国际工商管理百科全书

（第2版）

International Encyclopedia of Business & Management

[美] Malcolm Warner 主编

Limpberg 至 Operations management

第 5 卷

清华大学出版社

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Using the encyclopedia

The *International Encyclopedia of Business and Management* is designed for ease of use. The following notes outline its organization and editorial approach and explain the ways of locating material. This will help users to make the most of the encyclopedia.

Sequence of entries

The encyclopedia contains 750 entries arranged in a single, alphabetical sequence through seven volumes. Entries are listed in alphabetical order. Note that the sequence follows the order of words rather than that of letter, and that the words *and, in, of* and *the* in entry titles are disregarded. A complete alphabetical list of entries is given in Volume 8 (the Index Volume).

The Index Volume

Volume 8 is devoted to a comprehensive index of the key terms, concepts, countries and names covered in Volumes 1 to 7, allowing users to reap maximum benefit from the encyclopedia. A guide to the index can be found at the beginning of the index. The Index Volume also includes permission acknowledgements, listed in alphabetical entry order.

Cross-references

The encyclopedia has been extensively cross-referenced in order to signpost other entries that are likely to be of interest. There are three types of cross-reference in the encyclopedia:

'See' cross-references

Throughout the alphabetical sequence of entry titles, there are cross-references which direct the user to the entry where a particular topic is discussed either under a different entry title or as part of a larger entry. For example:

Corporate taxation: see TAXATION, CORPORATE

Ethics: see BUSINESS ETHICS; MARKETING ETHICS

'See' cross-references within an entry

Cross-references within an entry direct the user to other entries closely related to the theme under discussion. These other entries will normally give a fuller explanation of the specific theme. These cross-references appear in small capital letters.

'See also' cross-references

At the very end of each entry, 'See also' cross-references guide the user to other entries of related interest, such as more specialized entries, biographical entries and geographical entries, as well as related entries in other disciplines. These cross-references appear in small capital letters in alphabetical order.

Structure of entries

A numbered contents list at the beginning of each entry in the encyclopedia gives the headings of its main sections. The scope and structure of the entry can thus be reviewed and sections of particular interest easily located.

Thematic entries begin with an 'Overview' section that serves as a brief introduction to the topic and a useful summary of the entry's contents. Biographical entries begin with a summary of the significant dates and events in the life of the subject and a list of his or her major works. Every entry is followed by a 'Further reading' section (see below).

Authors

The name of the author or authors is given at the end of each entry. A full list of contributors, showing their affiliation at the time of

writing and the titles of the entries they have written, can be found in Volume 8.

Further reading

Each entry has a 'Further reading' section which gives details of all the references cited in the text. Additional suggestions for reading are also provided for those who wish to delve deeper into a particular subject. References cited in the text are preceded with an asterisk (*).

The Further reading list is arranged alphabetically by author/editor and chronologically under the authors'/editors' names. Publications with joint authors are listed under the name of the first author and are listed after any individual publications of that author. Where publications have been issued by an institution, the name of the institution is given as the author. English translations of publications in other languages have been given wherever possible.

Items in the Further reading list have been annotated with a brief description of the level, importance and usefulness of the publication listed.

References and suggestions for further reading are given in the Harvard style. The authors and editors have attempted to provide bibliographic data in the fullest possible detail.

Editorial style

Spelling and punctuation in the encyclopedia have been standardized to follow British English usage. The use of italics has been kept to a minimum and is normally restricted to foreign words and book or journal titles. Abbreviations and acronyms are spelled out in full on their first appearance in an entry. Chinese names have been westernized (i.e. Chen Derong becomes Derong Chen or Chen, D.). In alphabetical lists of names, *Mc* and *Mac* are treated as *Mac* and the next letter in the name determines the position of the entry.

Likert, R.: see HUMAN RELATIONS; LEADERSHIP

Limperg, Theodore (1879–1961)

Personal background

- born Amsterdam, The Netherlands, 21 December 1879
- practised as an auditor, 1901–22, and was a major influence on the Dutch auditing profession during its formative years
- Professor at Municipal University of Amsterdam, where he developed a theory of current cost accounting and a theory of auditing, 1922–50
- died 6 December 1961 in Amsterdam

Major works

Consequences of depreciation of the guilder for enterprise value and profit determination of the enterprise (1937)

Bedrijfseconomie (Business Economics) (1964–8)

Summary

Theodore Limperg, Jr (1879–1961) initiated the scientific study of accounting and auditing in The Netherlands. While his theoretical work was wide-ranging, demonstrating a comprehensive and practical approach to business economics, Limperg is best known outside The Netherlands for his advocacy of current cost accounting. In order to establish a basis for his cost accounting theories, he made the development of value theory a particular focus of study – accounting practices derived from this theory are especially pertinent in times of high inflation.

1 Introduction

Limperg's influence on the development of accounting practice and theory in The Netherlands has been pervasive, despite the fact that little of his scientific work was published during his lifetime. His students established a comparatively extensive practice of current cost accounting in The Netherlands, making that country a key point of reference in the international discussions on accounting for inflation during the 1960s and 1970s. In this way, Limperg's views have had considerable international influence, even though direct access to his work by foreign researchers has been hindered by linguistic difficulties.

