Short- versus Long Term Dynamics

The Example of Ecological Management

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Abstract

The natural environment has become a public issue of high priority. One of the great challenges to the management of firms today is achieving a balance between the economic, social and ecological dimensions. Managers and organizations are learning that dealing with ecological issues seriously is part of their responsibility. In this paper, the inherent rationality of an ecologically oriented approach to management is highlighted. For this purpose, a conceptual framework for a comprehensive fitness of organizations is presented. Based on this framework and on case studies in small businesses a simulation model has been developed. The structure of this model is outlined. Then, on the basis of simulation experiments, several aspects of ecological management are discussed. The focus is on tradeoffs between short- and longer term decisions, as well as the role of pre-control, and the vulnerability of one-sided strategies are discussed.

1. Purpose and Scope of this Paper

The purpose of this paper is to highlight the role of the ecological dimension in the context of a management for the long term. The focus will be on small firms. These are exposed to arguments, which tend to be unbalanced. Either the

importance of the ecological aspect is underestimated, or they are considered the one and only panacea. Both of these extreme views are non-systemic. The former one is reductionistic, following a one-dimensional logic, often expressed as “The business of business is business.” It forgets that economic activity is ultimately hinges on ecological (and social) sustainability. The latter one is simplistic as well, because it forgets that ecological and economic viability are two sides of the same coin. It is not accidental, that recently many prestigious firms have made serious efforts to balance their economic, ecological and social goals.

Even though such a balanced view is rapidly becoming accepted in the corporate domain, there is still a lack of understanding and of conceptual tools to deal with the complexity faced by organizations. The Systems Approach provides a powerful methodology to make progress towards a systemic management, which copes with the challenge of dynamic complexity. Already these days, any small firm can take advantage of modeling and simulation to improve decisions. Most important, managers can face the short term serenely, avoiding much of the proverbial stress, if they take their current actions with a long-term view.

In the following chapters, a conceptual framework for ecologically responsible management will be presented (Section 2) and then operationalized in a System Dynamics model (Section 3). Also, the game version of the model (Section 4) as well as model validation (Section 5) will be addressed briefly. In the longest part of the paper, the dynamics of the model will be analyzed (Section 6). A brief outlook will conclude the paper (Section 7).

2. A Conceptual Framework for Ecologically Responsible Management

There is still a large gap in the business world, concerning the knowledge and awareness about the interrelationships between the factors, which govern ecological matters. One of the deficits, which have curbed ecological progress in the past, has been the lack of an appropriate language for dealing with the environment. Of course, managers have started to change their minds; they have become ecologically more sensitive. But they still need better theories and

better instruments to deal with the environmental issues effectively. In terms of semantics, a new „language“ is needed, because „we read unconsciously into the world the structure of the language“ (Korzybski, 1958), and the meaning of the constructs we use. The power of orientation furnished by established theories of management is only strong with respect to the short-term horizon; until recently they had little solid to say concerning the long run.

Systemic thinking offers new possibilities to solve the conflict between the two domains of interest. A management-cybernetic theory of pre-control in corporate management has been developed[1], which shows the path leading beyond intuitive claims for an "ecologically responsible management".

Due to the theoretical progress made, an ecological approach to management need no longer be doomed as irrational or romantic. On the contrary, what becomes evident, is the inherent rationality of an ecologically oriented thinking, which transcends the boundaries of the traditional “business way of looking at things”. I shall outline this briefly by means of the following framework for a comprehensive organizational fitness, which has also been called “Framework for Systemic Control” (Figure 1).

[1]Schwaninger, 1989; see also: Schwaninger 1990, 1993.

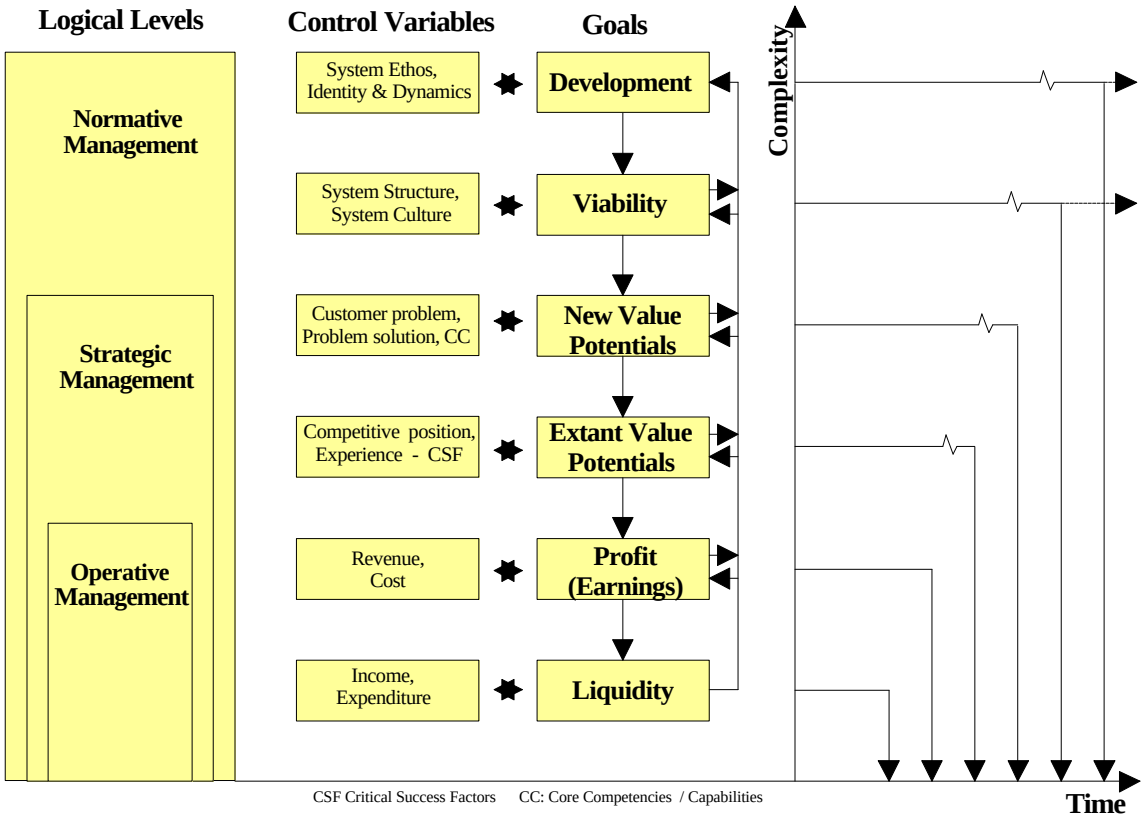

Figure 1: Framework for Systemic Control:

Reference variables at three logical levels of management

This conceptual framework has been expounded in detail elswhere[2]. It has not only been implemented in real business. Also, empirical studies have shown, that it is highly effective as a tool to support conversations a) among managers, and b) between managers and other stakeholders, namely in strategy-making (Schwaninger, 1988, 1989, 1997).

