Microeconomic analysis of the balanced scorecard: a case of Nokia Corporation

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Abstract

Purpose – The purpose of the research is to analyse the theoretical foundations of the balanced scorecard (BSC) with the aid of a microeconomic model and to illustrate the results in an empirical case.

Design/methodology/approach – The model includes demand, production, and objective functions. Demand is presented as a function of price and customer relationship management (CRM) costs. Production depends on labour, capital, and development and learning (D&L) costs. The strategy is depicted by objective function based on profit and net sales. The output variables are classified as four perspectives of BSC. Shadow prices and performance measures are analysed. The theoretical model is applied to the annual financial statement data from Nokia Corporation. Simulation is used to find appropriate estimates for the parameters of the model.

Findings – It is shown that a shift in the objective function (strategy) towards revenue maximization may alter the importance order of the BSC perspectives. Non-financial and financial performance ratios may change into opposite directions, when the strategy is shifted. The figures extracted from the data of Nokia Corporation give support to these interpretations.

Research limitations/implications – The theoretical model is based on the traditional assumptions of microeconomic analysis. Empirical analysis is only based on a naive estimation methods. The sensitivity of the results with respect to the assumptions should be analysed in further studies. The parameters should be estimated with more advanced statistical methods.

Practical implications – The focus of the BSC should be elastic and react to changes in the strategy. When evaluating the causal relationships between non-financial and financial performance measures, attention should be paid to potential shifts in the strategy. The present model for example in a worksheet version would be useful in analysing the optimal behaviour of a firm and the causal relationships within the firm. It would be useful also in teaching the BSC and in general the behaviour of the firm to university students and managers. The model offers a platform for teaching and learning how the market (demand) and production (technology) environments affect the performance measures in the BSC.

Originality/value – There is a lack of theoretical modelling and analysis of the BSC. The present mathematical model is discussed earlier in *Managerial Finance*. However, this paper throws light to modelling the approach in a real-life case of the Nokia Corporation and shows the value of the approach in interpreting the BSC in practice.

Keywords Microeconomics, Balanced scorecard, Resource allocation, Prices, Performance measures

Paper type Research paper

Introduction

The strategic allocation of resources in a rational firm should be made to maximize the value of the objective function drawn from the strategy, subject to constraints set on the resources. In practice, this allocation can be facilitated by a performance measurement system (PMS). First, a PMS can be used to focus attention on the most

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critical resources. Secondly, it can be used to induce consistency of decision-making and resource allocation (Neely *et al.*, 1994). Kaplan and Norton (1992) presented the balanced scorecard (BSC) as such a PMS. The founding idea is that the performance measures linked to BSC give to the management a fast but comprehensive view of the business. It guards against sub-optimization in the resource allocation, because it directs balanced attention on four critical perspectives: financial perspective; customer perspective; internal perspective; and innovation and learning perspective. Kaplan and Norton also loosely discuss the relationships between these perspectives. Later, they pay more attention to define these relationships and introduce a concept of the strategic map (Kaplan and Norton, 1996, 2000). This map is based on the cause and effect relation between the strategic objective and actions in a sequence determined by the perspectives.

In the past ten years, the BSC concept has successfully diffused all over the world. However, the criticism of BSC includes several points (Otley, 1999; Norreklit, 2000; Malmi, 2001; Laitinen, 2002). Let us take only two of such points. First, it is based on a priori selection of the critical areas as perspectives. BSC in its original form may include non-critical perspectives and exclude critical ones. Second, it is difficult to identify the relative importance of and the trade-offs between the perspectives (Otley, 1999; Ittner and Larcker, 1998). This identification is crucial when resolving the conflicts in the setting of targets on different perspectives and on the measures of the perspectives. Ittner and Larcker (1998) conclude that a key question is how to retain balance in managerial actions and performance evaluations in the presence of trade-offs. They also call for additional research on the treatment of the trade-offs that managers will need to make among various financial and non-financial performance dimensions. In conclusion, theoretical research is needed to highlight the foundations of BSC (Otley, 1999; Norreklit, 2000; Ittner and Larcker, 1998).

