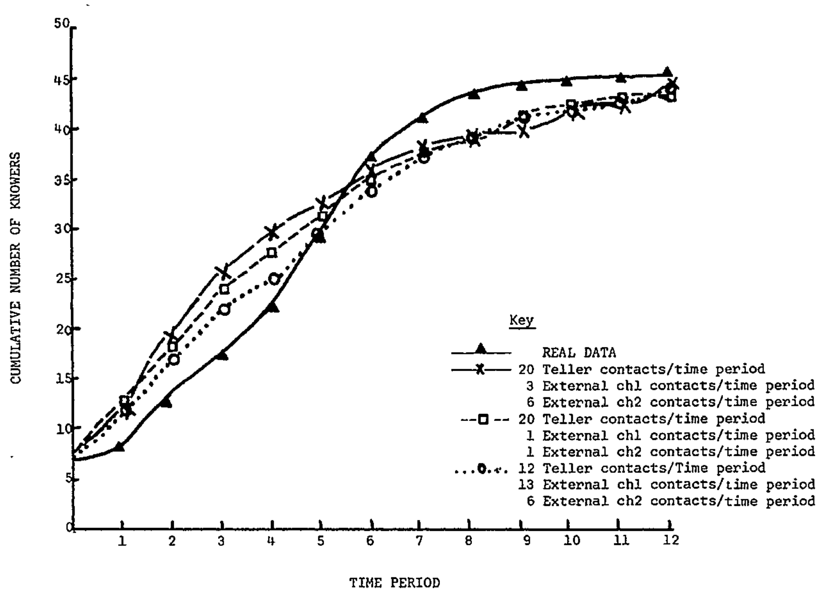

Figure 4. CUMULATIVE DISTRIBUTION PLOTS AND K - S TWO SAMPLE TEST

VARIABLE	SYMBOL	NUMBER	MEDIAN	RANGE	MEAN	STD. DEV.
SILO	X	88	65.00	32.75	65.25	5.95
Run 3	0	88	64.63	32.75	65.28	6.06

DMAX	ABSCISSA(DMAX)	PROB(H0)	AREA BETWEEN CURVES
0.0909	68.500	0.8631	0.5199