This scheme represents three different logical levels of management (operative, strategic, normative) with the respective goals and control variables relevant at each one of them[3]. Beyond the traditional orientors, profit and liquidity, insights

[2] The framework is also expounded, in more detail and at a higher level of generality, in Schwaninger 2001.

[3] Specifying these concepts in detail would reach beyond the scope of the present paper. A detailled derivation and specification of this framework and the notions contained therein were undertaken earlier (Schwaninger, 1989, pp. 169-215, in particular; see also: Schwaninger, 1984, 1993).

into categories, which operate in larger horizons of time and complexity, have been gained: Value potentials (or earnings potentials), viability and development.

These are more than just new words but they represent categories, which we have the means to calculate, to foresee their patterns of behavior and to influence (“control”) them. On the one hand, the three logical levels shown in the diagram represent different perspectives, none of which can be set aside for a company to prosper. The subject 'ecological management' has different meanings on each one of these levels; all of which must be taken into consideration, simultaneously:

- On the *operational level* the criterion of organizational fitness is efficiency, namely in terms of productivity, profitability, and quality. There are many ecologically oriented measures that directly impinge on profit. Many of them are a gain on both sides: Energy savings, for example, relieve the environment and reduce costs at the same time. As the costs of insurance, waste disposal etc. rise dramatically, it is prudent to avoid them from the beginning. In these cases it is simply rational in a financial and economic sense, to manage ecologically.
- On the *strategic level*, the criterion is effectiveness, which includes competitive and cooperative effectiveness (competition can spur cooperation, and vice versa). A strong market position in an ecologically sensitive market constitutes an excellent prerequisite for good earnings in the future. But sacrifices in the present such as investment in core competencies, for example via R & D and human resources development, which reduce profits (-) in the short term, are usually necessary to build up such value potentials (+). Beyond that, an ecological orientation is also apt to improve the competitive position in human resources markets.
- Again, another logic applies at the *normative level*, where the ultimate criterion of organizational fitness is legitimacy, i.e. the ability of a company to match the demands of all key stakeholders. Stakeholders include such groups as customers, staff, shareholders, allies, the State, the public and even future generations (represented by those who speak up for them). It

would be shortsighted to curtail the ecological aspects to the financial and the market rationality only.

At the normative level, the logic of culture and of social, ethical and esthetical values applies. Here managers have the widest field to creatively shape the destiny of their company (and of its environment). One option often insufficiently considered is to refrain from detrimental programs (by the way, more companies went broke from *not* refraining than from refraining).

If legitimacy is to be attained, normative management has to reconcile internal and external demands as well as the economical and ecological imperatives.

An essential insight expressed in the framework presented is about the pre-control-nature of the control variables of the logically higher levels with respect to those of the lower ones (cf. Gaelweiler 1990): Value potentials pre-control values delivered to stakeholders (e.g. profits delivered to shareholders); viability pre-controls value potentials, etc. A process controlled for profits (with revenues and costs) cannot be pre-controlled with these same levers. As outlined in the framework, other variables have to be used for that purpose. In sum, an integral model of management, which transcends the dominant logic of financial/economic steering, can be conceived rationally and accurately, not only in an intuitive, fuzzy mode.

So much on the new perspective proposed and needed. In practice, the attainment of a comprehensive organizational fitness requires managing the control variables on all three logical levels - operative, strategic and normative management - simultaneously. Balance must be maintained, even if contradictions between the imperatives of the three levels occur.

Simulation, eventually combined with optimization methods, is a viable approach not only for operationalizing the theory outlined here briefly, but also for helping managers to hone their skills of balancing complex decisions. For this purpose, a system dynamics model has been designed, which embodies the core of a „microworld“ for managerial training.

This conceptual system of multilevel control variables gives substance to the vague concept of "ecologically responsible management". It has been operationalized in a System Dynamics model with approximately 60 variables.

3. Outline of the System Dynamics Model

The model draws on qualitative insights gained from case studies of small and medium sized firms, in which the ecological dimension of management was studied. It was implemented, with the help of my research assistant Stephan Büttner, on the basis of the Stella software, and for the purpose of training (students and executives of small and medium-sized firms) as part of a case study called “Impraeg AG”. It comprehends five modules (Figure 2): Marketing, Production & Technology, Human Resources, Ecological Management, Finance. Due to the clear conceptual basis, it was possible to build a fairly comprehensive model, yet from a relatively small number of variables, altogether about 60.

