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An elementary dynamic model of a small start-up firm

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Abstract

A system dynamics model of a small start-up firm has been built. It includes assumptions, key variables and causal relations as described in business economics literature. The main motivation for building this model is to bring a dynamic perspective to university education in the field of business economics, especially management accounting and control systems. Some special assumptions and parameters reflect the specifics of a particular start-up firm in an attempt to get the simulation results close to real financial performance. The results of the simulation runs mirror the same growth patterns observed during the first three years of the firm's existence. The model can thus help an entrepreneur to understand growth paths in subsequent years.

Keywords

System dynamics; theory of the firm; modelling;
Small and medium enterprises (SME)

1. Introduction

The aim of the research presented in this paper[1] is to develop, model and understand the critical influences of variables which determine the basic characteristics of a firm as assumed in business economics literature. The main motivation is to bring a dynamic perspective to university education in the field of business economics, especially management accounting and control systems. Textbook literature in this field does not present a comprehensive model of the key interrelationships in an enterprise – neither a dynamic nor a static one. An understanding of such interrelationships is a necessity for postgraduate students of business administration.

There is another challenge to German universities. Business graduates are increasingly expected to found small enterprises and the universities have to teach the essential knowledge concerning the basic elements of such firms, their characteristic behaviour and their typical

[1] The authors thank an anonymous referee and Prof. Dr. Carmine Bianchi for comments on a first draft of this paper.

decision problems. These challenges are in agreement with Forrester (1958, 26) who saw the need for the "training of future managers … to improve their understanding of the interrelationships between separate company functions …. To set up a dynamic model for simulating company or industry behavior, one must adequately describe the real system which it represents. Getting the data will often be difficult. However, the kinds of information needed involve the basic characteristics of the company … the same items that one considers and tries to interrelate in the everyday management of a business."[2] After ten years he saw again the transformation of Industrial Dynamics into "a central core to unify management education" as a task ahead.[3] Even now in 2002 the topics of marketing, accounting and the other management functions are frequently taught as separate disciplines.

The dominating concept of interrelationships of a business firm has been the production function originating in the microeconomic theory of the firm. However this function reduces a real enterprise to 3 - 4 variables. The theory mainly uses static models, most of them built in the econometric tradition - if time is incorporated at all. Few models claim to show empirical relevance – using empirical time series - and the results of this research are rarely challenged by independent research and validation efforts. For example, Albach (1986) uses a production function with 3 variables in a model with approximately 15 variables.

Whereas this research is concerned with the theory of a whole firm – even if reduced and static - the System Dynamics literature is mainly concerned with partial models which describe the dynamics of some problem or a part within a firm (see e.g. Sterman, 2000, Schöneborn, 2001). Sterman demonstrated ways whereby different parts can be connected. Few exceptions concerned with the business dynamics of a whole firm are to be found and undoubtedly the relatively complex models of Zahn (1971), Coyle (1977) and Lyneis (1980) stand out. Initially, we made an unsuccessful attempt to replicate the Lyneis' model[4] for university teaching but reached the conclusion that for teaching purposes, other than specialised SD courses, we should create the simplest possible model of a whole firm.

In this paper we attempt to create a simple dynamic model of a whole firm that can be used by the university in management and control systems. This approach is near to Forrester's (1968) "market growth" model [5] in the sense Sterman (2000, 605) characterised it: "...Forrester set out to create the simplest possible model that could still capture the key decision rules of the entrepreneurs and chief executives he knew." The purpose of our model is to create the simplest possible model of a firm that captures the essential variables of the theory of a firm as treated in different fields of management education and at the same time display the growth behaviour of a small start-up firm.

The purpose of the model can be a theoretical one: to extend the static theory of the firm to a dynamic theory, to explore the addition of variables into the theory or to falsify the theory by

2 Forrester (1958, 25)
3 See Forrester (1975, 133, 148)
4 Schwarz and Maybaum (2000)
5 (see also the version of Sterman (2000, 605 ff.))

model experiments founded on observed, exactly measured, empirical data. It can be a practical and singular purpose: to solve a problem founded on similar data for a client. It can be a practical purpose that tries to be general. Sterman (2000, 605) characterised Forrester's "market growth" model this way: " Though based on the case of a particular firm, the model is quite general and its lessons apply to growing organisations in any industry".

Our orientation is much the same, but the purpose is somewhat different. We focus on the purposes of university education in management control and accounting specialisation for industrial engineers and on cash flow management as the condition 'sine qua non' for a successful growing firm. So the purpose setting the boundary of the SD model is educational: to bring dynamic perspectives into management education in different fields.

We start with the "basic characteristics of the company" and the elements found in the generalisations of the theory of the firm: Labour and capital are combined to produce an output as a supply that meets a demand. The firm tries to maximise its profit in the long term. Part of the profit is reinvested to support the growth of the firm. The theory of the firm generally describes the firm as a system. It uses stylised facts. This abstract and static model of a firm is the basis of university teaching in business economics. Our objective, to complement the prevailing static models of business economics with a dynamic one, determines the selection of the elements or variables on which the model is based.

We assume that the basic elements of the theory the firm includes the minimum number of elements necessary for a viable firm in the real world. Typically they can be found in a successful small enterprise. This approach restricts the model to the smallest possible scale and at the same time allows empirical falsification of the model. Accordingly we investigated a small Internet firm founded by a private individual with restricted financial resources. The firm's policy focuses on profitable growth avoiding the risk of bankruptcy. The selection of the model's elements was based on the current literature on the dynamic characteristics of a small enterprise.

To summarise: The model is built to be used in university education. The objective is to improve the understanding of interrelationships that exist in small enterprises and the effects they have on their basic elements. It is intended to bring a dynamical perspective into business economics and the theory of a firm and simulate results that are close to real financial performance.