Although Limperg had not been educated at a university, he showed himself dedicated to the establishment of business economics as an academic discipline. In his opinion, the scientific nature of business economics implied that its precepts should be based on deductive reasoning from economic principles, rather than on codification of business practice. Yet his ample experience of business life as an auditor meant that his deduced norms, which he presented with great authority, never became detached from reality.

2 Biographical data

Limperg was born in 1879 in Amsterdam, into a middle-class family. His father was an engineer in the service of the public works department of the city of Amsterdam. Limperg did not go to university, but attended a select practice-oriented school for commercial training. He joined an audit firm in 1900 and became a partner in 1901. Until 1922, he was to con-

tinue the practice of auditing in a succession of different partnerships.

During this period, he played an active role in the organized Dutch auditing profession. The first organization of auditors in The Netherlands had been founded in 1895, and Limperg used every opportunity to shape the still young profession according to his views. According to Limperg's vision, auditors should not confine themselves to a superficial checking of accounting records. Rather, they should develop a high level of theoretical and practical economic expertise in order to gain insight into the economic situation of the enterprise. This comprehensive understanding of the enterprise should form the basis of the opinion on financial statements and should make the auditor a valued advisor to business. Through his editorship of a professional journal and his involvement with professional education, Limperg was able to leave the imprint of his views on the practices and attitudes of Dutch auditors.

In 1922, when he was well established as one of the leaders of the auditing profession, Limperg was made a professor in the newly established faculty of economics at the Municipal University of Amsterdam. His teaching assignment reflected the wide area of knowledge he considered was necessary for auditors to master. In The Netherlands, the various areas of business administration, such as organization, finance, marketing and accounting, tend to be viewed collectively as one subject area, known as business economics, which derives a certain unity from a strong reliance on economics. Limperg was one of the first professors of *bedrijfseconomie* (literally, business or enterprise economics) in his country.

After being made a professor, Limperg gave up the practice of auditing, but remained closely involved with the organizational and theoretical development of the Dutch auditing profession. In keeping with the wide scope of his chair, he was also active in a number of areas other than accounting and auditing. First among these was his work on efficiency and scientific management. He did much to spread the knowledge of foreign ideas on this subject in The Netherlands. He was president of the Conseil International de l'Organisation Scientifique from 1932 to 1935 and honorary president of that body until 1953. Limperg retired as professor in 1950, after receiving an honorary doctorate from the University of Rotterdam. He married in 1906 and had three children.

3 Main contribution

Outside The Netherlands, Limperg is known chiefly for his advocacy of current cost accounting. Although the remainder of this article deals only with this aspect of his thinking, it should be kept in mind that his theoretical work had a far wider scope. In accounting, his contributions included valuable work in cost accounting, including standard costing and budgeting. Limperg's views, as outlined here, were developed during the 1920s and were substantially complete by the end of that decade.

Limperg did not aim directly at developing an accounting theory. In keeping with the notion of a comprehensive approach to business economics, he attempted to put forward an economic theory of the firm that would be the common starting point for more specific theories, such as income measurement. In order to develop a basis for his theoretical structure, he devoted much attention to developing a value theory. Limperg defined a concept of value that would be applicable in the context of a business, as opposed to the subjective value concepts of contemporary mainstream economics that were based on individual preferences and assessments of utility. He based his value concept on the notion of hypothetical deprival: the value of an asset could be determined by calculating what the loss to the enterprise would be if it were to be deprived of the asset.

In the simple case of a trading firm, assets are bought for resale at higher prices. It is economically rational for the firm to continue the process of buying and selling as long as there is a positive difference between buying and selling prices. If the firm were to lose one item of inventory, it could restore its former position by replacing the lost asset with a new one. It would be rational to do so if the purchase price of the replacement was lower than its

current selling price. In this case, then, 'value' is equal to current, or replacement, cost.

If the selling price of the asset fell below its replacement cost, it would no longer be rational to replace the asset when lost. Its value would therefore be equal to the revenue lost, that is, equal to the realizable value of the asset net of selling costs.

Thus, as a general rule, Limperg established that value is equal to either current cost or net realizable value, whichever is the smallest figure.

In the case of productive assets, net realizable value is usually not relevant for valuation, since these assets are not held for resale, but for the production of other goods intended for sale. The relevant quantity is the present value of the income generated by the sale of the products, and it is this present value that should be compared to current cost. However, productive assets will only be employed so long as the income they generate through production exceeds the revenue to be gained simply by selling them. Therefore, when present value falls below net realizable value, the latter will indicate the value of the asset to the firm.

The general rule of valuation established by Limperg can then be stated as: value is the *lowest* of (1) current cost and (2) the *highest* of (a) present value or (b) net realizable value.

It is evident that in an enterprise where continuous production is rational, the present value of an asset is higher than its net realizable value, and current or replacement cost is lower than present value. In ordinary circumstances of continuity, value is therefore equal to current cost.

It is this logical conclusion that led Limperg to advocating the use of current cost accounting. Almost as an axiom, he stated that accounts should be based on the theoretically correct measure of value. The propagation of current cost accounting could be supported by demonstrating that use of current cost was not merely the result of applying a correct value theory, but that it also led to beneficial results in practice.