The purpose of this study is

(1) to analyse the theoretical foundations of the BSC with the aid of a microeconomic model; and

(2) to apply the model to the financial statement data of Nokia Corporation.

This kind of model makes it possible to maintain a consistency between the strategy and the resource allocation. In this model, the strategy is described by the objective function to be maximized. With respect to this objective, the firm is assumed to optimize its actions subject to demand and production constraints as well as to constraints set on customer relationship management (CRM) and development and learning (D&L) costs. The shadow prices of the constraints are used to show the relative importance of perspectives for different strategies. The variables of the model are used to derive performance measures. Financial and non-financial performance measures are analysed in the context of a shift in the strategy. This theoretical model is presented earlier in Laitinen (2004). In the present paper, the model developed in Laitinen (2004) is applied to the data of Nokia Corporation and the relevance of the theoretical results is discussed. The purpose is to show that the information provided by the model is useful when analysing the importance of and trade-offs between alternative perspectives of the BSC. In addition, it can help us to understand the relationships between financial and non-financial performance measures in a strategic context.

Microeconomic model and the BSC

Microeconomic model

The microeconomic model is presented in Laitinen (2004) in detail. Thus, it is only briefly discussed here. The objective of the firm is specified as to maximize the present value of the sum of profit weighted by z and net sales weighted by $(1 - z)$, for a limited period of strategy. Let us assume that the total cost of the firm is only consisted of labour cost, capital cost, CRM cost, and D&L cost. All other costs are excluded or assumed to be included in these costs. Thus the objective function to be maximized, can be presented as follows

$$H = \sum_{t=1}^{T} \{z[p_t q_t - w_t L_t - c_t K_t - a_t - s_t] + (1 - z)p_t q_t\}(1 + k)^{-t} \quad (1a)$$

$$= \sum_{t=1}^{T} \{p_t q_t - z[w_t L_t + c_t K_t + a_t + s_t]\}(1 + k)^{-t} \quad (1b)$$

where T is the length of strategic period, p_t the price of output, q_t the volume of output, z the constant weight of profit $(0 < z \leq 1)$, w_t the unit cost of labor, L_t the labor input, c_t the unit cost of capital, K_t the capital input, a_t the CRM cost, s_t the D&L cost and k the rate of discount.

The form (1b) of the objective function shows that the original objective can be presented as to maximize the present value of profit with a constant weight of cost, z.

The framework will include restrictions for production, demand, CRM and D&L. First, the production volume of the output is assumed to depend on labour input, capital input, D&L, and cumulated D&L (stock of D&L) as follows

$$F^t(L_t, K_t, s_t, S_t) = q_t \quad (2)$$

Thus, the productivity of the firm is affected by its investments (cost) on D&L. These investments are accumulated into a stock of D&L as

$$\sum_{i=1}^{t} s_i(1 - v)^{t-i} = S_t \quad (3)$$

where v is a constant rate of decay for D&L.

Second, the demand volume of the output is a function of selling price, investment (cost) on CRM, and cumulated CRM (stock of CRM) as

$$D^t(p_t, a_t, A_t) = q_t \quad (4)$$

Thus demand volume (4) is, for simplicity, assumed to equal production volume (2) so that there are no inventories. The investments on CRM are accumulated into a stock of CRM according to

$$\sum_{i=1}^{t} a_i(1-b)^{t-i} = A_t \tag{5}$$

where b is the constant rate of decay for CRM.