The main **assumptions for the model** are based on the theory of the firm and the essential characteristics of a small enterprise: **Labour** and **Capital** are the main production factors and, as in the production function, they create an output of a single type of product. It is a **one-product firm**. The flow of the production factors and the sales of the products are expressed in **money** terms as **revenues** and **costs**. Their difference is the **profit** that has to be maximised. Moreover the customer base (or customer stock) is an important **intangible asset** of the firm. Further assumptions relate to **specific characteristics of** this **start-up firm** i.e. there are the added features and services of an innovative product and the use of the

Internet for advertising. It ships the product in a traditional way. Profit making is the dominant short and long term objective for the entrepreneur. The value added capabilities of the firm are unique and its market is not contested in the near future. Market demand is growing. It is assumed that the product can be sold only once to each customer. (This assumption is a simplification of reality). Orders placed by customers are completed when products are in stock and when both the staff and capacity are available. The components of the product are purchased when orders arrive (This policy minimises storage and capital costs). There are no delays in payments by customers.

The growth of the firm is assured by hiring staff and by investments in physical assets. The entrepreneur decides to expand the firm's activities only when hiring and investing is based on his own capital. Liquidity is his main decision criteria in the start-up phase. The firm has no long- term credits.

2. Outline of the basic model structure

Considering these assumptions and the size of the company investigated, it is possible to develop a system dynamics model for a small firm that covers all relevant elements and relations.

The first step is to discern the relevant elements of the system and describe their interaction. Because of the entrepreneur's specific knowledge of his business, it was possible to construct the following causal-loop diagram (fig. 1) which includes all the above assumptions. The diagram also illustrates the dynamic relations within the business between product and market characteristics, customer and financial elements.

Beginning with the market potential for the firm's product, the central line in the diagram shows the core business chain from market potential to the sale of the product. Depending on customer orders, components are purchased which increase stock and storage costs. The products can be shipped if components are in stock and enough staff capacity is available. The number of orders processed and the number of products shipped influence the order backlog. If the order backlog increases, hiring of added staff is necessary to adapt capacity to provide customers with the product within an acceptable delivery time. The number of products shipped and the product price determine the revenue. An increase in revenue leads to an increase in liquidity and profit. Profit is calculated as the difference between revenue and costs (material costs, staff costs, depreciation, storage and marketing costs). In addition to the bank credit line and revenue, the liquidity depends on other variables. All unavoidable payments by the firm decrease liquidity: the amount of money for purchasing components, storage costs, staff costs, marketing costs, investments as well as a payment for the entrepreneur. The latter is possible only if the profit of the past period is positive.

These descriptions are policies that reflect the decision making of the entrepreneur. They can be altered. For example, instead of purchasing components only after customers order products, one could introduce a raw materials inventory. Instead of hiring more staff only when the order backlog increases, one could hire staff in anticipation of orders. One of these policies can be used as a reference mode. In our case we assumed the entrepreneur takess money from the firm whenever there is a profit. He could take money out when there is no profit, placing the firm in debt.

There are two basic feedback loops for the expansion of the firm that are both determined by liquidity as the main control variable. If the firm has accumulated enough liquidity this is invested in new experts (right hand loop) and for marketing (left hand loop). Hiring of new staff (when needed because of an order backlog) is given priority over marketing expenses. When new experts are hired an investment in equipment is necessary. Growth in staff and equipment allows for greater production. This is a policy decision. Instead of a marketing budget, after hiring extra labour and the purchase of equipment, money could be targeted to the three outlay areas: labour, equipment, marketing in advance. A third feedback loop reinforces new customers and customer stock. New customers are won through marketing efforts and site recommendations by former customers.

Based on these causal relationship between variables determining the growth of the firm, a system dynamics model was developed. The corresponding stock and flow structure of the system dynamics model is shown in fig. 2.

It consists of a customer sector with variables influencing the dynamics of new customers. The second part of the model represents the value chain of the firm: order processing, component purchase and product delivery. The third and most interesting sector of the model, according to the authors, captures the dynamics of the liquidity (represented by the bank account) which controls the growth of the firm. Revenue and all payments are modelled as flows. Further sectors include variables influencing the growth of staff and equipment as the main restrictions on capacity. Capacity expansion by hiring or investing is important for the internal growth of the firm. The feedback loop starts with budgeting where the financial opportunities as well as staff and investment demand and additional marketing activities are modelled. After staff and investment demand is covered a marketing budget is left which is used to acquire new customers.

The starting point of the model was the observation of a real start-up firm. One objective of this model was to get a simulation result that is close to the real financial performance of an observed firm. Therefore in the structure of the model as shown in fig. 2 some **specific assumptions** about parameters and initial values describe special features of the real firm:

- The entrepreneur takes 10 % of the profit made in the month before for private purpose. That pay-off decreases the bank account. This is a policy decision which one can change in the simulation runs.
- An increase in new customers is based on recommendations of former customers with a delay of one month. 10% of former customers give a reference for one new customer per month.

- The customer base will decrease by 15 % per month because of “forgotten service’ leading to less recommendations.
- The standard order rate is 1 product / new customer.
- The price per product is constant (750 Euros / product) and accepted by the market.
- For every product 1 component is needed. The price per component is constant (450 Euros / product).
- Storage costs are constant (35 Euros / product / month).
- There is a delay of one month between orders received and purchase of components.
- Normal staff capacity is 100 products / month / head. There are no differences in productivity.
- The bank account credit line is 10.000 Euros.
- If the bank account plus the bank credit is zero then there is no growth budget for additional staff, equipment or marketing.
- Staff is hired when a budget is available and staff is needed. Cost per head is fixed to 3.000 Euros / head / month.
- Additional investment in equipment is necessary for each employee hired. The amount to invest is 3.000 Euros / head.
- The depreciation period (lifetime) of capital assets is 36 months. There is a re-investing function with a delay of 1 month.
- The customers acquired depend on the marketing costs according to a table function.
- There is no need to fire employees if the firm grows.
- All customers pay 100% of the amount invoiced without any delays.

