

THE INFORMATION COMPONENT IN DECISION-MAKING: A FRAMEWORK FOR ANALYSIS

A pragmatic definition of 'information' is proposed and discussed in the context of the decision-maker's fundamental objectives. Major facets of the decision-maker's environment are delineated and the significant contribution of information in this environment is demonstrated. Theoretical issues involved in quantifying the value of information contained in a given set of data for a particular decision maker at any particular time are analysed and related to the IDUPOM Research Project whose major characteristics and objectives are described in the context of governmental decision-making in Nigeria.

INTRODUCTION

"...The effective use of information and the information-transfer process is a vital component of effective government. It is critical to good decision-making and good administration..." (President Gerald R. Ford).

There is a general tendency to dismiss the words quoted above, which are taken from President Ford's greetings to the 39th Annual Meeting of the American Society for Information Science, as the typically crafty statement of a politician who desires to be all things to all people. But, the fact remains that Ford's words are true.

Empirical evidence abounds to show that no country in the world has recognised the crucial significance of information in national development better than the United States of America. For example, one of the conclusions of a recent survey is "that 20 to 40 percent of the (U.S.) Gross National Product and one-half of the nation's workers are involved in information processing."

It has been estimated that this ratio is only slightly lower in Japan, West Germany, Switzerland, and Sweden. The result is that we now have an increasing number of "post-industrial", "information-age" countries whose most conspicuous economic feature is that they maximize the world's information resources for their nation's growth and continued world economic domination.

Before we proceed any further, however, it would be necessary to clarify two vital words: 'information' and 'decision-making' that appear in the title of this paper.

The word 'information' connotes very different things to different people in different situations and at different times. Without discussing other valid uses of the word, we shall for the purpose of this paper, define 'information' as: "Alpha-numeric or symbolic data of value in decision-making".

In the context of this paper, this is an appropriately pragmatic definition. It is also a comprehensive one since it covers all formats in which information can be displayed. This definition also introduces the need to clarify the highly subjective word, "value". We shall, however, postpone consideration of this word until later on in this paper.

'Policy-making' and decision-making' are frequently used interchangeably in the professional literatures of political science and library science. Generally, however, 'policy' connotes "a course of action over a considerable period of time by governments and institutions" while 'decision' is normally heuristic as exemplified in Paolo's definition: "the act of choosing among several alternatives in a situation of incomplete information."

We all make decisions everyday of our lives, but to formulate a single policy usually requires a host of decisions. Thus, although the primary concern of this study is information-input in decision-making processes, it automatically implies that we are also interested in the formulation of policies that are an aggregate of several individual or group decisions. 'Decision-making' and 'policy-making' will, therefore, be used interchangeably throughout this paper.

The rest of this paper is a discussion of how information can be measured and evaluated within the essentially pragmatic context of the governmental decision-making environment. In doing so, we shall focus our attention on the following assumption:

"Efficient decision-making is a function of the amount, accuracy, and timeliness of relevant information utilized in the process".

DELINEATING THE DECISION-MAKERS INFORMATION ENVIRONMENT

Information analysts who consider information as inextricably connected with decision-making, as our definition implies, are primarily interested in the functional components of a generalized information systems model.

The model formulated by Yovits and Ernst has all of such components and is reproduced here in Fig. 1. The IAD module (Information Acquisition and Dissemination) processes data for the system. Both exogenous (external environmental) and endogenous (internal feedback) data are acquired by the IAD module.