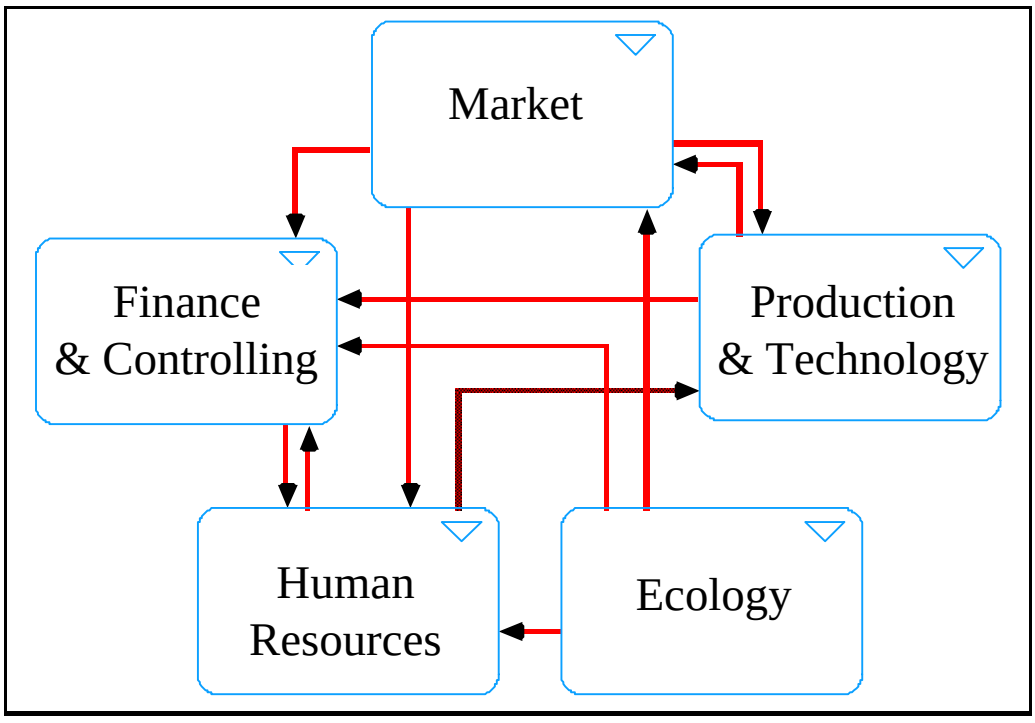

Figure 2: Modules of the model

The stocks-and-flows-diagram is documented in the Appendix. The logic of the model and the equations shall be elaborated separately in more detail (Schwaninger, forthcoming), which would be beyond the possibilities of this paper. In the following, the logic of the five modules will be outlined in a condensed way; the names of model variables are typed in italics:

1. *Market:*

Impraeg operates in a market described by the stock *Market Volume*, which grows as a function of a *Market Growth*, which starts at 25% per annum, approaches saturation and then decline. *Demand* for Impraeg's product is triggered by the *Relative Competitiveness* (which is a function of the product's *Quality* to *Price* Ratio and *Ecological Image*) and Impraeg's *Marketing Effort*. *Sales* volume is the minimum between *Demand* and *Finished Products* in stock, *Market Share* the ratio of *Sales* to *Market Volume*. *Output* to be produced is set by the model users, hereafter called "players".

2. *Production & Technology:*

This module is about Research and Development and the Production process. Players can change three parameters:

- *Quality Management* effort, which impinges on *Output per employee* (a measure of productivity), *Product Quality* and the cost of *Defects*.
- *Salary per hour* for production employees, which influences *Cost of Labor per Unit* produced.
- *Cost* for *Research and Development* (R&D) which triggers *R&D intensity* and the level of *Process Maturity*.

Output per employee is determined by three values, those of the Quality Management parameter, and the variables *Process Maturity* as well as *Performance level*. The latter comes from the Human Resources module. *Process Maturity* is also a function of the *Experience* curve (In line with empirical evidence (cf. Ghemawat 1985, Henderson 1974) a gradient of -0.25 is assumed, i.e. unit cost is reduced by 25 percent with each doubling of cumulated output).

3. *Human Resources:*

This module is mainly about human factors influencing the performance of employees. The *Performance level* is a function of *Motivation* and *Qualification level.* The latter accumulates or degrades depending on the level of *Training expenses* (a parameter set by players). *Motivation* is also stock, fed, on one hand, – via a feedback loop – by *Performance level*. This corresponds to the need for achievement, emphasized by motivation theory. On the other hand, the *Salary* level and Impraeg's *Attractiveness as Employer* impinge on *Motivation* (cf. Herzberg 1987), the latter being calculated as a weighted average of *Quality of Workplace, Intensity of Training, Profit Level* and the firm's *Ecological Image with Staff* as well as its general *Ecological Image* (i.e. its image in the marketplace).

4*. Ecological Management:*

In this module, players can adjust three parameters:

- The cost spent on *Environmental protection*, which influences the level of environmental protection and thereby both, Impraeg's general *Ecological Image*, and its *Ecological Image with Staff*.
- The cost spent on *Promoting Ecological Consciousness of Staff*. This impinges on the *Level of Environmental Protection*, via changes in *Environmental Consciousness of Staff*.
- The cost spent on *Ecological PR* (Public Relations), i.e. on efforts to make the efforts of environmental management known. PR does not change *Ecological Image* on its own, but only in conjunction with the actual *Level of Environmental Protection*.

5. *Finance:*

In this module all the decisions and processes coming from the other modules are modeled as to their financial consequences, resulting in the values which constitute profit and loss statement and balance sheet.

Profit and Loss values: All the cost components are aggregated in the variable *Costs*. *Sales* and *Costs* result in *Earnings before Interest and Taxes*. Based on

the respective values, different levels of *Profit – before taxes*, and *after taxes* - are calculated.

Balance Sheet values: *Current Assets* are the sum of *Goods in Stock, Debtors & Liquid Assets. Fixed Assets* are calculated as a fixed initial value plus a variable component which depends on the level of *Output*. Debt is the difference of total assets minus *Equity*. The initial value of *Equity* is over time changed by *Profit after taxes*, which a) is reinvested (inflow), in case it is positive, and b) diminishes *Equity* (outflow), whenever it is negative.

Finally, a number of indices is calculated, the most important of which also appear on the overview in the Cockpit: *Debt Ratio*, *Return on Sales, Return on Capital*, *Return on Equity* (Figure 3).

4. The Game Version of the Model

We designed a case study around the model, which relates to a producer of chemical products and allows players to take decisions affecting anyone of the modules over a number of rounds (representing quarters of business years).