Some of these parameters can be changed according to the different strategic options of the entrepreneur. This will be the subject of further research. In the appendix all equations of the model are given. This allows the replication of the system dynamics model itself and the simulation results.

3. Results of the simulation runs

The simulation time is from 01/01/1999 to 01/01/2008 and the time step is one month. After running the simulation the results are displayed through spreadsheets and graphs. The following results focus on the dynamics of the growth of the firm using customers, orders, products, staff and capital assets as indicators as well as key financial figures.

The development of customers is shown in fig. 3. It consists of the customers who buy the product because of a recommendation of former customers (*customer rec*), customers acquired by marketing activities (*customers acq*), and finally the customer base as the sum of customers who bought the product in the past and are the base for recommendations. This base is diminished by a loss rate.

There is a sustainable growth of the customer base. Their recommendations bring new customers to the firm. During the first periods of the simulation the number of new customers acquired through marketing is oscillating because strong financial restrictions do not allow marketing activities in every period. After a time there is enough budget for marketing. Therefore the upper limit of new customers achievable by marketing (240 customers) will be reached each period. A further increase is not possible.

Figure 4 displays the development of orders and products shipped as well as the development of the components in stock. The oscillations of the customers in the first periods are mirrored in the dynamics of the orders received and products shipped. Any delay between orders received and products shipped is the result of restricted staff resources. If the capacity of staff employed does not meet the needs of incoming orders these orders will not be met despite the fact that there are sufficient components in store. Staff is expanded in discrete steps and fixed over certain periods. This explains the stepwise dynamics of products shipped in later periods.

An important and interesting indicator of the growth of a firm is the development of staff and assets (fig. 5). There is a growth in both variables. As assumed, the hiring of a new expert is an additional investment in equipment that the firm needs to process the products. Therefore the staff and the capital assets show the same time behaviour.

Revenues and profits are key figures for a firm's growth in the long term (fig. 6). Oscillations during the first simulation periods are due to orders received and staff restrictions. Products could be shipped only with a time delay. Because of fixed costs the profit sometimes becomes negative. After several periods, the volume of products ordered and shipped increases steadily, as well as revenue and profit. The firm is earning money permanently. Here the development of the bank account as an indicator for liquidity is interesting. It is oscillating around zero for a long time within the simulation period because the marketing budget is fully spent. However, additional marketing makes no sense after the acquisition of new customers has reached its limit and then the marketing budget does not rise anymore. Therefore the bank account accumulates liquidity (fig. 7).
We assumed that the entrepreneur takes money out of the firm each period when there is a profit (10 % of the profit). If we change this policy and assume that he takes out 60 % of the profit the firm goes bankrupt. This is a crucial parameter distinguishing successful and less successful start-up firms.

4. Conclusions

The model presented in this paper reflects the basic concepts of the theory of a firm and the attitudes and working experiences of an entrepreneur who has founded a small start-up firm. The results of the simulation show that basic business dynamics are replicated. The observed firm is real and successful. The policy of the entrepreneur not to take long-term credit from banks leads to discontinuous growth. Only after enough capital is accumulated will it be used for new staff and equipment. The second priority is the marketing budget.

The model can be used as an additional learning tool for entrepreneurs of start-up firms. It shows that liquidity is an important control variable to avoid bankruptcy. Moreover it emphasizes the role of flexible bank credit. Bankers should be aware of this during its initial period of operations. Liquidity oscillates heavily and approaches zero in some periods. Here a higher short term credit would be an adequate response to oscillations which seem to be the norm for start-up firms.

Another insight entrepreneurs can gain from studying the model concerns the private consumption of the entrepreneur. That variables influence the time to achieve a sustainable growth path without oscillations..

We have not investigated different scenarios for the growth of a small firm. This will be the object of further research. Here the assumptions concerning the parameters and initial conditions will be changed. The model should be tested for different reference modes. We also hope to get new ideas from the usage of the model in the management education process.

The model is restricted to the minimal set of elements of a viable firm and by strict assumptions which can be relaxed. In further research one may assume a contestable market. A more principled direction of further research could expand the elements, sectors and problems incorporated. This model focuses on cash flow management because cash is regarded in business economics literature and among start-up entrepreneurs as the condition sine qua non of a viable firm and essential to growth dynamics.

The authors believes that other areas of management education should be explored in a SD context: production management, innovation management, human resources and knowledge management, customer relations' management.

These topics are usually approached without a SD perspective by business management professors. It would be interesting to explore the effect of more intangible assets and of important factors influencing productivity, such as research and development and the use of human resources.