In times of inflation, the calculation of income as the difference between revenue and historical cost of goods sold may lead to a financing problem if all income is distributed to the owners. In this case, the enterprise may not be able to finance the higher replacement cost of the goods sold, and its continuity may be threatened. When cost of goods sold as reported in the income statement is determined by the current rather than by the historical cost, this problem is evaded. Any remaining income can then be distributed safely without impairing the continuity of the enterprise (see INFLATION ACCOUNTING).

To implement his theory of current cost accounting, Limperg proposed that companies create a 'reserve for price differences', which would be credited with the excess of current cost over historical cost of goods sold. Negative differences could be debited to this account, but only to the extent that the account had previously been credited with positive differences. Otherwise, according to Limperg, prudence would dictate that inventory be marked down and a loss taken when current costs fell below historical costs.

4 Dissemination and influence

Limperg began to teach his value theory, and its implications for accounting, in his classes at the Municipal University of Amsterdam during the 1920s. After a few years, he and his students began to introduce his ideas into the courses and professional examinations of the Dutch Institute of Auditors. Limperg's stature within the auditing profession, of which he had been one of the leaders since the first decade of the century, ensured that his ideas received due attention.

Unlike Germany, with its hyper-inflation following the First World War, The Netherlands experienced fairly stable prices through most of the 1920s and 1930s. During this period, therefore, Limperg advocated current cost accounting not as a practical solution to a pressing problem, but as the theoretically correct method of accounting, irrespective of actual price changes. Within the academic community, his ideas were received and debated on their theoretical merits.

When price changes did occur, at first with the 1936 devaluation of the guilder, and more severely in the late 1940s and early 1950s, Limperg's current cost accounting proposals suddenly acquired considerable practical sig-

nificance. The educational efforts of Limperg and his students had made a large number of auditors and accounting staff familiar with current cost accounting, and when inflation increased, voices from within the business community began to advocate the use of current cost data for tax purposes, financial reporting and price controls. From the early 1950s onwards, a number of large Dutch companies began to use current cost data in their published financial statements. Since financial reporting was largely unregulated at the time, there were no legal impediments to companies experimenting with current cost accounting in this way. The Dutch tax authorities, however, never accepted the use of current cost accounting for taxation purposes.

Most notable among the companies practising current cost accounting was the electronics group Philips, whose financial statements were based on current cost from 1951 until 1992. Officers from the Philips group propagated current cost accounting at home and abroad, and the company became a standard example in English-language discussions on the practical nature of such methods.

Although the accounting practices of Dutch companies using current cost methods did not always coincide in every detail with Limperg's ideas, the fact that current cost accounting was used in practice at all in The Netherlands can be traced directly to Limperg's considerable influence on accounting education. This influence extended to the field of company law. In 1983, for example, Limperg's tripartite value concept was used to adapt Dutch law to the provisions of the Fourth European Community Directive on Company Law.

Regarding the acceptance of current cost accounting in practice, developments in The Netherlands differed markedly from those in Germany. Accounting theoreticians in the latter country, notably Fritz Schmidt (1882–1950), were ahead of Limperg in proposing current cost accounting during the hyperinflation of the early 1920s. However, partly owing to the more restrictive nature of German company law, current cost accounting has never gained a lasting foothold in Germany.

Limperg published many polemical articles in professional literature while he was active as an auditor, but he published little of the scientific work he developed since 1922. While only the outline of his theories on current cost accounting was published in Dutch in 1936 and 1937, the details of his views were transmitted readily enough in his lectures and by his students. In the 1960s, Limperg's collected lecture notes containing his views on all areas of business economics were published posthumously. Yet the absence of a full statement of Limperg's current cost accounting proposals by his own hand has made it difficult for accounting researchers in the English-speaking world to develop a clear perception of Limperg's significance.

In the English-speaking world, the origins of current cost accounting are often traced to US and UK publications of the 1930s, disregarding developments on the mainland of Europe. Limperg's tripartite value concept is therefore often encountered in the English literature as 'value to the owner' or 'deprival value', and as such it is traced to the work of the American, James C. Bonbright of 1937. Although the Dutch and Anglo-American concepts are identical, they have, in fact, been developed independently, showing that developments in accounting theory could occur in relative isolation until the latter part of the twentieth century. It was only during the 1960s and 1970s, when there was growing international interest in accounting for inflation developments, that the English-language literature began to appreciate developments in continental Europe.

By the 1960s and 1970s, the practice of current cost accounting was well established in The Netherlands, and could serve as an example to others. For example, in developing its favourable stance to current cost accounting, the UK Sandilands Committee report of 1975 was based in part on the fact that forms of current cost accounting were practised on a substantial scale in The Netherlands.

5 Conclusion

Whether or not Limperg's proposals on current cost accounting will continue to have direct practical relevance depends on the

recurrence and severity of inflation. In a more general sense, his permanent contribution, which he shares with other accounting theoreticians of the twentieth century, consists of a wider perspective on accounting. By suggesting that accounting does not have to restrict itself to continued applications of received practice, Limperg helped invest the discipline, at least potentially, with the flexibility to respond to changing circumstances and needs.

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Further reading

Brink, H. (1992) 'A history of Philips' accounting policies on the basis of its annual reports', *The European Accounting Review* 1 (2): 255–75. (An annotated chronology of Philips' current cost accounting practices with a good bibliography.)