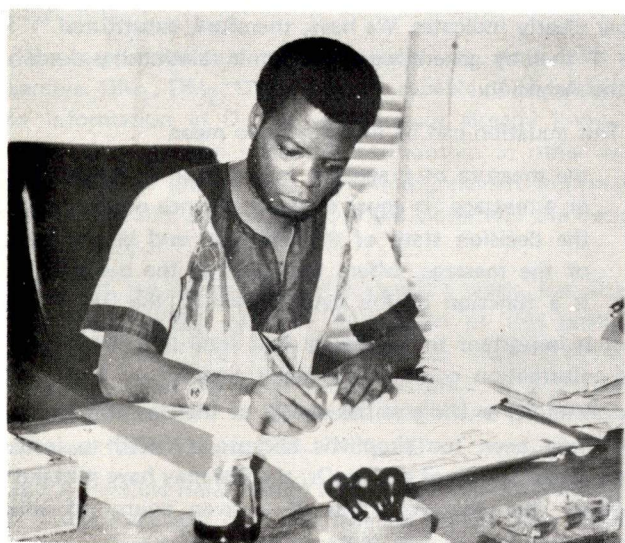
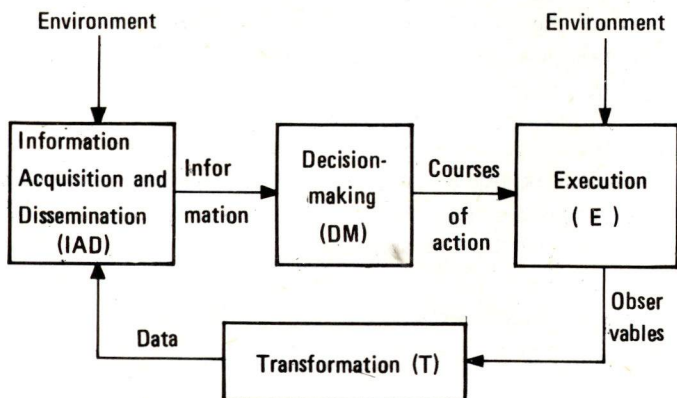
Whenever a decision must be made, the DM module (using all the data available) establishes the possible courses of action and selects the "best" one to execute. The Execution module executes the DM-chosen course of action, according to all pertinent external environmental factors, leading to various outcomes depending on the alternative executed. These outcomes will be some observable quantities.

They must be observable in a physical sense if they are to have any effect. The Transformation module takes all observables of the alternative executed and turns these observations into data. These data are fed back into the IAD module and we have come full circle, following the flow of information in the model.

This model of a generalized information system rests upon three basic hypothesis.

- H1 Information is data of value in decision-making
- H2 Information gives rise to observable effects;
- H3 Information feedback exists so that the Decision-Maker will adjust his model for later similar/decisions.

Fig. 1 The Generalized Information Systems Model.



...Being a paper presented at a Senior Staff Seminar of the National Library by Dr. W. A. Aiyepku, of the Department of Library Studies, University of Ibadan, who is also the Consultant/Project leader for IDUPOM Research Project.

The first hypothesis requires that information be used in a decision-making context. If information is received, but never used or applied to a subsequent decision, then its effect does not exist and it cannot be measured. Hypothesis 2 assures that if the decision-maker (DM) does make a decision, then the out-come of that decision can be observed and measured.

This precludes decision-making in a vacuum. Observables must exist if the decision-making and the courses of action are to be evaluated. Hypothesis 3 indicates that the DM learns from feedback data resulting from previous decisions.

Note that the observed outcomes of repetitive or related decision-making situations provide data upon which future decisions will be made. In the words of Whittemore and Yovits.

Virtually all situations involving the flow of information in a decision system can be described by this model...

this model can be used for all decision making processes. The decision making may be rational or irrational. The model may give rise to normative or descriptive procedures for decision making, and it encompasses all of the known variations that may be of significance with regard to decision making in general.

(pp. 34-5)

It is important to emphasize the simplicity of this model and to draw attention to the crucial points at which environmental factors impinge on a sequential decision-making process. One should also note the assumption that a decision-maker (DM) begins by predicting a decision path (with minimum to maximum information input).

It is in comparison with such a path that actual observables can be analysed with the result that the DM can verify the validity of his predicted decision path. In other words, the model in Fig. 1 assumes that there is a feedback between the resulting observables and the DM.

By observing the actual effects of his decisions and comparing them with those he has predicted, the DM is able to develop a judgement about the effectiveness or accuracy of his predictive model. The crucial role of information in this situation, then, is to either resolve or reduce the uncertainty that the DM has in the process of making the most accurate decision.

In general, uncertainty in a decision situation can be classified as either structural or relational; simultaneously, it may be executional, environmental or goal-associated. Fig 2 taken from the Whittemore and Yovits study already cited, illustrates these relationships.

In so far as the DM must master his decision variables thoroughly before he can appreciate the crucial role of information in making accurate decisions, it is important that the DM should learn to cope with all six categories of uncertainty depicted in Fig. 2.

Finally, in delineating the DM's information environment, it is important to consider what could be referred to as the 'personality variables' of the DM in relation to his assessment of the amount, relevance, accuracy, and timeliness of information available to him at any stage of the decision-making process.