Besides the usual „cockpit“, in this case with five decision levers for production and marketing, three for human resources and three more for ecology, as well as key financial indicators (capitalization and profitability indices), profit and loss statement and balance sheet (Figures 3 and 4), the layout for the simulation game provides alerts (e.g. whenever a decision leads to an equity/capital ratio lower than a defined threshold, the player is alerted). Furthermore, graphs showing the evolution of stock variables, e.g. equity, over time, form part of the standard layout. These devices have allowed for increasing the scope and number of potential decision levers, in order to help players enhancing their skills for coping with complexity[4].

[4] Some experts of the simulations and games community have pleaded for limiting the number of decision variables to 5 or 6.

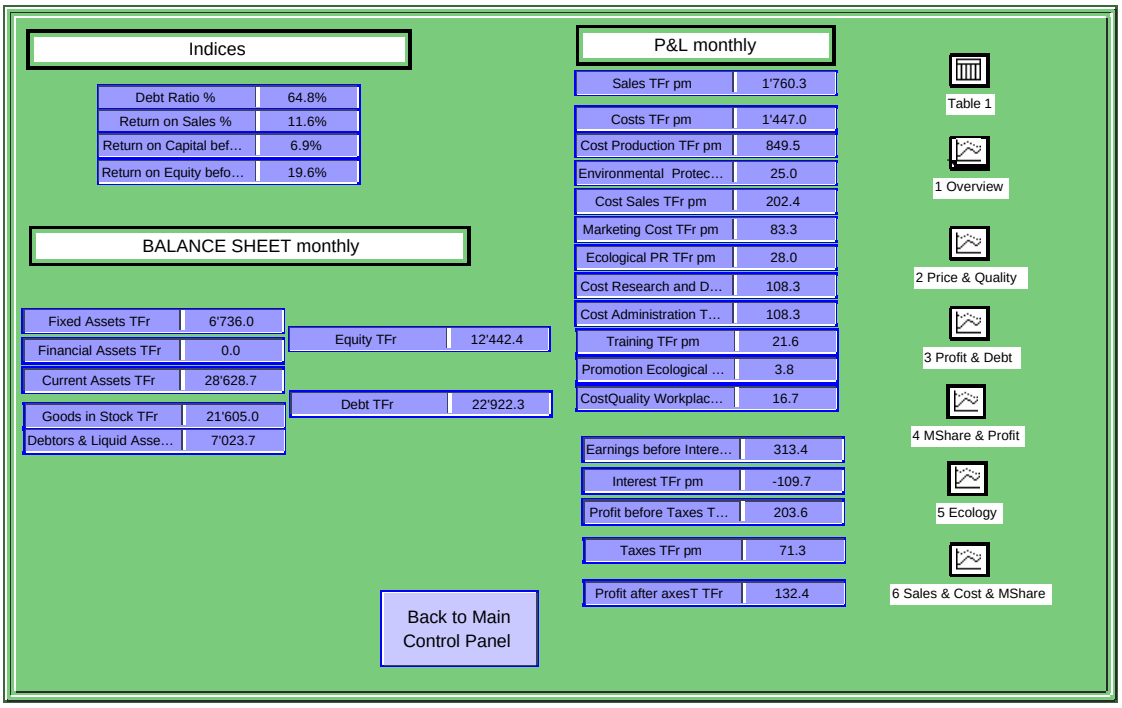

Figure 3: Cockpit I - Results

The model runs in monthly periods, the default version being set at quarterly decision intervals. In other words, the model runs each time for three months, then decisions can be made. The decision intervals can also be set differently, and they can also be eliminated altogether, e.g. for the purpose of scenario analysis.

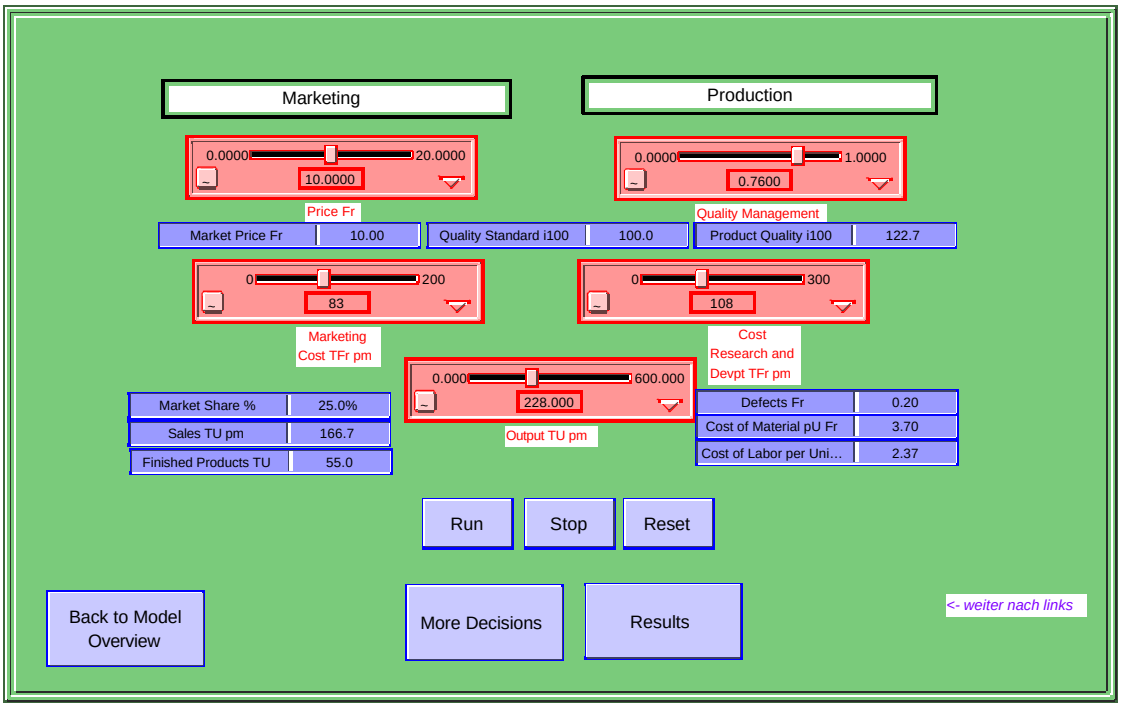

Figure 4: Cockpit II – Control Panel

5. On Model Purpose and Validation

The model was inspired by numerous case studies realized on ecological management in small industrial firms, and by one business unit of a real firm in the chemical industry of Switzerland, which operated in a market with a handful of players. However I cannot claim that this is a fully validated model; it is rather work-in-progress.