Burgert, R. (1972) 'Reservations about "replacement value" accounting in The Netherlands', *Abacus* 8 (2): 111–26. (Written by a leading Dutch academic, this is a critical review of Limperg's theory which remains relevant to accounting practice in the 1990s.)

Camfferman, K. (1998) 'Deprival value in the Netherlands: history and current status', *Abacus* 34 (1): 18–27. (A review of current applications of current cost accounting in the Netherlands in relation to Limperg's concepts.)

Camfferman, K. and Zeff, S.A. (1994) 'The contributions of Th. Limperg Jr (1879–1961) to Dutch accounting and auditing', in J.R. Edwards (ed.), *Twentieth Century Accounting Thinkers*, London: Routledge. (One of the longer introductory articles extant, with an extensive bibliography.)

Clarke, F.L. and Dean, G.W. (1990) *Contributions of Limperg and Schmidt to the Replacement Cost Debate in the 1920s*, New York: Garland. (Contains full-length English translations of key texts by Limperg and his students plus translated excerpts from Limperg's *Bedrijfseconomie* (1964–68).)

Flint, D. (1985) 'Professor Limperg's audit philosophy: the theory of inspired confidence', in J.W. Schoonderbeek (ed.), *The Social Responsibility of the Auditor*, Amsterdam: Limperg Institute. (An introduction to Limperg's views on auditing, which have not been covered in this entry.)

Limperg, T. (1937) 'Consequences of depreciation of the guilder for enterprise value and profit determination of the enterprise', in F.L. Clarke and G.W. Dean (eds) (1990), *Contributions of Limperg and Schmidt to the Replacement Cost Debate in the 1920s*, New York: Garland. (The most important statement of Limperg's current cost accounting theory made during his lifetime.)

Seventer, A. van (1975) 'Replacement value theory in modern Dutch accounting', *The International Journal of Accounting*, 11 (1): 67–94. (A less complete, but more readily available alternative to van Sloten (1987).)

Sloten, P.J. van (1987) 'The Dutch contribution to replacement value accounting theory and practice', ICRA Occasional Paper 21, Lancaster: International Centre for Research in Accounting, University of Lancaster. (An extensive discussion of Limperg's theory, later modifications by his students and practical application in The Netherlands.)

Whittington, G. (1981) 'The British contribution to income theory', in M. Bromwich and A. Hopwood (eds), *Essays in British Accounting Research*, London: Pitman. (A comprehensive review of theory development from a British point of view, with an attempt to position Limperg.)

See also: ASSET VALUATION, DEPRECIATION AND PROVISIONS; INFLATION ACCOUNTING; SCHMALENBACH, E.

Lindblom, Charles Edward (1917–)

Personal background

- born in Turlock, California, on 22 March 1917
- educated at Stanford University and Chicago
- taught at the University of Minnesota and Yale University
- Sterling Professor Emeritus of Political Science and Economics at Yale University

Major works

The Science of Muddling Through (1959)
The Policy Making Process, 2nd edn (1980)

Summary

Lindblom's enduring legacy for both public policy makers and managers making strategy was to expand on and develop the notion of incrementalism in decision-making processes. This represented a movement from what Hickson *et al.* (1986) later characterized as prescriptive theories of decision making towards more descriptive theory. He described what decision makers actually do when faced with complex problems and argued that while they do intend to be 'rational', the processes themselves do not follow the trajectories of rational decision making as described in the decision-making literature. This development has its roots in the limitations of policy makers to comprehend and process not only the data for a comprehensive review of alternatives but also in their limitations in clarifying the range of objectives to be achieved. In these respects his work not only mirrors but adds to the work of others such as Herbert Simon, James March and Richard Cyert (see SIMON, H.; MARCH, J.G. AND CYERT, R.M.) on decision making in organizations, as it highlights the interplay of both politics and rationality in decision-making processes. The notion of incrementalism also provided a significant input into later work on strategic management from such authors such as Quinn (1980) and Johnson (1988).

1 Main contribution

In the development of his ideas, Lindblom (1959) drew contrasts between two decision-making processes by using the image of a tree. Thus the first type of process he called the 'root', or rational comprehensive methodology, and the second a 'branch', or successive limited comparisons methodology. In the former the decision maker starts from fundamentals, the roots of the problem, each time they are called to make a decision. Past experience is used only to the extent that it is embodied in some sort of theory, for example in determining policy on inflation an administrator would probably compare alternatives by using some theory of prices. In the second process, the decision maker continually builds out (branches) from the current situation step by step, in small stages (increments). It is this type of process that he set out to formalize in the 1959 paper as 'the science of muddling through' (see DECISION MAKING).

He found it difficult to find examples of the root method in practice. It is perhaps more an ideal type rather than a reality as it fails to adapt to two crucial characteristics of decision making: decision makers and the problems they face. As with all ideal type constructions it is, however, useful as a framework to reflect upon actual situations and events.