Interpretation in the framework of BSC

The microeconomic model above has several characteristics that make it useful in analysing the BSC theoretically. The BSC emphasizes the linkage of measurement to strategy (Kaplan and Norton, 2001). Thus, the description of the strategy is in the focus when analysing the BSC. In the present approach, the objective function is used to direct strategy formation. The objective function is defined as the maximization of the present value of the weighted sum of profit and net sales. The weight of profit, z, in the objective function is used in this framework to depict the characteristics of the strategy adopted by the firm for T periods. The coefficient z can be interpreted also as a weight given to the present value of costs in optimization. It can thus be called either a weight of profit or a cost impact factor. This factor can be used to describe a shift in the strategy that may have a link to shareholder value creation that plays a key role in the BSC. When $z = 1$, the objective is to maximize the discounted value of profit (profit maximization). When $z < 1$, then the firms give also weight (that is, $1 - z$) to net sales (revenues) in the objective function and the strategy is shifted towards revenue maximization.

Kaplan and Norton (2001) emphasize two approaches to increase value, revenue growth and productivity. Revenue growth factually reflects revenue in the objective function of the firm. Simons (2000, p. 8) presents a triangle that describes the goals of the firm as tensions of profit, growth, and control. He states the following: "In all businesses, there is a constant tension between profit, growth, and control". In a way, the maximization of a weighted value of profit and revenue reflects the tension between profit and growth. In designing performance measurement and control systems, like the BSC, there should be a right balance between profit, growth, and control. In the recent time of intangible assets and knowledge-based strategies, monetary profits may not play as a dominant role as in the industrial-age competition. This tendency may lead the firms to adopt mixed strategies and to imitate leading firms (Kaplan and Norton, 2001). Theoretically, Rhode and Stegeman (2001) have showed that mixing imitative and profit-maximizing firms can distort behavior towards revenue maximization.

The present microeconomic model includes a set of variables that can be classified according to the BSC as in Table I. Kaplan and Norton (2001) state that the financial perspective reflects revenue growth, profitability, and risk from the perspective of the shareholder. In the present model, net sales (revenue) and profit are associated with

Financial perspective	Customer perspective	Internal efficiency	Learning and growth
Profit	Price	Labor	D&L cost
Net sales	Sales volume	Labor cost	D&L stock
	CRM cost	Capital	
	CRM stock	Capital cost	

Table I.
Model variables classified according to the BSC

this perspective. Because finance is excluded from the model, the risk aspect is not considered here. The customer perspective deals with value creation and differentiation (customer-value proposition) from the perspective of the customer. It describes the unique mix of product, price service, relationship, and image that a company offers (Kaplan and Norton, 2001). Price, sales volume, CRM cost and CRM stock are the variables of the present approach that belong to this perspective. For simplicity, all the costs associated with attracting, retaining, and deepening the relationships with the customers are called CRM costs. It is important that customer-value creation is described by a simple dynamics. CRM costs create goodwill (here, CRM stock) that has long-term (carry-over) effects on the demand of its products.

The internal-business-process perspective of the original BSC is called here internal efficiency. Kaplan and Norton (2001) say that improvements to business processes typically occur in stages, through increases in (short-term) operational efficiencies, in (intermediate term) customer relationships, and in (long-term) innovations. Only increases in operational efficiencies are here included in the internal efficiency perspective. The traditional production factors, that is, capital and labour, are considered in this perspective. Efficiencies in customer relationships are considered in the customer perspective while innovations belong to the learning and growth perspective. In the learning and growth perspective, managers define the employee capabilities and skills, technology, and corporate climate needed to support a strategy. In the present framework, this perspective is described by D&L costs with a simple dynamics. This dynamics is of crucial importance when taking into account of the nature of the perspective. D&L costs are spent to increase employees' capabilities and skills, technology, and corporate climate. However, through carry-over effects they create an intangible stock of D&L that cumulatively affects the production of the firm.