The purpose of the model was twofold. First, to formulate a model which incorporated social and ecological aspects, besides the usually included aspects of market, product and finance. Even though this implied a necessity to use qualitative variables, difficult to measure and validate, it appeared to be necessary to start with a model that would make these aspects discussable and allow to improve them consecutively.

Second, a model to highlight some aspects of management with students was desired, namely a) tradeoffs between short- and longer-term oriented decisions, and b) the necessity of taken multidimensional decisions in complex settings.

The model was submitted to validation procedures involving several structural and behavioral tests[5]. The most important aspect of validation at this stage was careful choice of the variables to be included and of their interrelationships. Wherever possible, these relationships were defined on the grounds of cogent logical links, e.g. where accounting figures, financial indicators, market volume, product output and stocks were calculated. Furthermore, empirical studies were used to define relationships, where available, e.g. in the case of the experience curve in production and motivation theory in human resources management. Where such a basis was not available, ad hoc assumptions had to be made and tested for their plausibility individually.

6. The Dynamics of the Model

By means of a number of scenarios, several important lessons about the dynamics of the model have been learnt, a few of which shall be recapitulated here. All of the runs were realized without changes of the parameter values over the period under observation.

1. Base Scenario

A Base Scenario run over 48 months shows the following development (Figure 5).

[5] For details, see: Barlas, 1996, and literature indicated therein.

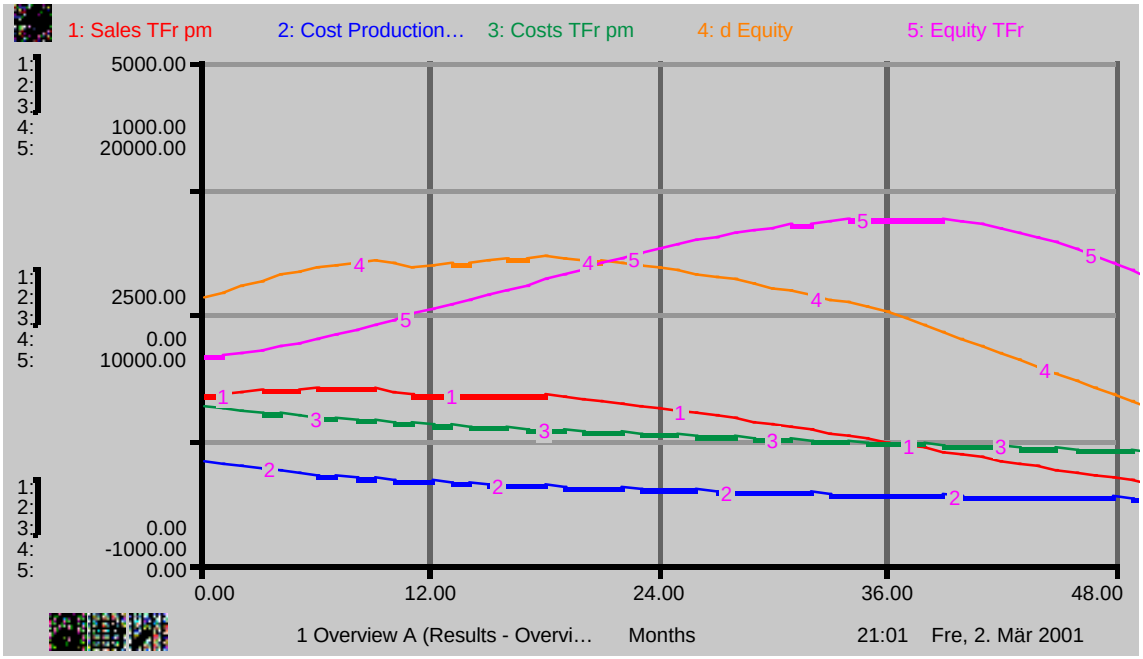

Figure 5: Results – Overview (B)

The firm will build equity, uninterrupted for three years (curve 5). Its premium strategy – high quality, high price apparently pays off. However, as the first derivative of equity (*d Equity* variable, curve 4) and the sales curve have heralded early on, this process is reversed, leading to a loss of equity at a growing speed, starting in month 39. One could insert, that the situation is not grave, - after four years the equity and the debt ratio are about the same as at the beginning. An inquiry into the causal relationships as unveiled by Figure 6 suggests a different diagnosis.

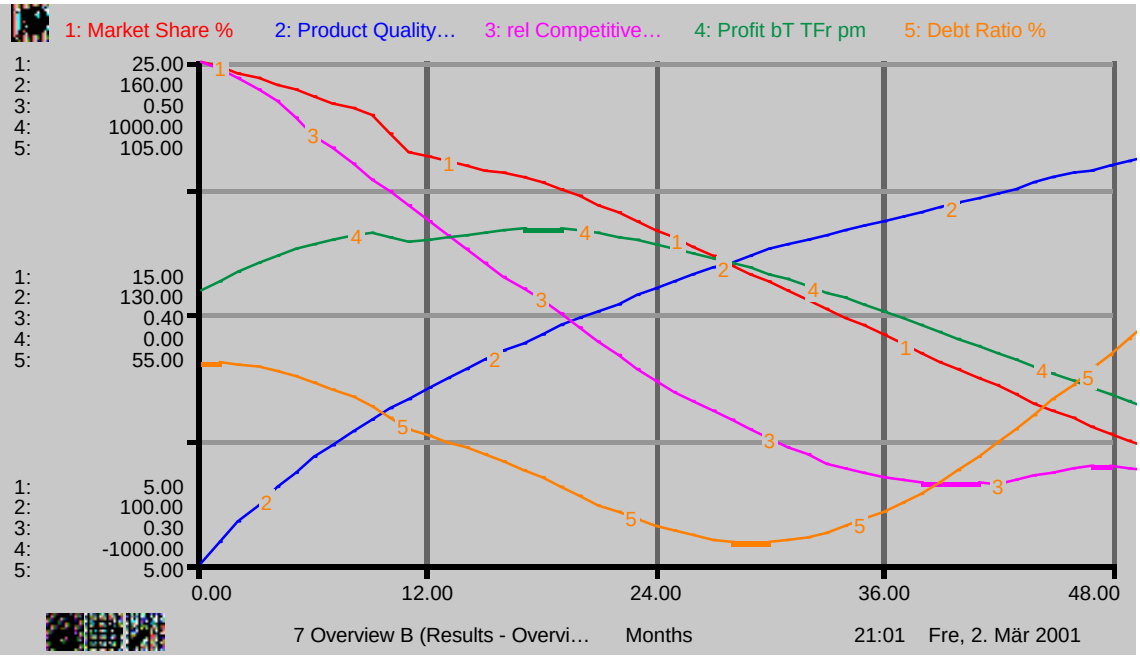

Figure 6: Overview (B)