How then do managers and policy makers actually cope with complex problems in the context of the lack of information and their own cognitive limitations? The root method requires that the values and objectives be clarified in advance of any development and examination of alternative courses of action. While this is a laudable goal, according to

Lindblom what actually happens is that interested parties or stakeholders disagree on many of the critical values and objectives. This situation may lead decision makers down various pathways. They may follow their own values for example, but each does not result in the uncertainty being eliminated and thus has to accommodate the many values without necessarily being able to rank them. In addition, preferences change so any process needs to be flexible and responsive enough to accommodate this additional source of uncertainty. Lindblom poses the question of how the relative importance of these conflicting values can be stated without reference to trade-offs between alternatives for solving the problem. The decision maker thus looks at how much of each of the set of objectives is satisfied by an alternative. It is thus impossible to consider objectives without considering the alternatives. In his terms 'one simultaneously chooses a policy to attain certain objectives and chooses the objectives themselves' (1959: 82). This, he goes on to suggest, focuses attention on marginal or incremental changes in values or objectives, which reduces the need for information on values and objectives compared with the root methodology and does not strain cognitive limits.

How then is the 'best' alternative chosen? The root method demands thorough analysis and choice based on which alternative is the most appropriate to achieve the desired ends but, as alternatives, objectives and values are so intertwined, discussion becomes focused on agreement on a policy (alternative). This becomes the only real test of correctness. Trying to ensure agreement on ends as well as means is not productive. Is this an inferior method to the root method of test against objective? Lindblom argues no, as the objectives themselves 'have no ultimate validity other than they are agreed upon. Hence, agreement is the test of best policy in both methods' (1959: 84). In his eyes, it is not irrational for a decision maker to argue that a decision is good without being able to fully specify what it is good for.

The root method should leave out no important factor, but limits to decision makers' intellectual capacity set very finite limits to this process. This allied to the complexity of problems means that decision makers must use simplification routines. Lindblom found that simplification is achieved by limiting consideration to those alternatives that differ only in a relatively small degree from those decisions already in effect. This results in the reduction of both the number of alternatives to be considered and the amount of analysis needed. Analysis is accomplished by investigating to what extent the consequences of an alternative differ from the status quo. This is the counterpart to the marginal (or incremental) comparison of values and objectives discussed above. In this way ends, or objectives, become adjusted to the means for achieving them. Thus they are changed as they are considered. This means that decision making is a serial activity. Problems are addressed but rarely solved and themselves become transformed in the process. It may then be argued that decision making involves a movement away from a series of situations or issues rather than towards a well-defined goal. Small improvements to a situation are made rather than major shifts in direction. In this way, complex problems can be coped with, information collection is limited, choice is restricted and time horizons short. Action can then actually be taken. The diverse values that participants might hold are recognized but the iterative nature of the process circumvents parties taking firm stands on principles as decisions may change their nature.

The result is a practical and elegant description of the way that decision making can proceed given the impossibility of attaining the ideals of a pure rational model of process. It is a working methodology which on the face of it looks conservative. Small changes which do not have major consequences are made and may be inappropriate for a situation needing radical movement. Yet Lindblom points out that it could be just as effective to make many small rapid movements. Each incremental step may be easy as it is not accompanied by major consequences. At the very least, it is a step that can be taken by decision makers who are not then overwhelmed with the enormity of following a more difficult route.

2 Evaluation

Although Lindblom developed his ideas within a framework of public administration and policy making they have gained currency, as evidenced by their frequent citations, in work on strategy making in other forms of organization (see ORGANIZATION BEHAVIOUR; ORGANIZATION BEHAVIOUR, HISTORY OF). They do provide managers with practical ways of coping with complex issues from whatever sector they operate in. That rationality becomes tempered by problem complexity and the views of interested parties has been refined, empirically explored and developed by others. Some examples are summarized in the following paragraphs.

Hickson *et al.* (1986), in their empirical investigation of strategic decision making in UK organizations from both public and private sectors, found that what they termed 'controls decisions' – those that involved planning and budgeting, funds allocations and data processing – 'were the prototype for incrementalism'. These decisions were not particularly novel, but had serious consequences and were subject to the political pressure of diverse interests. Yet the processes led to less change than most of the other topic types. They tend to mirror the locked-in balance of power between interests rather than reflect any sense of direction of activity. They accommodate interests (see INTEREST GROUPS).

Quinn (1980) also tested and developed the idea of incrementalism into what he terms logical incrementalism. In this view or process, strategy does not emerge from a stream of small muddling through decisions but has a more deliberate intent. The strategist has an idea for a suitable course of action but has neither the information nor the political support to realize it. Planning becomes very important as it allows information to be collected and discussion to be held with the various interests to build some form of consensus. During this process the strategy is shaped and reshaped and subsequently emerges. After many iterations and usually much time, implementation finally occurs. The key difference to Lindblom's original idea seems to be that throughout this process the broad view, if a good one, remains fairly constant and consistent. There is thus an overall strategic logic to the strategy making process which probably does involve incremental steps (see STRATEGY MAKING, POLITICS OF).

Johnson (1988) in his study of strategy making processes in a menswear retail group noted that as both forms of incrementalism rely on discussion and on negotiating an accommodation with the involved interests, managers may lose sight of any changes in the external environment. Thus strategic drift, the deviation between managers' decisions and environmental changes, is likely to occur. The internal focus, a source of strength in an incremental approach to decision making, may too easily become a comfort zone for managers. Johnson suggests that managers may be reluctant to break their thinking out of this zone. If drift persists then radical strategic change may be required if an organization is to survive. The managerial group will become forced to confront their views, or their paradigm, of how things work. Incrementalist methodologies may thus provide managers with an inappropriate and narrowly focused 'mental model' of the world.

