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The Input-Output-Simulation of Business Processes

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The simulation of economic relations on the basis of a set of linear equations has been acknowledged since the pioneering work in macro-economics carried out by Leontief. The following article develops an apropriate simulation concept for micro-economics. It is based on the thesis that the mathematical foundation of a set of linear equations is the basis for double entry bookkeeping and can replace it. It was constructed and verified with the help of a computer algorithm, which automatically and algebraically links the Statement of Cash Flows with the opening and closing Statement of Financial Positions (balance sheet), with the Statement of Earnings and the Statement of Investments by and Distributions to Owners. This gives the planning management completely new perspectives: the development of any company - be it an individual company or a corporate group or even a freely constructed business segment - can be simulated in an artificial "business-cosmos" with various alternatives and represented in its respective effects on profit and loss, cash flow, productivity, profitabiliy and financial development over the course of any period, true to the Statement of Financial Position.

1. Makro-economics and Micro-economics

The Input-Output Analysis developed by Leontief[1] has been regarded as an indispensable instrument for the examination and simulation of economic interrelations[2] in macro-economics for many years. At its core is the application of a linear equation system (LES) for overall economic relationships . Comparable observations for micro-economics so far only exist in a basic form[3]. The subject of the following exploration will be the depiction of past and future business processes on the basis of an LES . This concept is called an Input-Output-Simulation because of its reference to Leontief.

The idea of the Input-Output-Simulation is based on the thesis that the mathematical foundation of the LES is the foundation for double entry bookkeeping and can therefore replace the system of double entry bookkeeping. According to the mathematical laws of an LES, any given variable in that LES is clearly defined by the remaining, freely determinable variables on condition that the LES contains as many equations as variables. Bearing in mind that in the system

[1] "Input-Output analysis is a method of systematically quantifying the mutual interrelationships among the various sectors of a complex economic system. In practical terms the economic system to which it is applied may be as large as a nation or even the entire world economy, or as small as the economy of a metropolitan area or even a single enterprise. In all instances the approach is essentially the same. The interdependence among the sectors of the given economy is described by a set of linear equations expressing the balance between the total input and the aggregate output of each commodity in the course of one or several periods of time". Leontief W.,"Input-Output analysis", 1985, In"Input-Output Economics", Ox-ford University Press 1986, p.19. The essay was originally written for the German "Handbuch der Sozialwissenschaften". Because of its fundamental importance for economics it was later reprinted in revised form in the "International Encyclopedia of Social Sciences" and the "International Encyclopedia of Materials Science and Engineering".

[2] See also Fleissner P., Böhme W., Brautzsch H.-U., Höhne J., Siassi J., Stark K., "Input-Output Analyse - Eine Einfüh-rung in Theorie und Anwendung" 1993.

[3] Gümbel R., "Bilanz und Doppik als Mikroökonomische Formalstruktur", in FS Moxter, 1994, p.1130,1132: "Terms such as Input-Output-Relations and their derivatives, Systems of linear equations ... will continue to be received

of double entry bookkeeping a single variable, namely - profit -, is the quantity obtained through all bookkeeping processes, the connection between LES and double entry bookkeeping is obvious. *If a set of financial statements is defined by n business managemental quantities, the LES must therefore consist of n equations* .

This thesis was first established , tested and verified in an empirically-experimental way with the use of innumerable, constantly varied computer-sequences.[4] In the course of this a computer-simulation-algorithm was developed, which makes it possible to solve the LES based on double entry bookkeeping with regard to the profit (annual surplus)[5] . This will be mathematically proven later on (see 2). These explanations should not deter the more practical reader. They are *not* necessary for the understanding and the application of the Input-Output-Simulation in the normal course of business.

The Input-Output-Simulation converts the thesis to reality with the help of the simulation-algorithms. It is therefore possible to simulate business processes over the course of *several years* mathematically - *accurate from a bookkeeping point of view* - by creating a balanced - *linked* - set of financial statements with a statement of cash flows[6], a balance sheet and a statement of income (profit and loss account)(see 3). These are all based on mathematical, algebraical computations of independent - *unlinked* - global parameters.

Thus the Input-Output-Simulation gives the executive management (board, head of finance, accountancy and controlling) as well as those who have to assess the workability of planning schemes, such as supervisory committees, banks, auditors, analysts and administrators in bankruptcy proceedings, new perspectives: the development of a company can be forecast in an artificial *"business cosmos"* in different variations[7]. The comparison of forthcoming decisions, with all their many alternatives, is then possible, with all the respective effects on profit and loss, cash flows and the financial development of a company, immediately and without delay (for further fields of application of the Input-Output-Simulation see 4)[8].

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with understandable incomprehension". Chmielewicz K., "Integrierte Finanz-, Bilanz und Erfolgsplanungen" in "Hand-buch des Finanzmanagements", 1993, p.43, 65: "With the help of such simultaneous equational systems the interrelation-ships between liquidity, profit and the structure of the balance sheet can be illustrated and determined".

[4] This method (or technology) is not unusual anymore nowadays; see Mittelstraß J., "Technology is not only an applica-tion, but also a prerequisite for science, which in turn becomes technical too". At a meeting of the Foundation for German Science. FAZ, 7. Dec. 1994.

[5] The computer-simulation-algorithm (developed in the computer-language FORTRAN) is at the core of the complex UNIX-software-product ASRAP (Analytical-Synthetic-Raster-Planning). The past-orientated unlinked variables are filtered from the past-orientated linked Set of Financial Statements of a business (Statement of Cash Flows, Balance Sheet and Statement of Income (profit and loss account)) and shown on the screen. They can (but do not have to) be used as starting points for the choice of the future-orientated *unlinked* variables, which can be interactively differentiated at will or in "raster"-steps. The computer algorithm as well as the mathematical basis were developed by Wilhelm Dauner.