Figures

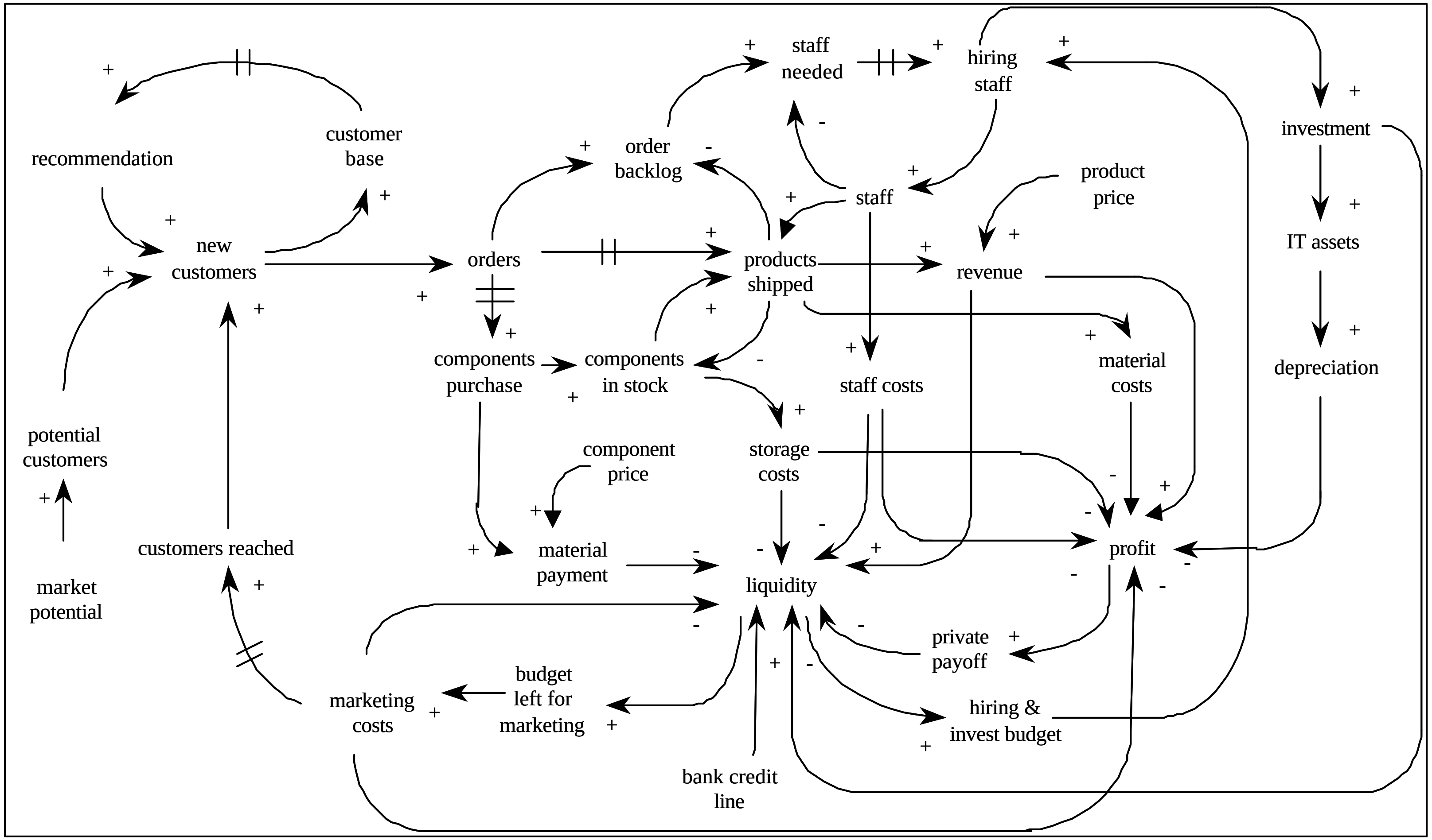


Fig. 1: Causal loop diagram of the firm

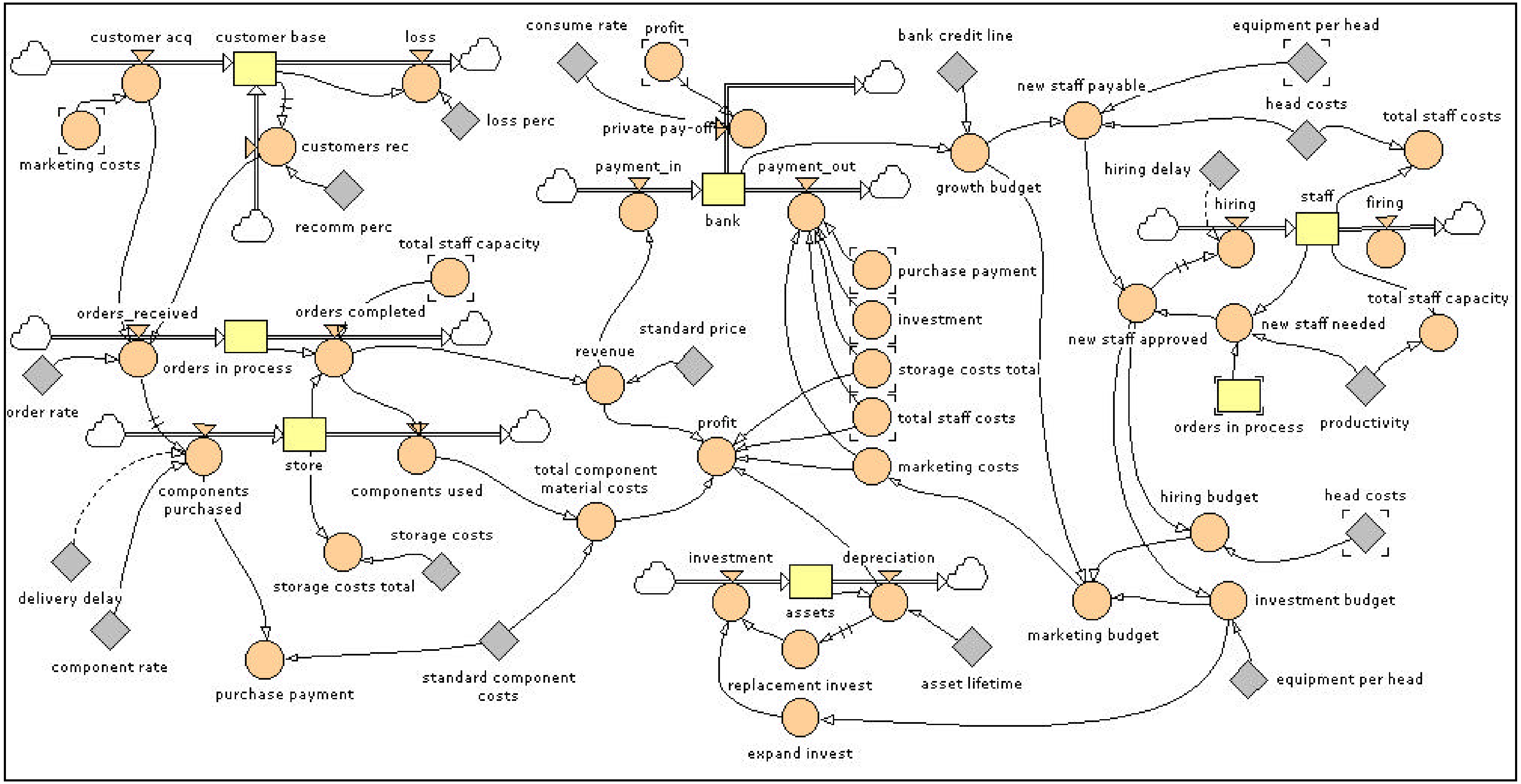


Fig. 2: System dynamics model of the firm

development customers

Zeit	customers rec	customer acq	customer base	loss
01.04.2005	278,00 customer/month	185,00 customer/month	2.835,00 customer	425,00 customer/month
01.05.2005	284,00 customer/month	117,00 customer/month	2.873,00 customer	431,00 customer/month
01.06.2005	287,00 customer/month	176,00 customer/month	2.843,00 customer	426,00 customer/month
01.07.2005	284,00 customer/month	198,00 customer/month	2.880,00 customer	432,00 customer/month
01.08.2005	288,00 customer/month	117,00 customer/month	2.930,00 customer	440,00 customer/month
01.09.2005	293,00 customer/month	168,00 customer/month	2.895,00 customer	434,00 customer/month
01.10.2005	290,00 customer/month	203,00 customer/month	2.922,00 customer	438,00 customer/month
01.11.2005	292,00 customer/month	122,00 customer/month	2.977,00 customer	447,00 customer/month
01.12.2005	298,00 customer/month	154,00 customer/month	2.944,00 customer	442,00 customer/month
01.01.2006	294,00 customer/month	203,00 customer/month	2.954,00 customer	443,00 customer/month

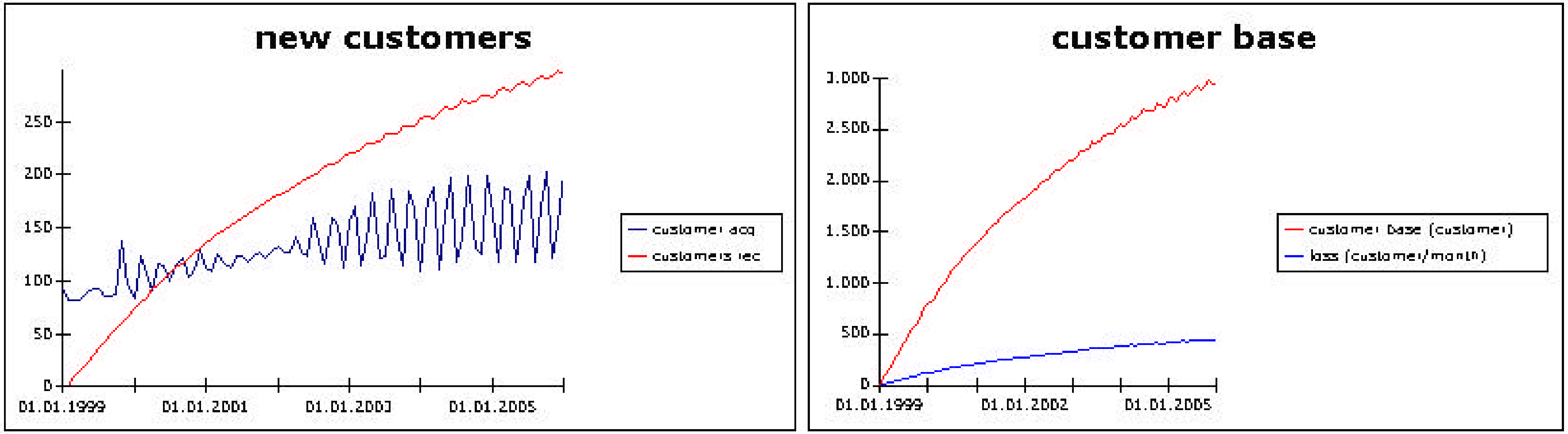


Fig. 3: Simulation results for customer development

development component storage

Zeit	components purchased	store	components used
01.01.1999	80,00 components/month	5,00 components	0,00 components/month
01.02.1999	93,00 components/month	85,00 components	85,00 components/month
01.03.1999	82,00 components/month	93,00 components	90,00 components/month
01.04.1999	91,00 components/month	85,00 components	85,00 components/month
01.05.1999	98,00 components/month	91,00 components	91,00 components/month
01.06.1999	112,00 components/month	98,00 components	98,00 components/month
01.07.1999	122,00 components/month	112,00 components	100,00 components/month
01.08.1999	128,00 components/month	134,00 components	100,00 components/month

development product orders

Zeit	orders_received	orders in process	orders completed
01.01.1999	93,00 product/month	0,00 product	0,00 product/month
01.02.1999	82,00 product/month	93,00 product	85,00 product/month
01.03.1999	91,00 product/month	90,00 product	90,00 product/month
01.04.1999	98,00 product/month	91,00 product	85,00 product/month
01.05.1999	112,00 product/month	104,00 product	91,00 product/month
01.06.1999	122,00 product/month	125,00 product	98,00 product/month
01.07.1999	128,00 product/month	149,00 product	100,00 product/month
01.08.1999	129,00 product/month	177,00 product	100,00 product/month