By explicitly recognizing the evolutionary rather than revolutionary nature of policy making the idea of incrementalism is also a way of helping us to understand behaviour in other organizations and social groupings, such as countries. We do not become solely focused on major discontinuities but on the evolution of institutions and systems which proscribe the behaviour rather than on describing differences in the behaviour and ascribing that difference to 'culture'. Locating international comparisons on such things as educational attainment in a policy-making framework makes them meaningful rather than just empty reporting of empirical data and reflections.

3 Conclusions

Lindblom's work on policy making has proved to be a significant and enduring contribution to our understanding of public policy making in particular, and strategy processes in all organizations in general. The practical and descriptive orientation of the methodology or 'the science of muddling through' has not

only informed managers but has provided a base from which scholars have developed further understandings of this complex managerial process. The recognition of the interaction between means, ends and values, the limited search and evaluation of alternative courses of action and the evolutionary rather than revolutionary nature of process provide insights of rare clarity and relevance.

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Further reading

(References cited in the text marked *)

* Hickson, D.J., Butler, R.J., Cray, D., Mallory, G.R. and Wilson, D.C. (1986) *Top Decisions: Strategic Decision Making in Organizations*, San Francisco: Jossey-Bass. (A major empirical study of strategic decison making behaviour in UK organizations which develops a taxonomy of process based on the complexity of problems and political interest.)

* Johnson, G. (1988) 'Rethinking incrementalism', *Strategic Management Journal* 9: 313–27. (Examines the implications of using incrementalism as a process of strategy formation. Builds on the problems of strategic drift and the development of strong paradigms of management thought and action.)

* Lindblom, C.E. (1959) 'The science of muddling through', *Public Administration Review* 19: 79–88. (Outlines the development of the root and branch methodologies discused at length in the body of this entry.)

Lindblom, C.E.(1980) *The Policy Making Process*, 2nd edn, Englewood Cliffs, NJ: Prentice-Hall. (A more detailed exposition of policy making and the interaction of politics with decision making.)

Lindblom, C.E. and Braybrooke, D. (1963) *A Strategy of Decision*, New York: Free Press. (Unites Lindblom's work with Braybrookes on utilitarianism and how these converge on how the notion of census functions in the policy making context.)

Morgan, G. (1997) *Images of Organization*, 2nd edn, London: Sage. (Develops the use of metaphor to characterize organizations. Lindblom's work appears in the organizations as brains metaphor.)

Pugh, D.S. and Hickson, D.J. (1993) *Great Writers on Organization*, Aldershot: Dartmouth. (An extensive collection of short summaries of the work of writers. Includes a discussion of Lindblom in the decision-making section.)

*Quinn, J.B. (1980) *Strategies for Change: Logical Incrementalism*, Homewood, IL: Homewood. (Discussion of strategy making in ten organizations using incrementalism as a base reference.)

See also: DECISION MAKING; MARCH, J.G. AND CYERT, R.M.; ORGANIZATION BEHAVIOUR; ORGANIZATION BEHAVIOUR, HISTORY OF; POWER AND CONTROL; PROBLEM SOLVING; PUBLIC SECTOR MANAGEMENT; SIMON, H.; SYSTEMS

Linear programming

Overview

Mathematical and other quantitative techniques have been used to solve problems from business and industry since the beginning of the industrial revolution. However, such methods had little impact on management's ability to analyse and improve an organization's current and future operations. All this changed in the last half of the twentieth century with the development of linear programming. Linear programming has proved to be the pre-eminent mathematical procedure with the broadest range of applicability to business and industry. Linear programming is a rare mathematical topic in that its deep theoretical results and related computational procedures combine to yield solutions to decision problems that have direct value in improving the day-to-day effectiveness of an organization.

One can find precursors to what we now call linear programming in the work of mathematicians and economists such as J. von Neumann, L.V. Kantorovich, W.W. Leontieff and others (Dantzig 1963). But it was the discoveries of the mathematician George B. Dantzig that gave us both the mathematical basis of linear programming and an efficient computational scheme (the simplex method) for solving decision problems that can be described mathematically as linear programmes. Dantzig's work grew out of his study of the planning activities of the US Air Force during and after the Second World War. By mid-1947, Dantzig had evolved the basic mathematical concepts and the simplex computational method (Dantzig 1982). Dantzig's seminal linear programming results are contained in the proceedings of the 1949 Cowles Commission for Research in Economics conference proceedings, edited by the economist T.C. Koopmans (1951).

Early applications of linear programming were confined to the military, for example crew training and aircraft deployment, maintenance scheduling, airlift routeing, and contract bidding. Industrial applications of linear programming were pioneered by A. Charnes and W.W. Cooper in their joint work with B. Mellon on oil refinery scheduling (Charnes, Cooper and Mellon 1952). Since that time, just about all areas of industry, business and government have benefited by having linear programming applied to its activities. In this article, we describe some of the mathematical aspects of linear programming and its applied and computational considerations.

1 Examples of linear-programming problems

The mathematical requirements of linear programming impose certain restrictions on the class of problems that can be resolved by linear-programming techniques. Although these restrictions, which are really assumptions, appear to be overly constraining, it turns out that the range of problems that conform to these assumptions or that can be suitably approximated is quite extensive. Before stating these assumptions and giving a description of the general linear-programming problem (model), we illustrate some typical decision situations and transform them into linear-programming problems.