[6] For the significance of Statements of Cash Flows see especially the pioneering essay by Busse von Colbe W., "Aufbau und Informationsgehalt von Kapitalflußrechnungen" ZfB, (Erg.h.l), year 36, 1966, p.81-114. See also: Küting K., Weber C.-W., "Die Bilanzanalyse", 1993, p.137-181, Siener F., 1991, "Der Cash-Flow als Instrument der Bilanzanalyse".

[7] Recently the term "virtual business" is being introduced into discussions about business management. See Scholz Ch., "Controlling in virtuellen Unternehmen", "Rechnungswesen und EDV - 16. Saarbrücker Arbeitstagung 1995".

[8] For practical applications of the Input-Output-Simulation see Dauner/Dauner-Lieb, BiBu 9/1994, p.193ff; BiBu 7/1995, p.152ff.

2. Theoretical Basis

2.1. The axiomatic idea of the cycle

To display the mutual dependences in a complex economic system, certain axiomatic ideas are necessary.[9] While macro-economics divides the economy of a country into sectors and flows of goods of a similar nature, micro-economics breaks a company down into cost centres, processes[10] and transactions. In doing this the Managing Accounting provides the rules by which monetary flows between the units of the system are described in detail.[11] In Financial Accounting revenues and expenses, gains and losses are combined with the help of double entry bookkeeping with the aim of determining the profit and the changes to company capital. The results affect the statement of financial position, the statements of earnings and the statement of cash flows. Double entry bookkeeping describes a cycle: a monetary cycle is present when the sum of all in- and outcoming cash flows equals zero[12] - in mathematical terms, if the sum of all positive (+) inflows is as high as the sum of all negative (-) outflows[13]. This is the case with any set of financial statements (or with business processes) generated by double entry bookkeeping. Double entry bookkeeping and the annual sets of financial statements represent (show) the monetary cycle of the company in the form of accounts. A graphic display is also possible.[14] However cycles are fundamentally accessible algebraically via an LES as well.[15] [16]

2.2. The LES as an algebraical description of the "structure of linkage".

With this in mind the starting-thesis can be stated more precisely as follows: an *LES exists which gives a clear, algebraical description of the "structure of linkage of the statement of cash flows with the opening and closing statement of financial position and the statement of earnings"*[17] (from now on shortened to: *structure of linkage*).

To back this up a digression into the mathematics of linear algebra is necessary. Innumerable problems in all sorts of (practical) areas of applied mathematics can only be solved with the

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[9] Fleissner (Fn.2), p.1.

[10] See also Kaplan R.,"New roles for management accountants", speech on the occasion of the awarding of an honorary doctorate by the University of Stuttgart. German version in "CONTROLLING" 2/1995, p.60,63: traditional systems for statements of cost are replaced by "Activity-Based Costing (ABC)" in many (American) service and production busi-nesses.

[11] See also Johnson T., Kaplan R., Boston Massachusetts 1987, "The Rise and Fall of Management Accounting".

[12] Fleissner (Fn.2), p.9.

[13] Fleissner (Fn.2), p.15.

[14] Busse von Colbe, "Finanzflußrechnung als Grundlage für Finanzierungsrechnungen", in "Handbuch des Finanzmanagements", 1993, p.25,37. see enclosure.

[15] Fleissner (Fn.2), p.16.

[16] The recently much discussed question of whether internal and external accountancy could be standardized, or might even have to be standardized, is not pursued here. Nevertheless, the conception and implementation of the Input-Output-Simulation could make a major contribution to this question. On this subject: Coenenberg A. "Einheitlichkeit oder Differenzierung von internem und externem Rechnungswesen: Die Anforderung der internen Steuerung", in Globale Finanzmärkte, p.137-161,1996, documentation of the 49. German business-management convention 1995. From the practical aspect: Sill H. (Siemens AG), "Externe Rechnungslegung als Controlling-Instrument!", "Stuttgart controller-forum 1995 .

[17] "Struktur der Verknüpfung der Finanzflußrechnung mit Anfangs- und Schlußbilanz und der Gewinn- und Verlustrechnung", Busse von Colbe (Fn.14), p.37.

help of an LES .[18] A linear equation system is a form of expression in which *n* linear equations are combined with *m* variables in a conjunctive (interdependent) way.[19] In the symbolic language of mathematics the following therefore applies:

a11x1 + a12x2 + ... + a1nxn = r1
a21x1 + a22x2 + ... + a2nxn = r2
. . . .
am1x1 + am2x2 + ... + amnxn = rm

The numbers a11, a12, a1n, a21, a22, a2n, am1, am2, amn are the so-called "coefficients", the numbers r1, r2, rm are the "absolute parts" and the values x1, x2, xn are the "variables" in the set. If r1= r2 = rm = 0 we speak of a "homogenous set of linear equations". Should an LES be such a homogenous set of equations and should m = n, i.e. the number of equations is equal to the number of variables, then, apart from the trivial solution x1 = x2 = xn = 0, there is *one* definite set of solutions. In other words: if the aforementioned conditions are fulfilled then any n-1 variables out of the n variables can be set as desired. The non-prescribed variable is the *definite* quantity of solution for the LES. In algebraical usage the LES is depicted as a "coefficient-matrix" without mention of the variables, in the following way:

a11	a12	a13	.	.	a1n
a21	a22	a23	.	.	a2n
.	.	.	.		
.	.	.	.	.	.
an1	an2	an3	.	.	ann

This *coefficient-matrix* describes (fixes) the *structure of linkage*. The *variables*, that is to say the countless bookkeeping entries or positions of business deals arising throughout the course of a period can then be set to any desired value, except for one, which is found in the solving of the LES. It is thus evident that there must be an enormous structural "flexibility" in the *algebraical depiction* of the structure of linkage. This flexibility is only possible if, with the help of a powerful computer and a clearly defined algorithm (which the programmer first has to translate into a programming language[20]), the solving of the LES is possible in practically no time at all and in unlimited variations. Keeping in mind that a Full and Articulated Set of Financial Statements in commercial law provides a wide range of positions[21] as variables and that each variable can, in principle, be varied from zero to infinite, the unimaginable number of possible combinations becomes readily apparent .