G Fig. 2: A Classification of Uncertainty in Decision-Making

		Execution of courses of action	UNCERTAINTY ABOUT	
			Goals	Environment
UNCERTAINTY ABOUT:	Structural components of the decision model	structural-executional uncertainty	structural-goal uncertainty	structural-environmental uncertainty
	Relationships among the structural components	relational-executional uncertainty	relational-goal uncertainty	relational-environmental uncertainty

The DM's level of confidence in his decisions vis-a-vis the varying amount of information available to him is thus a crucial facet of the DM's information environment. Hammer's definitive study of the interaction of these variables in a simulated military situation requiring rapid sequential decisions has, inter alia, demonstrated the large individual differences in judgements of confidence and amount of information.

That is basically why, as we shall see later on, attempts to quantify the value of a given information to a particular DM is still so difficult and largely experimental.

MEASURING THE VALUE OF INFORMATION

In every situation and at every stage of decision-making, the DM desires to have relevant information that will reduce to the minimum (if not eliminate altogether) the amount of uncertainty associated with the attainment of his decision goal.

If for a moment we remind ourselves of our working definition of 'information' for this study and of the categories of uncertainty delineated above, it follows that any data of value in decision-making can only have structural or relational or both types of information.

An example of structural information is the occurrence of a previously unknown decision outcome or the discovery of a new, viable course of action. In so far as the new data enhance the DM's understanding of the structural components of his decision model, they are structurally informative.

Conversely, data that enable the DM to assess more accurately the relative values of probable outcomes according to a given goal structure are relationally informative.

Although this distinction helps to clarify our thinking on the subject, it is of course, not realistic to consider these two types of data in isolation within the pragmatic context of the DM. Moreover, both types of information are really of significance in their combined effect on the DM's understanding of his decision situations.

What is of fundamental significance, therefore, is the value that a DM places on a given piece of information at any particular time. Thus, the value of information to a DM will vary according to:

- (a) the DM involved (personality variables),
- (b) the time the decision is being made,
- (c) the nature of the decision itself and
- (d) the environment in which the decision has to be made.

It is clear, therefore, that the same data will have different values to different DMs at the same time or to the same DM at different times.

This is the crux of the matter, that is, how does one quantify such a highly time- and personality-specific variable called 'information' and relate the result meaningfully to a given DM in a given decision state? In other words, how does one quantify such a highly relative commodity called 'information' and still produce a result that has general applicability to DMs?

Whittemore and Yovits have done substantial pioneering work in this area and the discussion that follows derives, in large measure, from their article. They proposed a "measure of pragmatic information" that defines the DM's decision state as a function ranging from a minimum of zero to a maximum of one.

The greater the amount of information available, the closer will the decision state be to unity. They define $V(DS_t)$ as the value of a decision state at time t . *I acknowledge the assistance of Dr. T. A. Oyejide, Department of Economics University of Ibadan, who helped to develop the mathematical description of this relationship as presented in the Appendix to this paper.

Since information has its impact on the various components of the decision model, the pragmatic information I contained in a set of data can be defined by the impact of the data on the value of the DM's decision state as follows:

$$I(D) = \frac{V(DS_{t+1})}{V(DS_t)} - V(DS_t)^*$$

*It appears to this author that the equation as published in the Whittemore and Yovits study contains a crucial error. The second part of it appeared as

$$\frac{V(DS_{t+1})}{V(DS_t)}$$

This connotes a static relationship between information and decision-making, a 1:1 relationship. That obviously was not the impression the authors wanted to give as the rest of their paper clearly indicates. We have, therefore, substituted '1' for the 'I' thereby generating the dynamic relationship described in the Appendix.

This equation can be interpreted to mean

the measure of pragmatic information in a set of data or a message is equal to the difference of the value of the decision state of the DM after and before receipt of the message, where the value of the decision state is a function of the determinism of the DM (p. 39).

It is important to emphasize that both positive and negative information could be of major significance to the DM. For example, a DM's initial model of his decision situation may have been too simplistic because it failed to include some viable course of action. Or, the DM may have mistakenly assumed that the execution of a given course of action always resulted in the same outcome.

Negative information that caused the DM to change his model in order to rectify either of these mistaken beliefs actually contributes to a more accurate model of the situation and is, therefore, clearly significant.

TOWARDS A DM's INFORMATION PROFILE

Our discussion so far has still not considered the ultimate objective of both the DM and the information scientist. Both specialists aim at a simple measure of the information contained in a set of data in terms of its overall usefulness for a range of DMs in different decision situations over a period of time.