Car-rental company example

A regional car-rental company has five pick-up and drop-off locations, with two of the locations being airports and the other three locations being cities serviced by the airport. At the beginning of the day, the company finds that the expected demand for mid-size cars is such that it does not have enough of them at the airports, whereas it has too many at

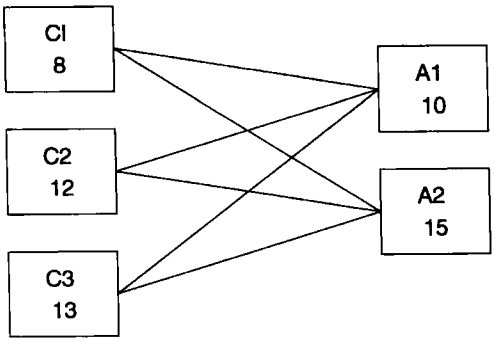

Figure 1 Car-rental problem

the city locations. It must arrange to move the cars from the cities to the airports. The problem is to determine how many cars from each city must be transferred and to which airport they should be sent. Of course, the company would like to accomplish the transfer at minimum cost. We denote the two airports by A1 and A2, respectively, and the three cities by C1, C2 and C3, respectively. For discussion purposes, we assume that A1 is short of ten cars, while A2 is short of fifteen. City C1 has a surplus of eight cars (after meeting its demand); similarly C2 has twelve surplus cars and C3 has thirteen surplus cars (see Figure 1).

As each city can send cars to each airport, we show this by lines starting at the cities and ending at the airports. These lines are graphical representations of the transportation routes along which the cars will be moved. The cost of moving a car from a city to an airport depends on the distance separating them. We assume that the cost of shipping a car is independent of the number shipped. These costs are assumed known and are summarized in Table 1.

The decision problem is to determine how many cars to send from each city so that each airport receives the number of cars it demands and the sum of the total cost of the shipments is minimized. Note that solutions to the problem exist as the total number of cars available at the cities is greater than the total number of cars demanded by the airports. For example, the trial solution summarized in Table 2 satisfies the demand at a total shipment cost of

$$\$401 = (\$15 \times 8) + (\$18 \times 2) + (\$14 \times 10) + (\$21 \times 5).$$

Table 1 Cost ($) of delivering a car

	A1	*A2*
C1	15	22
C2	18	14
C3	16	21

Table 2 Trial solution

	A1	*A2*	*Supply*
C1	8	0	8
C2	2	10	12
C3	0	5	13
Demand	10	15	

The reader can readily generate alternative trial solutions. The question of interest, is, of course, which solution yields the minimum cost? Even for small problems, such as this one, it is difficult to generate all possible solutions and then select the one with minimum cost. Making the problem more realistic by adding more cities and demand points further complicates it. Let us investigate how this problem can be formulated as a linear-programming problem and solved by linear-programming methods.

Implicit in the statement of the car shipping problem is the requirement that the agency managers at each city keep track of how many cars they send to each airport, while the managers at the airports need to account for how many cars they receive from each city. This is just good management practice. We shall see that this is basically the driving force behind the mathematical description of the problem, that is, the formulation of the related linear-programming decision model.

In Table 3, we define the mathematical notation that enables us to keep track of how many cars are sent from each city to each airport. Thus, the symbol C3A2 represents the number of cars sent from City 3 to Airport 2. In general, we denote the (to be determined) values of the shipments as follows:

Table 3 Table of notation

	A1	*A2*	*Supply*
C1	C1A1	C1A2	8
C2	C2A1	C2A2	12
C3	C3A1	C3A2	13
Demand	10	15	

C*i*A*j* = the number of cars sent from City *i* to Airport *j*, where *i* takes on the values 1, 2 and 3, and *j* takes on the values 1 and 2.

The set of C*i*A*j* unknowns are the decision variables of the problem, as illustrated in Table 3.

The sending of cars by the cities and the receiving of the cars by the airports are constrained by the following obvious conditions:

1 the sending cities cannot send more than their supply, and
2 the receiving airports must get exactly what they demand.

This translates into the following set of mathematical constraints:

$$\begin{aligned} C1A1 + C1A2 &\leq 8 \\ C2A1 + C2A2 &\leq 12 \\ C3A1 + C3A2 &\leq 13 \\ C1A1 + C2A1 + C3A1 &= 10 \\ C1A2 + C2A2 + C3A2 &= 15 \end{aligned}$$

The first three linear inequalities are due to condition (1), while the last two linear equations are due to condition (2). Any solution to the problem must satisfy this set of linear conditions. In determining values for each variable C*i*A*j*, it is standard to record a C*i*A*j* shipment as a positive number, with no shipment between a city–airport combination being set equal to zero. That is, we impose the condition that the values of the decision variables must be non-negative. Mathematically, this is denoted by $CiAj \geq 0$ for $i = 1, 2, 3$ and $j = 1, 2$. For our trial solution given above, we have the following values for each shipment:

$$\begin{aligned} C1A1 &= 8 & C1A2 &= 0 \\ C2A1 &= 2 & C2A2 &= 10 \\ C3A1 &= 0 & C3A2 &= 5 \end{aligned}$$