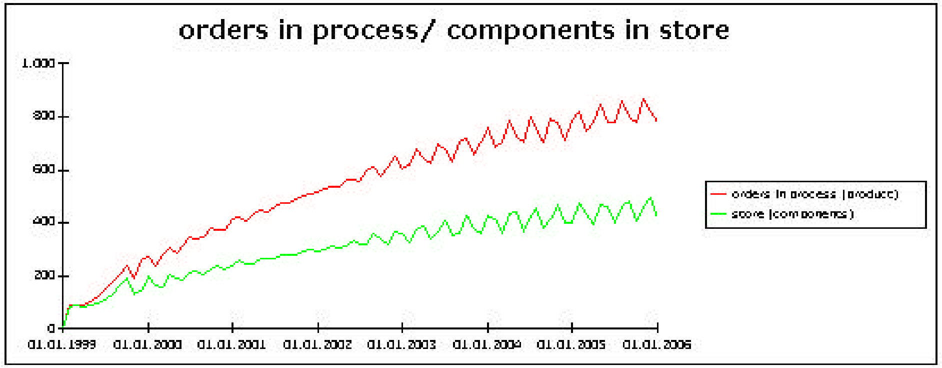


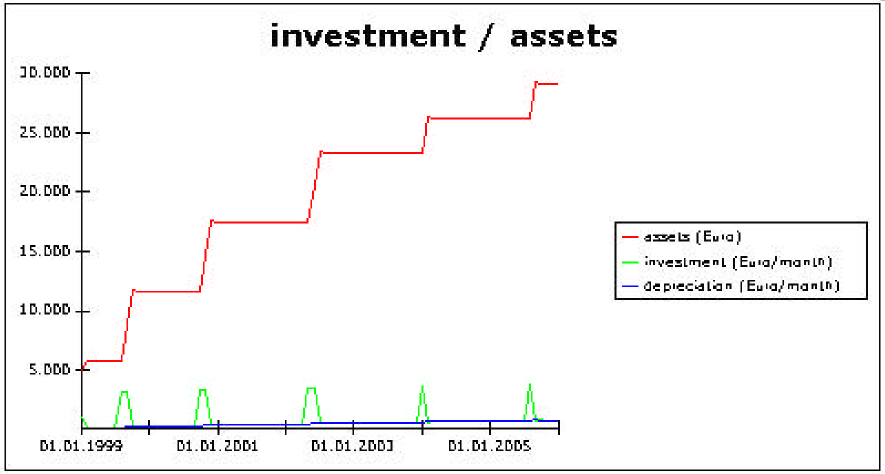
Fig. 4: Simulation results for orders and products

development assets

Zeit	investment	assets	depreciation
01.01.1999	1.000.00 Euro/month	5.000.00 Euro	139.00 Euro/month
01.02.1999	139.00 Euro/month	5.861.00 Euro	163.00 Euro/month
01.03.1999	163.00 Euro/month	5.837.00 Euro	162.00 Euro/month
01.04.1999	162.00 Euro/month	5.838.00 Euro	162.00 Euro/month
01.05.1999	162.00 Euro/month	5.838.00 Euro	162.00 Euro/month
01.06.1999	162.00 Euro/month	5.838.00 Euro	162.00 Euro/month
01.07.1999	162.00 Euro/month	5.838.00 Euro	162.00 Euro/month

development headcount

Zeit	hiring	staff	firing
01.01.1999	0.00 head/month	1.00 head	0.00 head/month
01.02.1999	0.00 head/month	1.00 head	0.00 head/month
01.03.1999	0.00 head/month	1.00 head	0.00 head/month
01.04.1999	0.00 head/month	1.00 head	0.00 head/month
01.05.1999	0.00 head/month	1.00 head	0.00 head/month
01.06.1999	0.00 head/month	1.00 head	0.00 head/month
01.07.1999	0.00 head/month	1.00 head	0.00 head/month



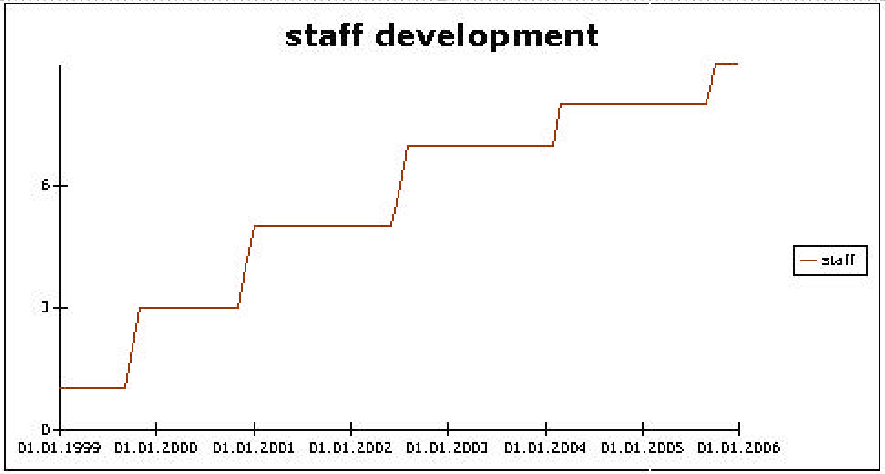
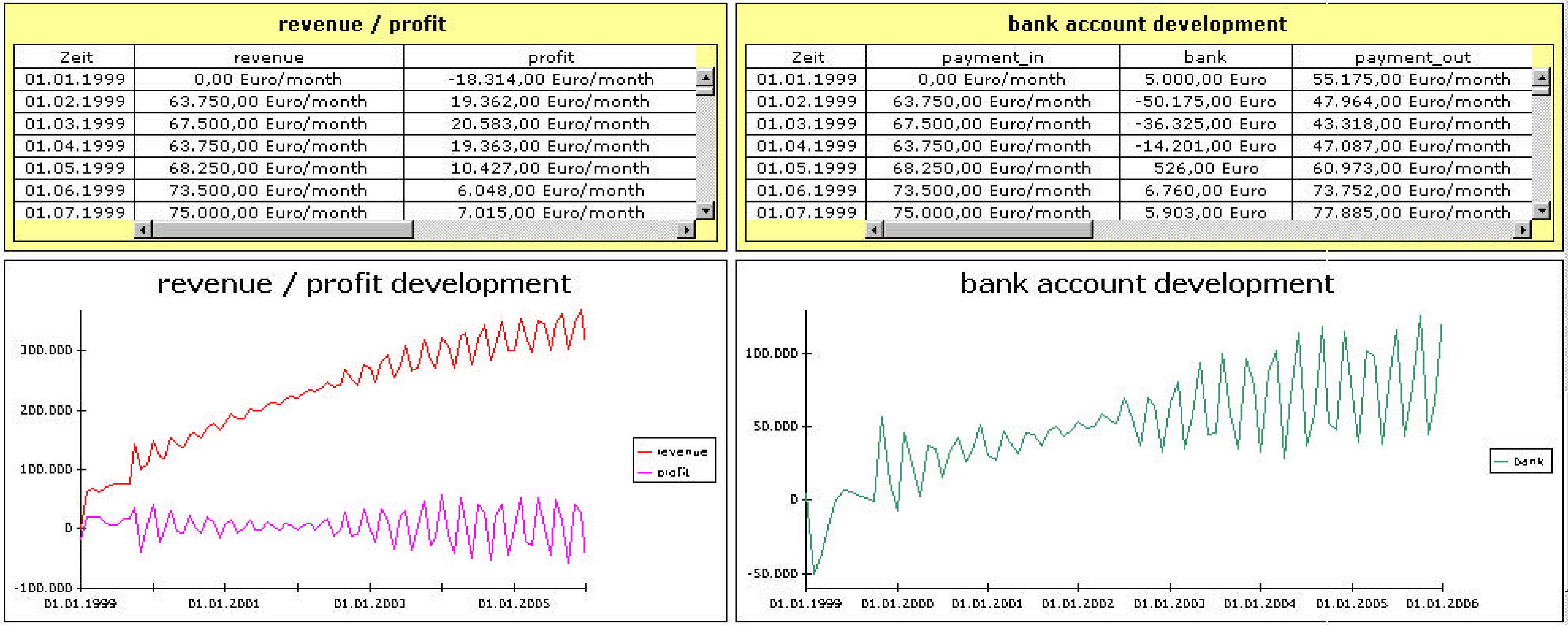