In a recent paper, Little discussed this problem in the context of a decision calculus that is, unfortunately, too advanced for the purpose of this paper. What is required is the formulation of an 'information profile' that assigns to a set of data a number indicating its composite value in terms of the composite information content of the data.

We would have to start by determining the relationship between the "effectiveness" of the DM* "effectiveness" is the aggregate of what the DM already knows as well as the personal attributes he brings to his decision situation that enable him to assess further relevant information quickly and accurately.) and the pragmatic information content of the data

for this particular DM.

In fact, since what is really desired is some indication of the value of this set of data (or "data source", or document or message) for the DM over a period of time, one might attempt to determine some index $I(D)$ of the average (over time) information contained in data set D (or derived from data source D).

Then, if it were possible to assess the effectiveness of each DM for whom this set of data serves as a source, it would be possible, by determining $I(D)$ for each DM, to formulate an information profile for data set D .

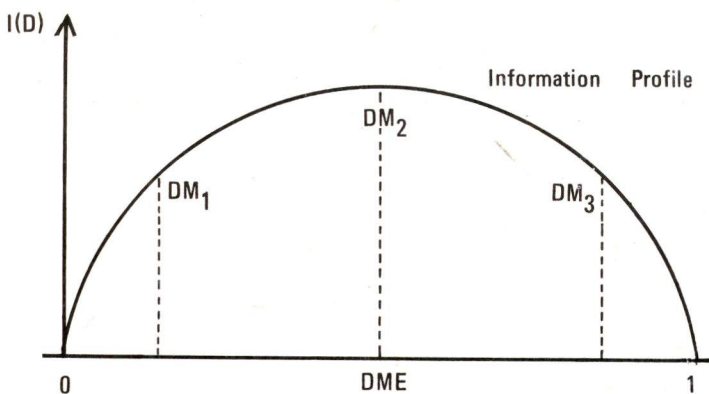
Fig. 3 illustrates what these relationships should look like. An ineffective DM (i. e., one who scores 0 or near 0 on the horizontal axis) will not appreciate the significance of D hence the overall information value of D for him will be minimal.

This DM is not sufficiently effective to develop any reasonable predictive model of his decision situation. Similarly, D is virtually of no value to the DM who scores 1 or almost 1 since he already knows almost all of the information contained in D .

Between these two extreme values are most DMs (for example, DM_1 , DM_2 , DM_3) who are capable of understanding the information in D , but who do not already know this information. We can state this relationship in other words by saying the greater the amount of relevant information available to, and used by, the DM the closer will the decision state to unity.

One of the conclusions of Hammer's study has already provided empirical evidence in support of this postulate. He found that "For final decisions, as more information was provided to decision makers, accuracy of performance increased from 46% to 81% and judgements of confidence increased from 52% to 68%..." (p. 6)

Fig.3 A Possible Relationship Between Composite Information Value ($I(D)$) and DM Effectiveness (DME) for a Typical Set of Data (D)



If such a profile can be developed for every data set or document in an information system, then this profile can serve as an index of the composite value of this set of data or document for the DM. Each data set in such a system would have an information profile attached to it which would then help to establish criteria for evaluating the information system from the DM's view point.

One must resist the temptation to regard the theoretical issues raised here as a sort of diversionary exercise from the pragmatic emphasis that has featured through most of this paper.

This theoretical discussion undoubtedly constitutes the basis for understanding the DM's pragmatic choice and use of relevant information. A logical follow-up would be to produce empirical evidence that helps the testing of the relationships proposed above or which at least enables us to construct different information profiles for different DMs.

Unfortunately, that kind of evidence is not yet available. Before we can test these propositions however, we need to know, in great detail, DMs' behavioural characteristics in a large variety of decision situations. In particular, we must, for every given decision environment.

- (a) identify who the DMs are and the administrative/organizational structures in which they operate;
- (b) identify those who are primary (proximate) or secondary decision-maker and describe their personality variables;
- (c) determine the DMs' techniques of decision-making;
- (d) describe the stages of a typical decision-making process, and
- (e) analyse, in detail, the implications for information transfer of each or combinations of (a) to (d) above

Then, and only then, can we meaningfully examine how, why, when, and which information is used or not used by DMs in a particular environment. This was how the idea of the IDUPOM Research Project started - to collect, among other objectives, empirical data necessary for testing the relationships described above.