The cost of a solution can be defined by a simple linear sum of the cost of shipping a car between a city–airport combination multiplied by the number of cars shipped. Thus, the cost function, or objective function, which for this problem we would like to be as small as possible, is given by:

$$\begin{aligned} COST = {} & 15C1A1 + 22C1A2 + 18C2A1 \\ & + 14C2A2 + 16C3A1 + 21C3A2 \end{aligned}$$

We can now state the linear-programming mathematical statement of the car-rental distribution problem:

Minimize

$$\begin{aligned} COST = {} & 15C1A1 + 22C1A2 + 18C2A1 \\ & + 14C2A2 + 16C3A1 + 21C3A2 \end{aligned}$$

subject to

$$\begin{aligned} C1A1 + C1A2 &\leq 8 \\ C2A1 + C2A2 &\leq 12 \\ C3A1 + C3A2 &\leq 13 \\ C1A1 + C2A1 + C3A1 &= 10 \\ C1A2 + C2A2 + C3A2 &= 15 \\ CiAj &\geq 0 \end{aligned}$$

($i = 1, 2, 3; j = 1, 2$)

This linear-programming problem can be solved readily by the simplex method to obtain the following optimal solution:

$$\begin{aligned} C1A1 &= 8 & C1A2 &= 0 \\ C2A1 &= 0 & C2A2 &= 12 \\ C3A1 &= 2 & C3A2 &= 3 \end{aligned}$$

with COST = $383. Note that cities C1 and C2 ship all their supply, with C3 shipping only 5 of its supply of 13. The theory of the simplex method tells us that there is no other solution that yields a lower cost. The general form of this type of shipping problem is called the transportation problem and it was well studied and solved early in the history of linear programming.

Plastic-production example

Another typical business situation that can be analysed by linear-programming procedures is that of a manufacturer who wants to utilize available resources to produce a variety of products at maximum profit. For example, an oil refinery, given available crude oil types,

must decide on which products and how much of each to produce to meet current and future demand. The following simplified production example illustrates a more general form of the linear-programming model.

Production problems are concerned with how to allocate limited resources to manufacturing activities so that the maximum profit contribution or minimum cost is obtained. A basic assumption of this class of problems, termed activity analysis, is that, for the production period being analysed, the manufacturer knows the amounts of each resource that are available. The resources can be employees and work-hours defined by skill category, supplies, storage, equipment availability hours and any resource the lack of which would restrict production of one or more products. We illustrate the structure of this type of linear-programming problem for a manufacturer of plastic containers.

The manufacturer makes plastic bottles in quarter-, half-, one- and two-litre sizes. The main ingredient in making the bottles is polyethylene, which is shaped into tubes that are then forced into bottle-moulding machines. The manufacturer has two moulding machines, Machine A that can make either quarter- or half-litre bottles and Machine B that can form either one- or two-litre bottles. To make a particular size of bottle, the requisite machine has to be stopped and the corresponding set of moulds installed. Bottles are made in batches of 144.

For the next production week, the manufacturer estimates that Machine A will be available for 35 production hours and Machine B will be available for 34 hours. On hand is 100 000 units of polyethylene. As the bottles come off the production line, they are given a quality review by a single inspector. The manufacturer wishes to utilize the available resources – machine times, polyethylene and inspector time – to make an inventory of bottles that will maximize the revenue obtained when the bottles are sold to the distributor. That is, the manufacturer needs to determine how many batches of each bottle can and should be made. To structure this production decision problem as a linear-programming problem we need to gather data that describes the current operation. What we need to know is how much time it takes to make a batch of 144 bottles on each machine, how much polyethylene it takes to make a batch of bottles of each size and how much time it takes to inspect a batch of bottles. Finally, we need to know the revenue received for each batch of bottles. The availability and correctness of such data are often the weakest part of a linear programming model but a well-run organization should be gathering and analysing such data continuously. For our purposes, we assume knowledge of the data and exhibit it in Table 4. First, we define the variables of the problem as follows:

B1 = the number of batches of quarter-litre bottles to be made
B2 = the number of batches of half-litre bottles to be made
B3 = the number of batches of one-litre bottles to be made
B4 = the number of batches of two-litre bottles to be made

We shall let Bi refer to the corresponding bottle size, with $i = 1, 2, 3$ and 4.

The linear-programming model for this production problem is as follows:

Maximize Revenue
$= 2B1 + 5B2 + 6.75B3 + 7.25B4$
subject to

$$0.5B1 + 0.6B2 \leq 35 \quad \text{(Machine A hours)}$$

$$0.4B3 + 0.5B4 \leq 34 \quad \text{(Machine B hours)}$$

$$300B1 + 600B2 + 900B3 + 1200B4 \leq 100\,000 \quad \text{(Polyethylene)}$$

$$0.3B1 + 0.3B2 + 0.4B3 + 0.4B4 \leq 40 \quad \text{(Inspection hours)}$$

$$Bi \geq 0 \quad (i = 1, 2, 3, 4)$$

Solving this problem using the simplex method yields the following optimal solution:

Revenue	=	$695.3125	
B1	=	0	batches
B2	=	58.33	batches
B3	=	8.33	batches
B4	=	47.92	batches