This graph visualizes a continual loss of market share, due to overpricing despite a gradual reduction of the market price level. Even though the level of product quality rises substantially, the relative competitive position is subject to erosion from the beginning. With a time lag of about one and half a year this induces a sustained decay of profit and ultimately losses, with a consequent rise of the debt ratio. This evolution is exacerbated if the time horizon is extended: The company is inexorably bankrupt after 63 months.

This case in point clarifies the contradiction between the *short and the long term* addressed above: Profit is an inherently short-term variable of the operative level. The variables, which pre-control it – quality, competitiveness and the like, obey a different logic, which is linked to the different time constants involved.

In the following, different strategies will be examined, pricing, quality, ecology.

2. Pricing and Quality Scenarios

Given the problem of overpricing in the base scenario, in the following runs, the price level was changed. The behavior is highly nonlinear, but in sum all of

these scenarios prove to be economically unsustainable sooner or later, i.e. bankruptcy occurs sooner or later (Second column, Table 1).

Price	Out of business after ... months	Remarks concerning price level
7	36	Minimum
8	68	
9	69	
10	66	Base Scenario
11	62	
12	59	
13	52	
14	46	
15	42	Maximum

Table 1: Variants of pricing strategy

Alternatively the variants of higher investments in Quality Management (TQM level) were examined. This strategy proves to be much less vulnerable, yet still insufficient to provide unconditional viability (Table 2). Even though profit and equity are boosted for some time, in the long run, as the quality standard in the market rises, i.e. as competitors also succeed in rising their quality levels, while the average market price level slowly erodes, profitability shrinks and eventually turns negative.

QM Level	Business loses money after ... months	Out of business after ... months	Remarks concerning QM-level
0.5	36	66	Base Scenario
0.6	41	74	
0.7	47	83	
0.8	53	93	
0.9	60	105	
1.0	68	118	Maximum

Table 2: Variants of quality strategy

3. *Ecology as part of the strategy*

The next question examined is whether an investment in ecological management can turn a strategy more robust. For this purpose, several of the scenarios examined up to this point were simulated. In all cases, the efforts on the ecological decision variables were doubled throughout[6].

The enhanced effort in ecological management leads to the following results:

3.1. *Variations of Price:*

3.2. Table 3 shows, that the life span can be extended significantly in the scenarios examined (except the one with the very low price of 7), in comparison to the results exhibited in Table 1. In other words, the ecology strategy alone cannot solve the problem of economic viability.

Price	Out of business after ... Months	Change of life span in months	Change in %	Remarks concerning price level
7	27	-9	-25	Minimum
8	88	20	29	
9	89	20	29	
10	82	16	24	Base Scenario
11	76	14	23	
12	69	10	17	
13	64	12	23	
14	60	14	30	
15	53	11	26	Maximum

Table 3: Variants of pricing strategy with enhanced efforts on ecology[7]

3.3. *Variations of Quality:* Table 4 shows that the life span can greatly be extended, in comparison to the results exhibited in Table 2, if efforts on ecology are increased. In other words, a strategy that combines quality and ecology is more promising, than a quality strategy alone.

[6] Cost of environmental protection (50000 instead of 25000 Fr. per month), spending on promoting ecological consciousness of staff (9000 instead of 4500 Fr. per month), ecological PR (34000 instead of 17000 Fr. per month).

[7] In the scenarios summarized in Table 3 the fact that the business-in-focus could survive at all with prices at roughly twice the market average (Fr. 7.32) is explained by increased retreat to special segments with low price sensitivity.

QM Level	Out of business after ... months	Change of life span in months	Change in %	Remarks concerning QM-level
0.5	82	16	24	Base Scenario
0.6	98	24	32	
0.7	117	34	41	
0.8	142	49	53	
0.9	178	73	70	
1.0	227	109	92	Maximum

Table 4: Variants of quality strategy with enhanced efforts on ecology

These results generated by the model are by and large corroborated by empirical studies (cf. Meffert/ Kirchgeorg 1992; Dyllick/ Belz/ Schneidewind 1997.). Even so, the results summarized in Table 4 suggest that this strategy is not indefinitely sustainable economically, despite the promising picture conveyed for a shorter time horizon (Figure 8).