Fig. 5: Simulation results for assets and staff



revenue / profit

Zeit	revenue	profit
01.01.1999	0,00 Euro/month	-18.314,00 Euro/month
01.02.1999	63.750,00 Euro/month	19.362,00 Euro/month
01.03.1999	67.500,00 Euro/month	20.583,00 Euro/month
01.04.1999	63.750,00 Euro/month	19.363,00 Euro/month
01.05.1999	68.250,00 Euro/month	10.427,00 Euro/month
01.06.1999	73.500,00 Euro/month	6.048,00 Euro/month
01.07.1999	75.000,00 Euro/month	7.015,00 Euro/month

bank account development

Zeit	payment_in	bank	payment_out
01.01.1999	0,00 Euro/month	5.000,00 Euro	55.175,00 Euro/month
01.02.1999	63.750,00 Euro/month	-50.175,00 Euro	47.964,00 Euro/month
01.03.1999	67.500,00 Euro/month	-36.325,00 Euro	43.318,00 Euro/month
01.04.1999	63.750,00 Euro/month	-14.201,00 Euro	47.087,00 Euro/month
01.05.1999	68.250,00 Euro/month	526,00 Euro	60.973,00 Euro/month
01.06.1999	73.500,00 Euro/month	6.760,00 Euro	73.752,00 Euro/month
01.07.1999	75.000,00 Euro/month	5.903,00 Euro	77.885,00 Euro/month

Fig. 6: Simulation results for key financial figures

total budget / marketing budget / marketing costs

Zeit	growth budget	marketing budget	marketing costs
01.01.1999	15.000.00 Euro/month	15.000.00 Euro/month	15.000.00 Euro/month
01.02.1999	0.00 Euro/month	0.00 Euro/month	0.00 Euro/month
01.03.1999	0.00 Euro/month	0.00 Euro/month	0.00 Euro/month
01.04.1999	0.00 Euro/month	0.00 Euro/month	0.00 Euro/month
01.05.1999	10.526.00 Euro/month	10.526.00 Euro/month	10.526.00 Euro/month
01.06.1999	16.760.00 Euro/month	16.760.00 Euro/month	16.760.00 Euro/month
01.07.1999	15.903.00 Euro/month	15.903.00 Euro/month	15.903.00 Euro/month