IDUPOM RESEARCH PROJECT

IDUPOM is an acronym for "Information Dissemination to, and its Utilization by, Policy-Makers in Nigeria". It was conceived by this author late in 1976 and successfully sold to the National Library of Nigeria early in 1977. The Library is funding the Project which is estimated to spread over a period of about two years starting from September, 1977.

This author has already been appointed by the Library as the Project Leader/Consultant of the research. I shall now briefly describe the objectives and scope of the Project.

Objectives

The focus of the ongoing research project concerns the effective and economical utilization of internationally-generated information as well as the effective utilization of locally-generated information by policy-makers in Nigeria.

Typical questions to which the study will attempt to provide answers include:

1. How could the policy-maker in Nigeria know what information support to demand in order to make a specific policy decision?
2. How could the policy-maker be sure that his decisions are at all the times based on the most relevant and up-to-date facts available?
3. In what respects are the information needs of the policy-maker in a developing economy like Nigeria's different from, or similar to, the information needs of policy-makers in developed economies? For example, in what packages does the policy-maker in Nigeria receive/prefer to receive his information?
4. What is the general level of the policy-maker's "information consciousness"? Or, how much emphasis does

the policy-maker in Nigeria place on information before, during, and after the process of decision-making? How could he best evaluate the relevance of the information he receives in relation to these stages of decision-making?

5. What is the policy-maker's role expectations of human intermediary processors and interpreters of information, such as librarians, information officers, data analysts, etc. in the policy-making process?
6. To what extent could the overall performance of policy-maker in Nigeria be the function of the quality and relevance of information available to, and used by, him? In particular, the study will
 - (a) isolate those factors that combine to make for easy and effective flow of relevant information to, and its absorption by, the Nigerian policy-makers, assess such factors, and relate them operationally to the policy-maker's information needs;
 - (b) evaluate any institutional constraints to timely and effective use of relevant information by policy-makers. For example, the statutory functions of the Federal Ministry of Information and NISER in this regard will be closely examined;
 - (c) indicate which elements have led to the success or failure of a given relevant information being taken into account in policymaking, e.g., the quality or format of the information, its timing, the method of disseminating it, and the professional training or disposition of the target audience.

The final stage of the study will involve the design of an information system that would maximize information input in decision-making processes for rapid development in Nigeria, with particular emphasis on cost-effectiveness, timeliness, relevance, and flexibility.

Scope

The study is designed to cover all processes of decision-making that involve the use of social science knowledge among top government officials at the Federal level. In other words, the study will try to achieve the objectives listed above by making a detailed analysis of the structure of social science information flow to, and its utilization by, governmental policy-makers in Nigeria before, during, and after specific policy decisions.

In order to facilitate the collection and analysis of data, the Project is divided into eight sections as follows:

Section One: Identification of Public Policy-Makers (PMs) in Nigeria and a description of Their Functions in Relation to Specific Decision Situation. That is detailed knowledge about the behavioural characteristics of PMs in Nigeria.

Section Two Perception and Utilization/non-utilization of Social Science Information by PMs in Nigeria.

Section Three: Characteristics and Functions of Information Processors Available to PMs in Nigeria. The words "information processors" here refer to librarians, information officers, information analysts, etc, who are concerned with the acquisition, analysis, and interpretation of relevant information for use by policy-makers and other information-seekers.

Section Four: Role, Expectations and Functions of the Federal Ministry of Information. Our assumption here is that this Ministry sees its role and functions essentially in terms of information output (comprising the functions and achievements of government) and not in terms of information input before, during, and after government policies are determined.

Section Five: Role Expectations and Functions of the Nigerian Institute for Social and Economic Research (NISER) in Relation to the Dissemination/Utilization of Social Science Knowledge in Nigeria, Since the focus of the Project is on the social sciences it is expected that knowledge about the utilization of NISER-generated research in Nigerian public policy-making processes would be crucial to our understanding of the central concern of the Project.

Section Six: Identification of Gatekeepers of Knowledge and Their Functions in Nigeria Policy-Making Situations. "Gatekeepers of Knowledge" refers to people in any institution who, though without formal training in information science, take more than average interests in the information dissemination and utilization functions of his institution.

The result is that a gatekeeper of knowledge manages to keep ahead of his colleagues in locating, reading, assessing, and utilizing all kinds of information that might enhance the effectiveness of his institution.