Strategically critical areas: shadow prices

Shadow prices

The objective of the firm is to choose q_t, L_t, K_t, s_t, p_t, and a_t so that equation (1a) and (b) will be maximized subject to equations (2)-(5). Thus the question is about an ordinary maximization problem with a set of equality constraints. The problem is the same as to maximize a Lagrangian function which consists of the sum of the objective function (1) and the constraints (2), (3), (4), and (5), each multiplied, respectively, by the multiplier λ_{Ft}, λ_{Dt},λ_{At}, and λ_{St}. These Lagrangian multipliers are the shadow prices of the constraints associated with production, demand, CRM, and D&L, respectively. The solution of the constrained maximization problem gives us the following shadow prices for the four constraints (Laitinen, 2004). First, the shadow price of production is as follows

$$\lambda_{Ft} = p_t^d \frac{1 + \varepsilon_p^t}{\varepsilon_p^t} \tag{6}$$

where ε_p^t is the price elasticity of demand. The superscript d refers to a discounted value. Thus $p_t^d = p_t(1+k)^{-t}$. For the value of elasticity less than -1 (standard assumption), the shadow price is positive.

The shadow price of demand is close to equation (6). Obviously

$$\lambda_{Dt} = -\lambda_{Ft} + p_t^d = -\frac{p_t^d}{\varepsilon_p^t} \tag{7}$$

Thus, in this framework, the shadow prices are closely related to the selling price and the price elasticity of demand. Equations (7) and (6) show that $\lambda_{Dt} > \lambda_{Ft}$, when $1 < |\varepsilon_p^t| < 2$. Moreover, $\lambda_{Dt} = \lambda_{Ft}$, when $|\varepsilon_p^t| = 2$, and, $\lambda_{Dt} < \lambda_{Ft}$, when $|\varepsilon_p^t| > 2$.

The shadow prices of CRM and D&L are more complicated. The system of equations gives us for the shadow price of CRM

$$\lambda_{At} = -1_t^d \left[\frac{p_t q_t}{A_t} \frac{\varepsilon_A^t}{\varepsilon_p^t} \right] \tag{8}$$

where ε_A^t is the CRM stock elasticity of demand.

The shadow price of D&L is obtained as

$$\lambda_{St} = -1_t^d \left[\frac{p_t q_t}{S_t} \frac{\left(1 + \varepsilon_p^t\right)}{\varepsilon_p^t} \varepsilon_S^t \right] \tag{9}$$

where ε_S^t is the D&L stock elasticity of production.

Interpretation in the framework of BSC

The shadow prices presented above show how the value of the objective function is affected when the constraint in question is marginally relaxed. Thus, they reflect the sensitivity of the value of the objective function to the constraints set on the maximization problem. They are related to the strategic importance of these constraints and can be used to identify strategically critical areas in business operations. Thus, referring to the BSC framework, shadow prices would be useful in directing attention to strategically important areas. This attention directing is crucial when recalling the original idea of the BSC. Actually, its main task is to focus attention to the critical areas of the business. Kaplan and Norton (1996, p. 12) summarize, for example, as follows: "The process of building a balanced scorecard clarifies the strategic objectives and identifies the critical few drivers of the strategic objectives". Shadow prices of the constraints can be useful when searching for the critical drivers, focusing attention and designing the BSC or a similar performance management system. These prices also reflect the trade-offs between the constrained resources.

Table II shows the shadow prices of the constraints as classified according to the BSC framework. For the financial perspective, there is no shadow price, because this perspective factually reflects the outcome of the maximization model. It is important to understand how the behaviour of the shadow prices will change when the strategy of

Table II.
Shadow prices classified according to the BSC

Financial perspective	Customer perspective	Internal efficiency	Learning and growth
	Demand CRM	Production	D&L

the firm is shifted from profit maximization ($z = 1$) towards revenue maximization ($z < 1$). The interpretation below is based on a set of simplified assumptions (Laitinen, 2004). The shadow prices of production and demand decline both at the same rate as the price, when z moves from unity towards zero. Thus, their relative importance, trade-off, will stay constant when the strategy is shifted towards revenue maximization. However, this importance depends on the price elasticity of demand. If the absolute value of the elasticity is higher than unity but less than 2, then, on the basis of the shadow prices, demand is more critical than production. If this value exceeds 2, then the opposite holds.