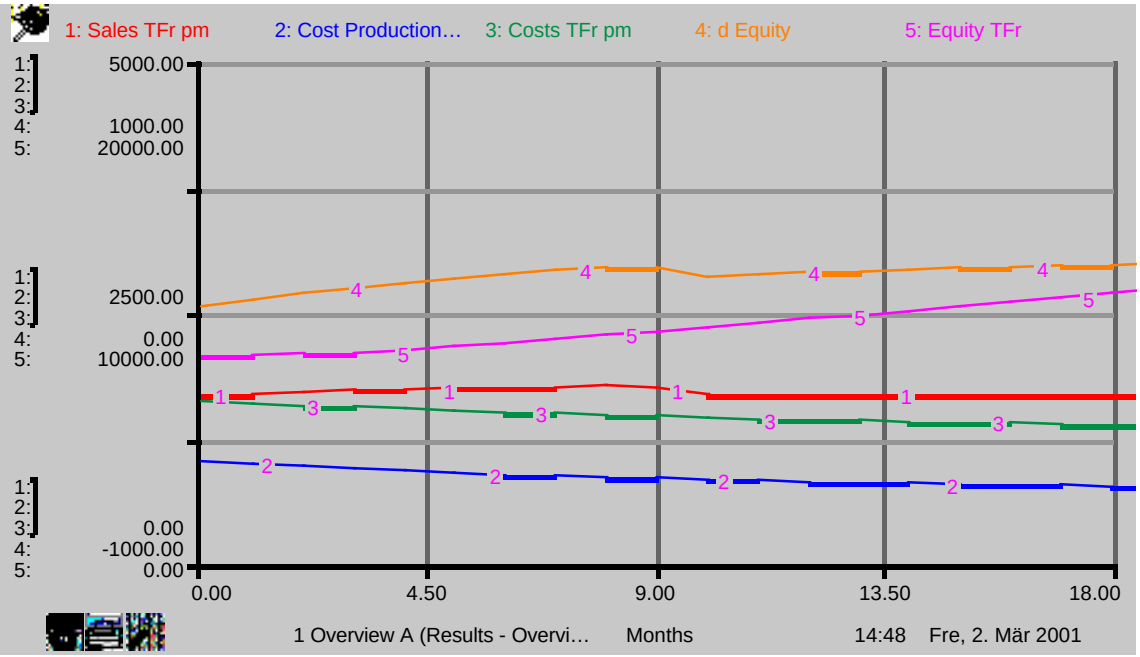

Figure 8: Short term results for Base Scenario with increased efforts in ecology

Finally, exploratory scenarios with various decision levers have shown that the economic viability can be greatly extended. For example, by increasing

spending on R&D, Marketing and Training of Staff in a balanced way, in addition to the adjustment of quality and price, our firm can reach a dominant market position, and hold it for a long time, without changing the strategy.

4. One-sided strategies versus multidimensional strategies

The analysis up to this point illustrates that advances towards sustainable strategies require a combined activation of different decision levers, which are complementary. Pursuing this logic further, in the following a combination of three aspects of strategy will be tested, - price, quality and ecology. A number of scenarios were examined. For all of them, the ecology parameters were doubled in relation to the values of the base scenario (values were given in footnote 7), while the values for price and quality were varied. Figure 12 summarizes the values for equity generated in each scenario over t=72 months.

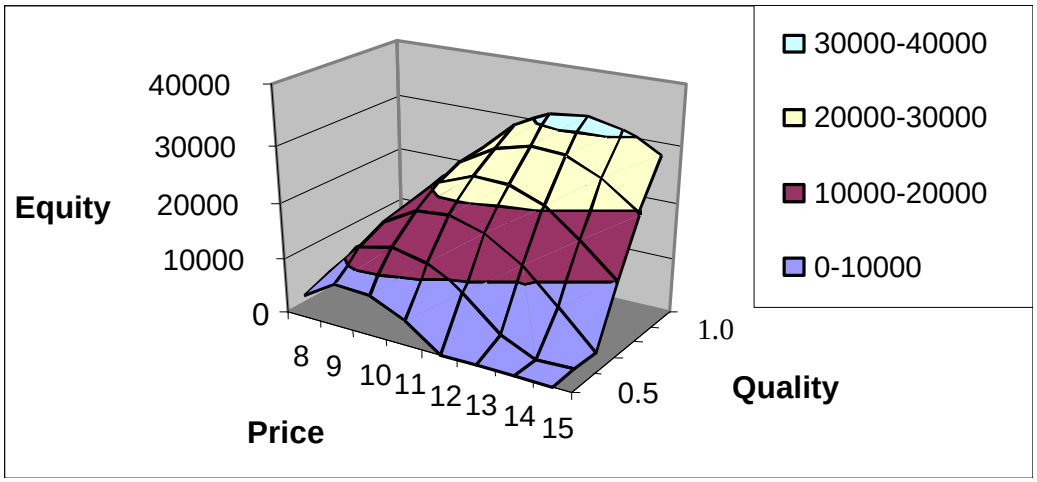

Figure 12: Results of scenarios for high ecological commitment with variations on price and quality effort

In those cases, which show an equity of zero, bankruptcy was the case at t=72 or earlier[8]. This applies for low levels of quality effort with high prices, despite the ecological commitment. At too low price levels bankruptcy follows early on, even if high quality efforts are made; e.g. at price of 7 bankruptcy follows after

[8] For Quality=0.5 and for Price={12,13,14,15} at t={69,63,62,65). For Quality=0.6 and for Price={14,15} at t={69,62}. For Quality=0.7 and for Price=15 at t=72.

between 21 months (for quality = 1.0) and 27 months (for quality = 0.5).[9] The graph also shows that, provided ecological commitment, a high price strategy can be maintained if adequate quality efforts support it. These have their limitations, not only in the price sensitivity of the market, but also in the limited size of price-insensitive segments. The superiority of these multidimensional strategies is visible alone from the fact, that the life span exceeded that of one-sided strategies (only price, cf. Table 1 or only quality, cf. Table 2) in all cases.

5. Ecology as strategy

Up to this point, only three variables have been examined as components of ecological management, - Cost of environmental protection, Promotion of ecological consciousness of staff, and ecological Public Relations. A strategy, which would rely on these three or a similar set of variables only, should not be called “ecological strategy”. Spending on environmental protection tends to account for “end-of-pipe” measures, and spending on ecological PR does not say anything about the substance of ecological activities of the firm. A genuine ecological orientation characteristically pervades all areas of an organization, and is not limited to the punctual manipulation of a few variables that wear the label “ecological” (cf. Schwaninger 1990).

In this vein, the ecological dimension is implicit in many variables of the model expounded here. For example, the concept of Product Quality immanent in the variable of that name is not confined to the conventional attributes of quality, but includes to a large extent aspects of ecological benefit for customers. Similarly, spending on R&D, e.g. for “clean processes” or for products with environment-friendly properties, Training of staff etc., are manifestations of the quest for ecological progress, as also manifested in the organization under study. For this reason, in the model at hand, only the more conventional aspects of ecological management, easy to be separated, are expressed in a small number of variables, and clustered in a separate module. Overall however, the model conceives of the ecological dimension as an integral part of the business process and its management.