Section Seven: Researchers' Role Expectations and Functions in Relation to the Dissemination/Utilization Functions. The assumption for this section of the Project is that most developmental research in Nigeria (and elsewhere) is planned and completed with little or no regard to how its results will be utilized. Thus, the view is often heard that "the road to political inaction is paved with unused [and unusable] research reports."

Section Eight: Finally, it is hoped that the Research Project will culminate in the Design of an Information System for Public Policy-makers in Nigeria that would maximize information input in decision-making processes to achieve the rapid a systematic development of the nation.

We can summarise the IDUPOM Research Project by saying that it is designed to collect and analyse empirical evidence concerning the amount, relevance, accuracy, timeliness, and feedback characteristics of social science information in the generation/utilization mode of information and PMs in the Nigerian context.

The study should also throw valuable light on the interplay of personality variables vis a vis the use of non-use of relevant information by PMs. Armed with such multi-faceted knowledge, it is hoped that the design of an information system specifically for PMs in Nigeria will maximize relevance and cost-effectiveness.

CONCLUDING REMARKS

This paper discusses some of the theoretical issues involved in a proper evaluation of the critical role of information in a decision-making environment. It is suggested that our understanding of these theoretical foundations helps us to appreciate and relate more meaningfully to the essentially pragmatic considerations of the use and non-use of information by DMs.

Although no empirical evidence is presented here, the

objectives and scope of the IDUPOM Research Project are described in order to illustrate the kind of empirical evidence desired for testing and improving the ideas pertinent to our central concern: the most effective utilization of information by DMs in every decision state.

APPENDIX

As indicated in the text, the corrected equation should read:

$$I(D) = V(DS_{t+1}) - V(DS_t)$$

$$V(DS_t) = V(DS_t) - V(DS_{t-1}) = I(D_t)$$

$$(1) V(D_t)^* = \alpha + \beta I(D_t) + u_t$$

$$(2) V(DS_t) - V(DS_{t-1}) = \lambda [V(DS_t)^* - V(DS_{t-1})]$$

where $0 \leq \lambda \leq 1$ is an adjustment coefficient.

Solving (2) for $V(DS_t)^*$, we obtain

$$(3) V(DS_t)^* = \frac{1}{\lambda} V(DS_t) + \frac{\lambda-1}{\lambda} V(DS_{t-1})$$

Substitute for $V(DS_t)^*$ from (3) into (1), we have

$$\frac{1}{\lambda} V(DS_t)^* + \frac{\lambda-1}{\lambda} V(DS_{t-1}) = \alpha + \beta I(D_t) + u_t$$

$$\frac{1}{\lambda} V(DS_t) - \alpha + \beta I(D_t) - \frac{\lambda-1}{\lambda} V(DS_{t-1}) + u_t$$

$$(4) V(DS_t) = \alpha \lambda + \beta \lambda I(D_t) + (1-\lambda) V(DS_{t-1}) + \lambda u_t$$

$$\text{from (4) } V(DS_t) - V(DS_{t-1}) = \lambda [I(D_t) + u_t]$$

$V(DS_t)^*$ = optimal or desired value of decision state at time t . An attempt is constantly being made to bring the actual level of $V(DS_t)$ to its desired or optimal level. But this attempt is only partially successful at any given point in time. The reasons are imperfections deriving from one or more of the variables listed at the end of this Appendix.

Boon To All Federal Ministry/ Department Libraries

A few Weber Minigraph Duplicators — a compact, portable printing machine designed for use of libraries for the production of catalogue cards — have been acquired by the National Library of Nigeria for distribution to interested libraries.

The duplicator which reduces the cost and time of producing catalogue cards, is very simple to operate. It produces printed cards from Weber stencils which can be prepared on any standard typewriter.

The stencils incorporate pre-printed registration marks to ensure accurate printing, Catalogue cards, plain or pre-punched can be fed into the minigraph which print, counts and stacks.

Each set now being distributed is complete with catalogue cards, stencils, ink and Instruction Manual. A set which costs ₦700.00 is made up as follows:—

(i)	Minigraph Duplicator	1
(ii)	Stencils	100
(iii)	Ink	2 bottles
(iv)	Blank Catalogue Cards	3,000

In view of the limited number of these duplicators, no library will be allowed to buy more than one set and it will be sold on first-order-first-service basis. Interested libraries are therefore advised to mark their orders "Minigraph Duplicator" and send them to:

The Director
National Library of Nigeria
4, Wesley Street,
Lagos.