Conversely, one can say that a clearly defined working algorithm can be brought into play to prove a mathematically formulated thesis. The thesis put forward above can therefore be expanded: if a computer-algorithm - developed in whatever way - can guarantee the *structure of linkage* without doubt, then this is only possible because that very algorithm solves the (ini-

[18] Lehmann E., "Lineare Algebra", 1990, p.87.
[19] Lauter J. and others "Analytische Geometrie und lineare Algebra", 1992, p.97.
[20] Lehmann (Fn.18), p.96 .
[21] Hauschild J./Lecker J., "Bilanzanalyse unter dem Einfluß moderner Analyse- und Prognoseverfahren", BFuP, 3/95, p.249,252: "The full Set of Financial Statements in commercial law provides 220 positions for the formation of ratios".

tially merely conceptionalized) LES. An LES which replaces double entry bookkeeping has so far not been put forward for two reasons. First of all it is not needed to prove the theory. The infallible computer-algorithm of the Input-Output-Simulation provides a definite proof, verifying itself in the process.[22] Secondly, the actual existence of the computer-algorithm in the form of a *usable* programme is completely sufficient for practical applications - which are of primary interest here.

2.3. Example of a practical illustration of an LES

To simplify the comprehension of the interrelations, the following reflection will nevertheless show what the formulation of the LES, which algebraically depicts double entry bookkeeping, would need to look like: if a Full Set of Financial Statements has *n* positions, then the LES, which depicts the *structure of linkage* algebraically, consists of *n* equations. In principle the *matrix of coefficients* then has n*n coefficients. However nearly all equations are merely weak representations. In other words: a great number of coefficients of the matrix are = 0. Furthermore, most coefficients which are not = 0, = 1. Three randomly chosen equations will serve as examples to elucidate this.

- Suppose the following: sales (revenues) = a11x1, material costs = a12x2 , balance of other operating expenses, other operating income, further taxes and expenses for pension schemes = a13x3, personnel costs (not including expenses for pension schemes) = a14x4, balance from the setting-up and dissolving of provisions (opening balance sheet to closing balance sheet) = a15x5, operating profit[23] = a16x6.
  Equation 1 is as follows: a11x1 -a12x2 -a13x3 -a14x4 +(!)a15x5 -a16x6 = 0.

- Suppose: provisions (opening balance sheet) = a27x7, provisions (closing balance sheet) = a28x8, balance from the setting-up and dissolving of provisions = a25x5.
  Equation 2 is: a28x8 -a27x7 -a25x5 = 0 .

- Suppose: inventories (opening balance sheet) = a39x9, inventories (closing balance sheet) = a310x10, change in inventories (from opening to closing balance sheet) = 311x11 .
  Equation 3 is then: a310x10 -a39x9 -a311x11 = 0 .

The matrix - *variables and coefficients* - of these equations can therefore be written as follows:

x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	.	xn
+a11	-a12	-a13	-a14	+a15	-a16							
				-a25		-a27	+a28					
								-a39	+a310	-a311		

or purely as a *coefficient matrix* in figures:

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[22] On technological proof of scientific theses, see Fn.4. An infallible computer-algorithm is *technology* as a *precondition for science*.

[23] The value of the "operating profit" is defined differently in the Input-Output-Simulation than in the English use of the term for practical reasons. To keep this (in percentage of Sales) important reference value "free of subjective expectations and thus free of arbitrariness in assessment" (Busse von Colbe, Fn.6, p.97) " the offsetting (non-cash-flow) items such as depreciations, writing-offs, valuation adjustments, setting-up and dissolving of provisions" (Busse von Colbe, Fn.6, p.92) are not included or "filtered out". Equation 1 describes the definition precisely. To obtain the operating profit in the Anglo-Saxon sense, the depreciations and the balance of the setting-up and dissolving of provisions has to be subtracted.

+1 -1 -1 -1 +1 -1

-1 -1 +1

-1 +1 -1

The *coefficient matrix* can, in principle, easily be extracted from the source-code of the experimentally developed simulation-algorithm of the Input-Output-Simulation. It can already be seen to exist therein in form of the necessary number of equations.

3. The concept of the Input-Output-Simulation [24]

3.1. Conception

The basis for the Input-Output-Simulation is an existent opening balance sheet, which has previously been read into the computer algorithm or simulated. The input can consist of values for any positions which are required, but also sufficient for the representation of a business process. These are the *variables of theLES*. Examples of this are revenues (turnover), cost of materials, number of employees, average costs of employee per year, other operating revenues and expenses, inventories, receivables and liabilities from trade, other receivables and other liabilities, investments to (and desinvestments from) property, plant, equipment and intangible assets, investments by and distributions to owners. A *fundamental* divergence from the usual plan requirements lies in the fact that principally neither interest revenues nor interest expenses can be stipulated. The interest balance (the difference between interest revenues and interest expenses) is an *element* as well as a *result* of the statement of cash clows, the statement of earnings and the statement of financial position. Only *one* such value fits *smoothly* into the cycle. Instead the average interest rates in respect to assets and liabilities have to be laid down as variables. The computer-algorithm guarantees the proper inclusion of these interest rates into the cycle.[25] Every Input-value can be set to an absolute value, to a percentual rate of change or to absolute change of values. Each position is called up by the computer inter-actively. Input-values which are *not* entered are automatically generated *plausibly* according to the structure of the opening balance sheet.

On the basis of the parameters the computer-algorithm creates a balanced - *linked* - set of financial statements of the business with a statement of cash flows, a statement of earnings and a statement of financial position (balance sheet). It is able to convert an "old" set of financial statements, without the help of double entry bookkeeping, - after running through a business process with any prescribed Input-values - into a "new" set of financial statements which is accurate from a bookkeeping point of view and therefore fully adequate.