[9] The scenarios for Price=7 are not pictured in the graph.

Finally, it must be noted, that the present model relates to a situation of five competitors, all of which – due to a new technology - have an ecologically high-performing product with similar features. For cases, where additional differential value could be created by ecological product design (e.g. in certain segments of the food market), the model would have to incorporate new features and the dynamics would change concomitantly.

7. Outlook

At the outset a conceptual framework was presented to highlight the rationality of an ecological approach to management. The framework is based on a logical distinction between three levels of management. Each one of these levels shows different control variables, with a pre-control relationship between those of the higher in relation to those of the lower levels. In order to achieve a comprehensive organizational fitness, it is necessary to maintain the variables of all levels under control simultaneously, in the longer run. For this purpose, a System Dynamics model can be of great help.

In this paper, a model has been presented, which includes control variables of all three logical levels. Certainly, the operative level is represented in more detail and clearness than the other two levels. This is due to the fact, that the modeling of the pertinent variables and relationships, which refer to liquidity and profit, can build on a long-established method. This is the method of double entry book-keeping (introduced by Fra Luca Pacioli, in 1494). The variables at the other two levels are less established, the pertinent methodologies less mature and “softer”. Nevertheless, it is necessary to make efforts for incorporating them into the models. Several variables of the strategic level have been included. These relate mainly to extant value potential, - competitive position and experience. Some aspects of new value potential, namely core competency have been incorporated in the human resources module others would require an enlargement of the model (e.g. new problem solutions / value propositions, and related processes of technological substitution). The aspect of normative management modeled is related to organizational ethos and culture, namely environmental consciousness.

Many of these qualitative aspects have not yet been sufficiently developed for accurate representations. Yet to make progress towards valid models tentative modeling of this kind are necessary, to make proposed variables, parameters and relationships at least discussable.

The model outlined here is work-in-progress. The experiments documented here are only steps towards a better model. But they may also be of some didactical value. For a start, they at least illustrate the tradeoffs between short- and longer term decisions, the importance of pre-control and the vulnerability of one-sided strategies.

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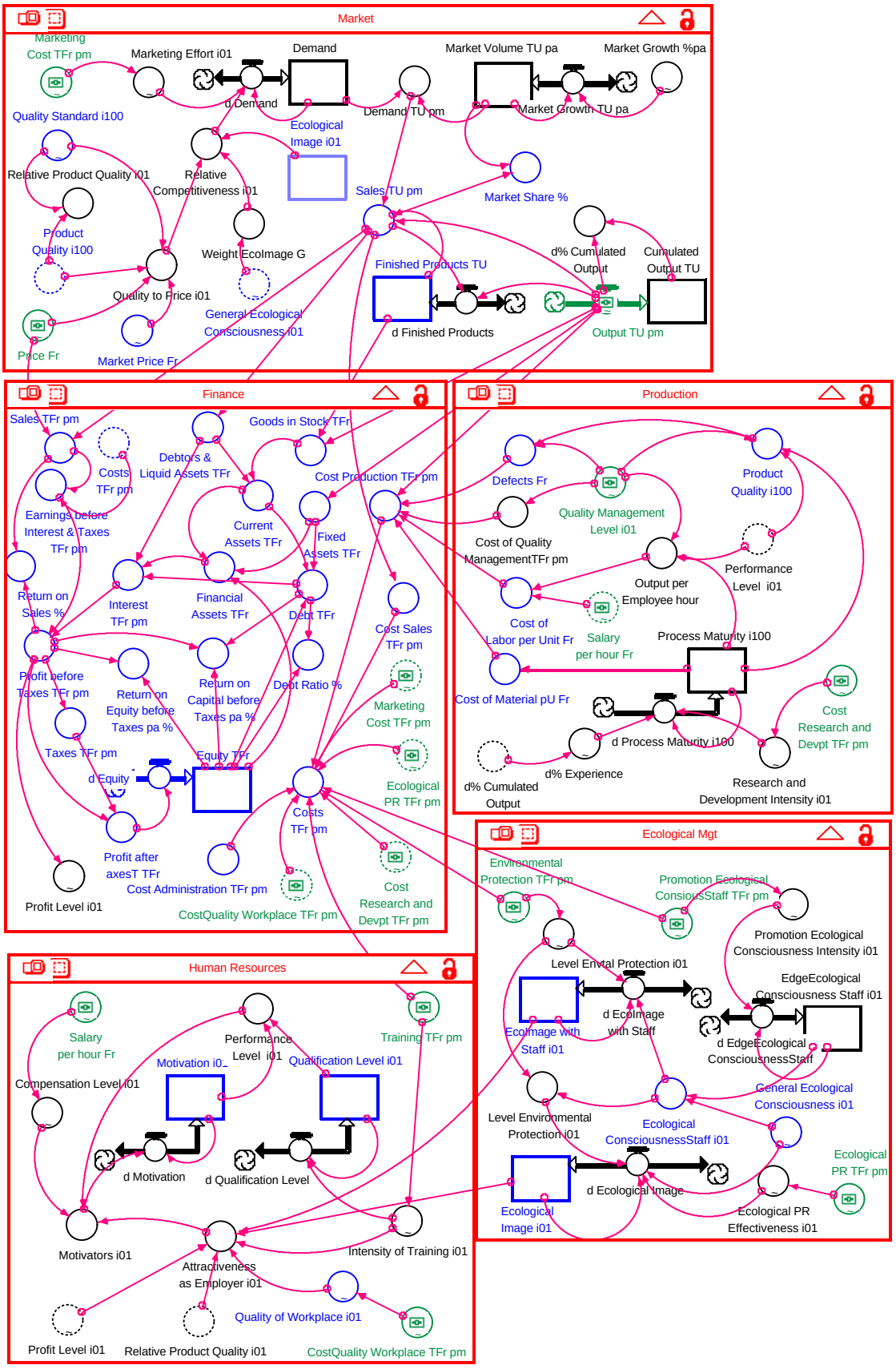
Appendix:

Stock-and-Flow-Diagram



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