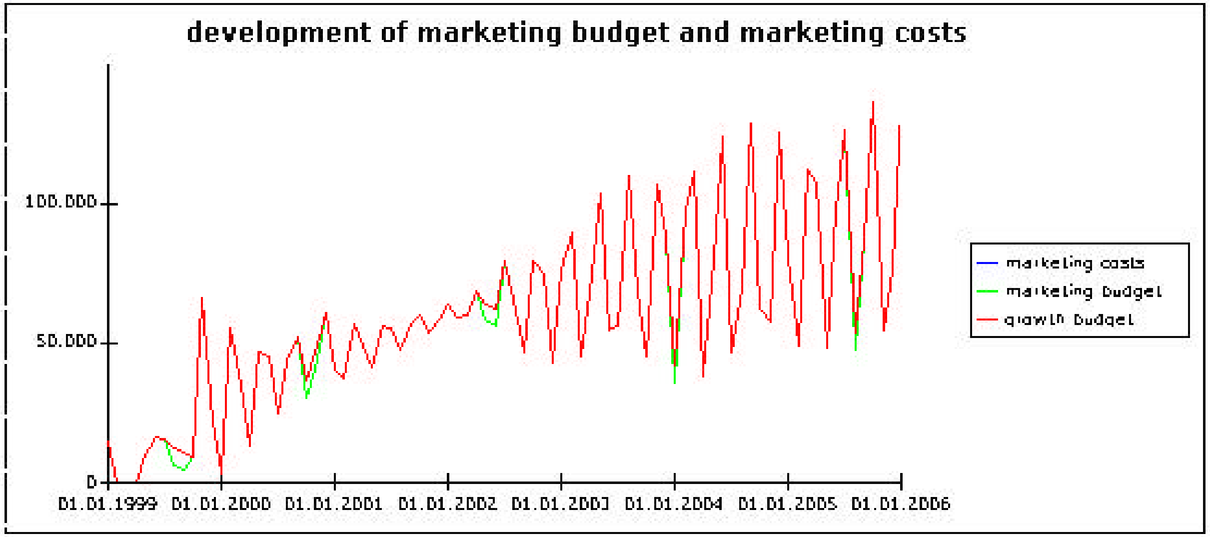


Fig. 7: Simulation results for the marketing budget

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Appendix: Equations of the model

```
asset lifetime = 36,00 month
    := 36
assets = 29.189,00 Euro
    := 5000
    investment
    depreciation
bank = 125.696,00 Euro
    := 5000
    payment_out
    payment_in
    'private pay-off'
bank credit line = 10.000,00 Euro
    := 10000
component rate = 1,00 components/product
    := 1
components purchased = 452,00 components/month
    = DELAYPPL(orders_received;'delivery delay';80<<product/month>>)*'component rate'
components used = 413,00 components/month
    = 'orders completed'*1<<components/product>>
consume rate = 0,10
    := 0,1
customer acq = 203,00 customer/month
    = ROUND(GRAPH('marketing costs';0<<Euro/month>>;20000<<Euro/month>>;{82;95;111;127;161;179;195;205;211;214//Min:0;Max:250//}<<customer/month>>);1<<customer/month>>)
customer base = 2.954,00 customer
    := 0
    loss
    'customer acq'
    'customers rec'
customers rec = 294,00 customer/month
    = ROUND('recomm perc'*DELAYPPL('customer base';1<<month>>;5<<customer>>);1<<customer/month>>)
delivery delay = 1,00 month
    := 1
depreciation = 811,00 Euro/month
    = ROUND(assets/'asset lifetime';1<<Euro/month>>)
```

```
equipment per head = 3.000,00 Euro/head
    := 3000
expand invest = 0,00 Euro/month
    = 'investment budget'
firing = 0,00 head/month
    = 0
growth budget = 135.696,00 Euro/month
    = IF(bank+'bank credit line'<0<<Euro>>;0<<Euro>>;bank+'bank credit line')/1<<month>>
head costs = 3.000,00 Euro/head/month
    := 3000
hiring = 0,00 head/month
    = DELAYPPL('new staff approved';'hiring delay';0<<head/month>>)
hiring budget = 0,00 Euro/month
    = 'head costs'*'new staff approved'*1<<month>>
hiring delay = 1,00 month
    := 1
investment = 811,00 Euro/month
    = 'replacement invest'+'expand invest'
investment budget = 0,00 Euro/month
    = 'equipment per head'*'new staff approved'
loss = 443,00 customer/month
    = ROUND('loss perc'*'customer base';1<<customer/month>>)
loss perc = 0,15 1/month
    := 0,15
marketing budget = 135.696,00 Euro/month
    = IF(('growth budget'-'hiring budget'-'investment budget')<0<<Euro/month>>;0<<Euro/month>>;'growth budget'-'hiring budget'-'investment budget')
marketing costs = 135.696,00 Euro/month
    = 'marketing budget'
new staff approved = 0,00 head/month
    = ROUND(IF('new staff needed'<0<<head>>;0<<head/month>>;MIN('new staff needed';'new staff payable')/1<<month>>);1<<head/month>>)
new staff needed = -1,00 head
    = ROUND('orders in process'/1<<month>>/productivity;1<<head>>)-staff
new staff payable = 23,00 head
    = ROUND('growth budget'/('head costs'+('equipment per head')/1<<month>>);1<<head>>)
```

```
order rate = 1,00 product/customer
    := 1
orders completed = 413,00 product/month
    = MIN(FLOOR(((MIN('orders in process';(store*1<<product/components>>)))/1<<month>>);1<<product/month>>);'total staff capacity')
orders in process = 781,00 product
    := 0
    orders_received
    'orders completed'
orders_received = 497,00 product/month
    = ('customer acq'+'customers rec')*'order rate'
payment_in = 309.750,00 Euro/month
    = revenue
payment_out = 381.397,00 Euro/month
    = ROUND(investment+'purchase payment'+'storage costs total'+'total staff costs'+'marketing costs';1<<Euro/month>>)
private pay-off = 0,00 Euro/month
    = ROUND(IF(profit>0<<Euro/month>>;profit*'consume rate';0<<Euro/month>>);1<<Euro/month>>)
productivity = 100,00 product/head/month
    := 100
profit = -54.097,00 Euro/month
    = revenue-depreciation-'storage costs total'-'total staff costs'-'marketing costs'-'total component material costs'
purchase payment = 203.400,00 Euro/month
    = 'standard component costs'*'components purchased'
recomm perc = 0,10 1/month
    := 0,10
replacement invest = 811,00 Euro/month
    = ROUND(DELAYPPL(depreciation;1<<month>>;1000<<Euro/month>>);1<<Euro/month>>)
revenue = 309.750,00 Euro/month
    = 'orders completed'*'standard price'
staff = 9,00 head
    := 1
    hiring
    firing
standard component costs = 450,00 Euro/components
    := 450
```

- standard price = 750,00 Euro/product
  - := 750
- storage costs = 35,00 Euro/month/components
  - := 35
- storage costs total = 14.490,00 Euro/month
  - = 'storage costs'*store
- store = 414,00 components
  - := 5
  - 'components purchased'
  - 'components used'
- total component material costs = 185.850,00 Euro/month
  - = 'components used'*'standard component costs'
- total staff capacity = 900,00 product/month
  - = productivity*staff
- total staff costs = 27.000,00 Euro/month
  - = staff*'head costs'

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