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[24] An in-depth theoretical and practical description of the conception and realisation of the Input-Output-Simulation with examples of the *technically* unrestricted manipulation and simulation of business processes (of single companies as well as of corporate groups and over the course of several years) with various comparisons (benchmarking) (also of Financial Statements of corporate groups with individual companies of the group) has been made and is intended to be published. The many computer-printouts enclosed in the text elucidate (and prove empirically) the practical applications and the uni-versal variability of the concept.

[25] This mathematical law is certainly not, as might be supposed, a peculiarity of the algorithm; rather, it is "structurally inherent" for the structure of linkage. Therefore the statement in 1, that the LES produces as a result the profit (annual net income), is shortened. The Input-Output-Simulation determines the change in indebtedness (balance of interest-bearing liabilities and interest-bearing assets) automatically to a necessary level for the financing of the business process. Therefore the computer-algorithm not only produces as a result the annual net income but also the (net) change in indebtedness.

3.2. Distinction from conventional simulation-models [26]

The Input-Output-Simulation differs considerably from conventional equational models intended for the simulation and control of financial development.[27] It is not a *constructed* system. The linear equation system (LES), on which double entry bookkeeping is based, is not a model in that sense. One would not normally think of describing double entry bookkeeping as a model, let alone a simulation model. The LES-solving simulation-algorithm leads, like double entry bookkeeping, more or less automatically to a self-contained, linked set of financial statements of a business. Since interests and tax are both elements and results of the Input-Output-cycle there is no repetition process.[28] The computer-algorithm works *accurately* on the basis of the *mathematical laws* of the LES.[29]

3.3. Distinction from prediction methods

The Input-Output-Simulation is *not a method of prediction*. A prediction makes a statement about one or several future events, which is based on observations as well as on a theory.[30] Instead the Input-Output-Simulation is, like double entry bookkeeping, a technique. Predictions are made by the user through the laying down of variables. To do this he may, if he wishes, take existing methods of prediction into account. Whether the chosen prediction-combination is realistic or frankly absurd, is of no relevance to the mathematics. It is quite possible to insert - as variables - a negative revenue (turnover) or also a negative capital distribution, for exam-ple. The computer-algorithm always leads to a mathematically indisputably correct result. The usefulness of the result for planning depends on the quality of the parameters. No computer can replace the central role of the entrepreneur in developing future prospects for the busi-ness.[31] However, the Input-Output-Simulation makes it easier for him by automatically asking him the right questions in the correct form and facilitating the exact assessment of the conse-quences of various ideas. Because of the need to set realistic parameters, i.e. decide which combination of variables should be tested, a beneficial disciplining in the planning process is necessary right from the start .

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[26] Compare in Hahn D., Taylor B., "Strategische Unternehmensplannung - Strategische Unternehmensführung", 1990, Hahn D., Hölter E. and Steinmetz D."Gesamtunternehmensmodelle als Entscheidungshilfe im Rahmen der Zielplanung, strategischen und operativen Planung?", p687-717. Zwicker E.,"Entscheidungsunterstützungssysteme - ein neues Konzept der computergestützten Planung?", p.667-686.

[27] Busse von Colbe (Fn.14), p.40: "In literature and practice complex simulation models for financial control have been developed (See the survey by Hahn,1989). The cash-flow statement plays an important part as the basis for financial decisions".

[28] Hahn (Fn.26), p.703: "Since the gross credit demand is not the same as the net credit demand for reasons of interest and tax and other factors, the model has to approach the total outstanding credit and lending cautiously, depending on preset conditions, by means of a repetitive process".

[29] Lehmann (Fn.18), p.138: "if the process chosen for the solution of the mathematical problem (LES;authors note) were an iterative process", then this would be a so-called "processing fault".

[30] comp. Hansmann K.-W. "Prognose und Prognoseverfahren" in BFuP 3/95, S. 269-286.

[31] Henry Mintzberg, "The Fall and Rise of Strategic Planning", HARVARD BUSINESS REVIEW, January-Febuary 1994, p.108: "The outcome of strategic thinking is an integrated perspective of the enterprise, a not-too-precisely articulated vision of direction", p.111: "My research and that of many others demonstrates that strategy making is an immensely complex process, which involves the most sophisticated, subtle and, at times, subconscious elements of human thinking".

4. New Perspectives of Strategic Business Management and Planning

4.1. Balance sheet policy and balance sheet analysis (ratio analysis)

First of all the Input-Output-Simulation is also applicable *outside of* planning, in the field of balance sheet policy and analysis with respect to business processes that have *already happened*. Its use means that the, so-far, unlinked Input-variables are extracted from an existing set of financial statements (also of a corporate group) which was obtained in the usual way by means of double entry bookkeeping, stock-taking and, group consolidation. The algorithm which solves or solved the LES is "run again in reverse", so to speak. Alternatives in balance sheet policy can be simulated at will, timeless and are always accurate from a bookkeeping point of view by exchanging the Input-variables depreciations, writing-offs, valuation adjustments and setting-up and dissolving of provisions, which, as *offsetting items* [32], are more or less fictitious values and influence the cash flows merely through a possible change in taxes on income and therefore also in interest-balance. The mathematical/algebraical rules of the LES ensure without doubt a correct integration of these alternatives, whereby integration means that all positions of the set of financial statements which are affected by the change of the *offsetting items* as a consequence of the reciprocal-linkage, are changed, i.e. adapted. The computer-algorithm ensures without doubt that the already existing set of financial statements, now changed in terms of balance policy, has definitely correctly linked the statement of cash flows, the opening and closing balance sheet and the statement of income. It is important, in this context, to note that the various input-combinations must necessarily be based on the *previous year's* Set of financial statements of business.

The changeability of the Input-variables makes it possible to adapt a German set of financial statements of business to international standard with the help of the Input-Output-Simulation.[33] As long as no variables are changed, which might in turn change the elements of cash flows, the renewed solving of the LES produces *the same* business process, but expressed in a different, *adapted* set of financial statements of business.

It is furthermore worth noting that the generation of a "Statement of Cash Flows on the Basis of a Fund of liquid Means with the three areas, the Current Operations, the Investments and the External Financing"[34] , necessitated by the Anglo-American conventions and recommended by the IASC, is *system-inherent* in the Input-Output-Simulation. In the set of financial statements of a corporate group, the system-contrary practice of clearing the consolidational goodwill from the first consolidation of capital along with the retained earnings without affecting the statement of income[35] can only be done with the help of an artificial "cash flow trick". A clearance which does not affect the statement of income requires in the Input-Output-Simulation the input of a fictitious distribution of capital, which then balances the statement of cash flows

[32] Busse von Colbe (Fn.6), p92, see also Fn.23.
[33] See Busse von Colbe W., in BFuP,4/95, p.373-391, "Anpassung der Rechnungslegung von Kapitalgesellschaften an internationale Normen".
[34] Busse von Colbe (Fn.33), p.377,378.
[35] Busse von Colbe (Fn.33), p.379.

with the balance sheet. This is a result of the algebraic description of the *structure of linkage*. The same goes for the deconsolidation.

In summary one can say that regional or legal differences in regulations and accounting pratice do not play a role in the mathematical processing of the Input-Output-Simulation, as they are taken into account or intercepted in the setting of the Input-values.

4.2. Planning the set of financial statements of a single business

A *planned Set of Financial Statements* which deserves this description must be correct in the *structure of linkage*. This predisposes that the financial plan and the planned set of financial statements were generated simultaneously. Such a simultaneous generation would be theoretic-cally possible by projecting the laws of double entry bookkeeping into the future. An attempt in this direction was propagated by Chmielewicz. Whether this is feasibly applicable in busi-ness practice cannot be discussed in detail at this point. A "change in the standard form of accounts, EDP-programmes, organisation procedures, etc." would be necessary.[36] The use of double entry bookkeeping for business planning would certainly be awkward, costly and re-quire a great deal of effort . With the help of the LES the result which is aimed at in double entry bookkeeping is achieved easily, cheaply and quickly. Since the planned set of financial statements can be varied at will with the help of the LES and can therefore be adapted to inter-nal and external developments at any time, it takes on a completely new meaning as an in-strument for business-management.[37]

A reader less familiar with the laws of linear algebra might express doubt at this point and refer to the better known methods of conventional planned sets of financial statements and capital requirement planning. However, there are fundamental differences. This is illuminated by the following representative conclusion in the section Planned Set of Financial Statements of the "Handwörterbuch des Rechnungswesens" (Standard Dictionary of Accountancy): "in respect to the discussed assessment of plausibility (of the planned set of financial statements, author's note) the auditor can only confirm the consistency of a logical link between the hypotheses and certain probable consequences thereof."[38] This is the essential point: whatever one might un-derstand by hypotheses in connection with planning, in the mathematical formulation of the Input-Output-Simulation not hypotheses but unlinked variables are used for planning. The planned set of financial ftatements generated by the computer algorithm of the LES and de-scribed in detail by the standardized Computer-Output cannot undergo an assessment of its plausibility. It is depicted in a *self-verifying* way and is without doubt "credible in respect to the total accounting"[39]. An assessment of plausibility is now only necessary with regard to the unlinked planning figures.

The explanation so far shows that the planning can clearly also be done over the course of *several* years and varied as desired, even in *different business-processes*. The - as a rule varied

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[36] Chmielewicz (Fn.3), p.59.

[37] Schedlbauer H., "Planabschluß"in"Handwörterbuch des Rechnungswesens", 1993, p.1538: "Its main purpose is there-fore established as an instrument for business management".

[38] See Schedlbauer (Fn.37), p.1542/1543; Suggestion for the confirmation of a planned Set of Financial Statements by the auditor: "We confirm that the planned Set of Financial Statements is credible in respect to the total accounting".

[39] Schedlbauer (Fn.37), p.1543.

- characteristics automatically defined by the software of the Input-Output-Simulation (separately for each year) can be used to carry out "the same analytical balance sheet investigations (balance sheet analyses) as in retrospective balance sheets."[40].

Digression: one could easily imagine that an extensive LES which is solved by an appropriate computer-algorithm, can also replace the past-orientated process of double entry bookkeeping, i.e. the method of accounting. For if the thesis is true, that the basis of double entry bookkeeping is the mathematical basic structure of an LES, then it must be also possible to formulate that LES in any equational order and solve it with an algorithm in a definite way. Double entry bookkeeping would then simply become a detour. The "farewell to double entry bookkeeping" predicted by a Swiss specialist journal for the year 2000 might become reality.[41]

4. 3.The profitability-orientated overall company target planning

Standard methods of planning from bottom to top are increasingly proving to be too awkard and expensive for the living and constantly developing and changing organism of a business. More and more frequently planning is done primarily from top to bottom. This begins with a *profitability goal*. The cost-reduction needed to achieve this goal is estimated as a lump sum. From these conclusions are drawn as to the necessary increase in productivity, the optimum number of employees and possibly even the necessity of transferring production to more economical locations.

Such approaches to "top-down"-planning are so far very simple and imprecise. The Input-Output-Simulation makes it possible for "top-down"-planning to be carried out *continually* and for there to be a *market and labour cost orientated* overall company target planning. The starting point for all further planning considerations is the laying-down of the aspired aims (*profitability, labour productivity (per employee and year), cash-flow, change in equity and financial debts etc.*). Then the paths by which these aims can be achieved have to be determined. In doing this it is important that the considerations are not reduced straight away to one or two likely business processess. Instead a series of scenarios have to be developed which are feasible for the examined future of the business from the present viewpoint. The various scenarios are generated automatically by the Input-Output-Simulation from the many variations and combinations of the unlinked Input-variables. The results of these are always exact from a bookkeeping point of view because of the laws of the LES. In a further step the different scenarios are examined as to whether they correspond to the planned targets. With the help of a search-process, those, which achieve the required target-profitability or other aims, are dug up (Data-Mining). The "permissible" scenarios are therefore determined unambiguously. In the case of an "error message" there are two possibilities: either the global variables have to be adapted; a check must then be made as to how figures, that have so far been deemed impossible, might be made possible; or the target values have to be reduced. If both paths prove to

[40] This is a pronouncement of Schedlbauer (Fn.37), p1541:"the key figures arrived at by this method simplify and encourage the assessment of the creditworthiness of the company considerably. One can therefore only advise every credit institution to demand the submission of such planning data".

[41] Behr G., "Megatrends der Rechnungslegung - Bilanzen und Finanzen nach dem Jahr 2000", in "Der Schweizer Treuhänder" 9/1994, p.635, 639 onwards. (reference is made to the work of "Yuji Ijiri and Robert Kaplan").

be impassable, in the latter case because the target values were already at the very edge of profitability, then this is a clear indication that the business cannot survive in the long run.

4. 4. Constructing business segments

From the laws of linear algebra it follows that the variables of the LES, which replaces double entry bookkeeping, can be taken apart and added to at will. The *unlinked* Input-variables extracted from an actual set of financial statements[42] can thus be split up onto any freely constructed *business segments*. In running the computer algorithm a separate, self-contained business process emerges for each business segment, containing an interrelated set of financial statements, i.e. with a statement of cash flows, a statement of financial position, a statement of earnings and (possibly) a statement of investments by and distributions to owners. In actual fact these sets of financial statements are not simulated but a result of the definition of the business segments. They can be added up (or consolidated). They must be equal in sum to the original set of financial statements in all positions.

A completely new constructed business segment exists if all the positions of the respective starting set of financial statements are zero. By stipulating certain Input-values any number of business processess starting at zero with full sets of financial statements can be simulated over the course of several years. Especially in the *synthetic construction* of business segments the superiority of the mathematical formulation is shown with the help of the LES .[43]

4.5. The corporate group set of financial statements

In the same way in which the (global) corporate group is becoming a superordinate coordinating, controlling and briefing unit (with a large degree of decentralisation of the management responsibilities), the corporate group set of financial statements is becoming particularly interesting to science and business practice as a *decision-backing system*. It should be distinguished by ease, clarity, comparibility as well as by being up to date.[44]

An authoritative lecture by Küting shows how little the present methods of corporate group consolidation are able to fulfill these criteria: "Rechnungslegung im Umbruch - Ein Plädoyer für ein Rechnungswesen des Konzerns. Konzernrechnungswesen des Jahres 2000".[45] Therein the corporate group set of financial statements is described as "theoretically ideal", which are developed straight "from the corporate group set of financial statements of the previous period [...] without having to make a detour through the individual sets of financial statements of the considered businessess". The consolidation necessary at present to draw up the corporate group

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[42] See 4.1

[43] Leontief (Fn.1), p.14. He also uses the same phrase, *synthetic construction*, but for macro economics: "By the same token, with somewhat more involved computation, we can *construct synthetically* a complete input-output table for the entire economy".

[44] See Ballwieser W., "Kritische Würdigung der Vorschläge zu einer eigenständigen Konzernbuchführung" in "Die Zu-kunft der Konzern-Rechnungslegung - Von der Nachschau zur Konzernsteuerung", conference of the FAZ information services in cooperation with the KPMG, 1995.

[45] Küting K., "Das Konzernrechnungswesen des Jahres 2000", in "Rechnungswesen und EDV - 14. Saarbrücker Arbeitstagung 1993", p.359-389.

set of financial statements would become dispensable. Furthermore the consolidation procedure is very costly and does not fulfill the demands for "lean management".[46] With the use of the Input-Output-Simulation these theoretical ideals might become practical reality. Again the mathematical laws of the LES play a decisive role. As the *unlinked* Input-variables can be added together, it is sufficient to add up the *corporate group* Input-variables of the *individual businessess*, which were defined with a self-contained corporate group cycle in mind. The solving of the emerging corporate group LES leads to a self-balanced corporate group set of financial statements. This original corporate group set of financial statements is generated not "on the basis of individual entries analogous to individual sets of financial statements"[47] and thus with the help of double entry bookkeeping. Instead it is generated in a mathematical-algebraical way from the sum of the global cash flow values of the individual businessess and with the global offsetting items[48] for depreciations, writing-offs, changes in provisions etc. as prerequisites. "Distortions of financing calculations" because of offsetting the amount of difference (consolidational goodwill) from the starting consolidation against the corporate group retained earnings without affecting the corporate group statements of earnings can therefore not appear using this method of generation. This is because the changing of the corporate group retained earnings is an automatic consequence of the solving of the corporate group LES and it is therefore system-inherent that it is not open to manipulative intervention. If, in the course of the Input-Output-Simulation, the amount of difference (consolidational goodwill) is to be offset against the retained earnings *without affecting the statements of earnings*, then the *payment-(cash flow)-effective* "investment in goodwill "[49] must be compensated for by stipulating a fictitious corporate group (equity-)capital distribution. (see also 4,1).

However, it is not only possible to use the Input-Output-Simulation to create a corporate group set of financial statements for a previous period. The Input-Output-Simulation is also a highly effective instrument for the corporate group management to use for *planning and control*. In doing so the Input-variables of the individual businessess can, on the one hand, be collected as estimated values and added up. On the other hand, the top-management of the corporate group can initially make the estimates alone, without including the individual group-companies. There is much to be said for the fact that the carefully balanced and varied estimates made by the corporate group top-managers and their managerial staff better describes the future corporate group situation than the sum of the separate values of each corporate business, which are almost impossible to check.[50]

4.6. The shareholder-value approach

The aim of the shareholder-value concept is an increase (maximization) of the shareholder-value of a business or part of a business (strategic business segment). The concept combines the teachings of strategic planning and the business management theory of capital. The target is

[46] Küting (Fn.45), p.374, "The application of the regulations of the code of commercial law in the case of corporate group accounting requires very extensive minor calculations in order to attain a corporate group account from the individual accounts of the corporate businessess considered for the corporate group account".
[47] Küting (Fn.45), p.374.
[48] Busse von Colbe (Fn.6), see also Fn. 23.
[49] v.Wysocki K., "Konzern-Finanzierungsrechnung" in "Handbuch des Finanzmanagements", 1993, p.67,75/76.
[50] Küting (Fn.45), p.385.

reached if, during the course of future business processess the cash flows are maximized and the capital costs are minimized.[51] The shareholder-value approach "supplies the aims, with the help of which ex ante strategic decisions, decisions about distribution and allocation of capital in the business, are made and ex post the achievements of the management are to be judged. In addition to this it has to supply the planning instruments so that the maxims can be attained".[52]

It is hoped within business practice that the application of the shareholder-value concept will have the following advantages over the usual balance sheet analysis:

- The ability of a business unit to achieve future cash flows and profits will become central to the judging process. Comparisons with alternatives in the market will be made. For each area of business the "whole spectrum of alternatives - if in doubt even a 'make or buy' can then be simulated".[53]
- The putting forward and assessing of alternative strategies for the future will be compulsory. "The goodwill value as an expression of the present value of future capital reflux can only be judged in connection with the underlying strategy". "Without the analysis and assessment of the underlying strategy any occupation with the values of goodwill degenerates to a mere juggling of numbers".[54]
- The compulsory "developing of a scenario calculation for the future market value of the company capital". Stipulations as to the "minimum yield which a business must exceed in order to generate the expected positive yields for the owner".[55]
- The stipulation "of a quantifiable target figure with which all strategic decisions can be compared". A task for the strategic business field (segment) "to obtain a certain lasting, individually set minimum yield from the invested total capital". With the use of minimum yields and required contributions to the business value "universally applicable, quantifying values are incorporated into the strategic discussion". Precise, verifiable targets can be defined in the strategy finding process. Strategic controlling will receive a very definite content.[56]

In all these comments by leading business practitioners the opinion, that the shareholder-value approach obviously only makes sense if *alternative future scenarios* with *quantifiable cash flows* and *variable capital structures* can be produced by calculation, is a central theme throughout.[57] It is precisely this which the Input-Output-Simulation enables, in the shortest possible time and with the least expense. Only with its application are varying costs of loan capital automatically integrated into the simulation of the future scenario, in the form of stipulatable interest rates (changeable from year to year) with regard to assets and liabilities as well as one's own capital costs in the form of planned (company) capital distribution and (company) capital supply. The capital structure varies from period to period and is always automatically *exact*. Therefore there is much to be said for the idea that only the *mathematical*

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[51] Bühner R.,"Der Shareholder Value Report", 1994, p.54

[52] Ballwieser W.,"Adolf Moxter und der Shareholder Value Ansatz" in FS Moxter, 1994, p.1378,1383 .

[53] Obermeier G. (Viag), in Bühner (Fn.51), p.77-90 "Die Umsetzung des Wertsteigerungskonzepts in einem Holding-Konzern".

[54] Mirrow M. (Siemens), in Bühner (Fn.51), p.91-105, "Shareholder Value als Instrument der internen Unternehmensführung".

[55] Siegert T. (Franz Haniel), in Bühner (Fn.51), p.107-126, "Markwertorientierte Unternehmenssteuerung".

[56] Baan W. (RWE), in Bühner (Fn.51), p.127-143, "Die Rolle des Shareholder-Value-Konzepts in der strategischen Planung des RWE-Konzerns".

[57] See Ballwieser (Fn.52), p.1405: "the weighted capital cost rate assumes a constant capital structure in the course of time, which does not fit into the concept of cash flow-estimates".

basis of an LES and its solving through an *interactively controllable* computer-algorithm can give the shareholder-value approach a sturdy basis for calculations in scenario-planning (calculations of business policies, strategies). Its application not only determines cash flows from predictions about cash flows[58]. It constructs (from year to year) faultlessly *linked* full sets of financial statements and that means complete business processess, quantitatively, without delay and exactly from any number of Input-variables.

4.7. Benchmarking - formalized business comparison

The possibility to freely combine and formally describe various alternative processess with the help of the Input-Output-Simulation gives rise to perspectives that go far beyond the scope of the usual business comparisons[59]. Apart from the usual business comparisons the following so far hardly, if at all, considered approaches to *benchmarking* can be made:[60]

- between various companies, even spanning borders and balancing with different currencies[61], for the same year or different years.
- between the actual set of financial statements of a company and any alternative set of financial statements, which was varied as desired in the offsetting items, of the same year.
- between various business processess which were constructed differently *over the course of several years*, for one or more companies.
- between *single companies* and *corporate groups*.
- between various companies partly with actual set of financial statements, partly with simulated business processess (i.e. with simulated sets of financial statements) for different years.

The latter possibility might seem quite unrealistic and theoretical at first. However, it can be highly interesting for the development of global business strategies; not only globally operating corporate groups, but also medium-sized businessess, which are compelled to look for more economical locations for production because of cost pressure, could gain incalculable use from such comparisons. If, for instance, new production locations are being considered in Eastern Europe or in the developing countries of Asia or Africa, then it is extremely important that one can simulate plausible business processess for these locations, in different variations, over the course of *several* years, instantly, and without having to employ expensive specialists. In doing so not only the construction of these business processess themselves, but above all the ensuing comparison of the processess e.g. of the third and fourth build-up year with the actual process of the past or present year at home, produces important insights. One could imagine, for ex-

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[58] Ballwieser (Fn.52), p.1385: "Cash-flows are determined from cash-flow forecasts on the basis of certain business policies (strategies)".

[59] Küting/Weber (Fn.6), p.43, "Only a comparison referring to static analysis" is "the traditional or classical instrument of decision-making in the field of balance analysis".

[60] See Fn. 24. A selection of approaches for an *innovative benchmarking* in the *descriptive language* of the Input-Output-Simulation in form of computer print-outs is included in the mentioned manuscript.

[61] The comparability is a result of the description of nearly all the positions of a business process in percent of turnover. Moreover the software-product ASRAP enables the instant conversion of any fed-in or simulated Set of Financial Statements (with the Statement of Financial Position, the Statement of Earnings, the Statement of Investments by and Distributions to Owners and the Statement of Cash Flows) into any comparative currency. With benchmarking the labour-productivity, the average personnel cost per employee as well as the difference of these values are compared as operating profit per employee. (For the definition of operating profit in the Input-Output-Simulation see Fn. 23). In an age of global competition the comparison and constant control of these values (also those simulated for the future) have an almost existential significance.

ample, that the first two years of the business process constructed in a developing country, with comparatively low personnel cost per employee and year, but so far not being used to capacity (and thus with a low productivity) and a high element of borrowed capital, would lead to an operating profit still too low for a cheap-wage country (although in comparison with Germany it would be acceptable). With a high negative interest balance and high depreciations and writing-offs it would also lead to a low or even negative profit, always measured in percent of sales. This situation could be completely reversed within the third or fourth year though, in the sense that, because of rising capacity utilization and therefore a rising productivity, with far more slowly rising personnel cost per employee, the operating-profit in percent of sales (turnover) would rise and soon be extremely high,while the negative interest balance would quickly diminish and maybe become positive. The annual surplus in percent of sales would, accordingly, become positive or very positive. The Input-Output-Simulation can depict such feasible business processess *quantitatively and precisely* and then, according to preference compare, say, the fourth year of the constructed business process of the planned company with the current year of the parent-company. For example, the (possibly very different) values for the change in debt per year, for the average labour-productivity, the average expected personnel cost per employee, the cash flows, the annual surplus in percent of turnover and the different profitability ratios are compared.

4.8. Computer Based Training (CBT)

The LES, which replaces double entry bookkeeping, and its immediate solving by a computer-algorithm, provide the tools for the conveying of knowledge and skill in the field of strategic business management and planning (see 4. 1-7). The Input-Output-Simulation allows for an almost unlimited number of "flexibly-applicable learning processess, which the user can control interactively"[62]. The only hardware necessary is a modern Unix-workstation (not very expensive nowadays), or even a notebook , which serves - along with the software[63] - as a highly effective training tool. Online-learning, and even Tele-online-learning for business executives with the trainee's *own* figures are easily possible. Strategic thinking is not merely an exercise; at the computer-screen it becomes business practice. In the face of real data from one's own company any of the many variants of forthcoming decisions can be simulated in realistic scenarios.[64]

5. Summary

The authors are putting forward the thesis that the mathematics of linear equational systems (LES) are the basis of double entry bookkeeping. If this is the case, then the *"structure of linkage of the Statement of Cash Flows with the opening and closing balance sheet and the Statement of Income"*[65] can be presented algebraically by an LES. An LES is not some constructed or assembled model, but a basic mathematical-algebraical structure. It is described by means of "coefficients" and "variables". While the coefficients for a certain LES are unchange-

[62] See "Computer und Kultur prägen die neue Welt der Weiterbildung", "Blick durch die Wirtschaft", 22. September1995.
[63] Compare Fn. 5
[64] See also WirtschaftsWoche Nr.7/11.2.1994, p.70 onwards "Planspiele - Künstlicher Kosmos". At the Massachusetts Institute of Technology (MIT), USA, there are learning laboratories. Project teams or whole company boards simulate strategic moves in so-called microworlds. In principle the Input-Output-Simulation is the most suitable instrument for this.
[65] Busse von Colbe (Fn.14).

able (they algebraically describe the *structure of linkage*) the variables can be altered at will. If the LES has as many equations as variables then *one* variable is always the definite quantity of solutions of all the remaining variables. This theoretical insight is made practicable with an LES-solving computer-algorithm. Its application - as well its formulation - is, admittedly, not possible without the use of modern Unix-workstations with X-Windows and OSF/Motif-interface.[66] The Input-Output-Simulation[67] relieves the user (be he an advocate of classical accountancy or a planner) of all considerations with regard to the "strict standards of a consistent accounting system"[68]. While the use of the LES guarantees this standard, modern computer technology makes for an instant linking of accounts. Balance sheet policy makers, financial planners, controllers and the company management, but also advisers to the management, auditors, supervisory committees, analysts and administrators in bankruptcy proceedings can concentrate fully on the variable model construction, i.e. the design of any number of business scenarios. The values for the statement of cash flows, the statement of income, the opening and closing balance sheet with the ratios of the capital structure, as well as the profitability and productivity, resulting from the running of the scenarios, can immediately be read off the screen and/or be printed out in form of computer tables and computer diagrams. With the help of "Computer Based Training" the Input-Output-Simulation could, because of the simplicity of its mathematical approach, be extended to become the ideal instrument for the conveying of management knowledge and skills.

[66] For the realisation a client-server-model would also be feasible, in which a Unix/Linux-server or a Unix-workstation would be used for the calculations and an X-Terminal or a conventional PC with an X-Server function would be applied as the frontend for the user.

[67] See also Fn. 5.

[68] See also Hauschild/Leker (Fn.21), p.256: "The advocates of classical accountancy are backward-looking and not - or hardly - forward-looking. Typical planners, on the other hand, are not used to following the strict standards of co-ordinated accountancy".