Thus, a shift towards revenue maximization does not change the relative importance of the demand and production constraints but their original relation depends on the price elasticity. The relative importance of CRM and D&L depends on the elasticities of demand with respect to the CRM and D&L stocks, respectively. Similarly as above, a shift towards revenue maximization does not change their relative importance because the shadow prices both decline at the same rate. In fact, the prices decline at the same rate as z. However, if the rate of change in z is different from that in price, the relative importance of demand and production in comparison to that of CRM and D&L will change when the strategy is shifted towards revenue maximization. This implies that the strategic focus, and the BSC, should also change. In a special case, the priority order of the constraints can change when the strategy is shifted.

Financial and non-financial performance measures

Cost-to-net-sales ratios

The optimal solution of the model allows us to calculate the cost structure of the firm that means the ratio of costs to net sales defined for each resource variable. The labor-cost-to-net-sales ratio is as follows

$$\frac{w_t L_t}{p_t q_t} = \frac{1}{z}\left[\frac{\varepsilon_L^t\left(1+\varepsilon_p^t\right)}{\varepsilon_p^t}\right] \tag{10}$$

which is inversely related to z.

Similarly, the capital-cost-to-sales ratio is obtained as

$$\frac{c_t K_t}{p_t q_t} = \frac{1}{z}\left[\frac{\varepsilon_K^t\left(1+\varepsilon_p^t\right)}{\varepsilon_p^t}\right] \tag{11}$$

which differs from equation (10) only by the elasticity of production.

The non-steady state solutions for the CRM-cost-to-net-sales and D&L-cost-to-net-sales ratios are complicated. For simplicity, let us only consider the steady state solution. The CRM-cost-to-net-sales is then

$$\frac{a}{pq} = \frac{1}{z}\left\{-\frac{\varepsilon_a}{\varepsilon_p} - \frac{\varepsilon_A}{\varepsilon_p}[b(1+k)/(k+b)]\right\} \tag{12}$$

which factually is a dynamic discrete counterpart of the Dorfman and Steiner's (1954) theorem extended for the weighted objective function.

Similarly to equation (12) we can get an expression for the D&L-cost-to-net-sales ratio as follows

$$\frac{s}{pq} = \frac{1}{z}\frac{(1+\varepsilon_p)}{\varepsilon_p}[\varepsilon_s + \varepsilon_S v(1+k)/(k+v)] \tag{13}$$

which is inversely related to z similarly to the previous cost structure ratios.

Sales-volume-to-cost ratios

The results from equations (10)-(13) for the cost structure can be used to derive a set of productivity measures or sales-volume-to-cost ratios for the allocated resources L, K, a, and s. These ratios can be presented as follows

$$\text{Sales-volume-to-cost ratio} = \frac{1}{\text{Cost-to-net-sales ratio}}\frac{1}{p_t} \tag{14}$$

defined separately for L, K, a, and s. Thus, the relation between cost structure ratios and productivity ratios depends on the behaviour of selling price. For L, the ratio of equation (14) can be transformed to a sales-volume-to-labor ratio by multiplying the ratio by w_t. Similarly, this kind of transformation can be made for K by multiplying the ratio by c_t.

Interpretation in the framework of BSC

In the BSC framework, performance measurement plays a central role. The performance measures can be financial, non-financial, or combination measures. Combination measures refer to such measures that have both financial and non-financial items. The present framework includes measures from all the categories. These measures can however be classified into two classes. First, there are cost structure ratios that are defined as the ratio of cost-to-net-sales. These cost-structure ratios can be classified according to the four perspectives of the BSC as shown in Table III. In this classification, the financial perspective includes the profit-to-net-sales ratio that is obtained when all cost-to-net-sales ratios are deducted from unity. All the cost-to-net-sales ratios are inversely related to the cost impact factor z so that they can be presented as the profit-maximizing ratio times the multiplier $1/z$. Thus, when the strategy of the firm is shifted from profit maximization towards revenue maximization, all the cost types will grow by the same proportional rate. This factually implies that the proportional structure of costs does not change due to this shift.

Second, a set of performance measures is consisted of sales-volume ratios. These ratios are defined as ratios of sales volume to production factor or its cost. These ratios

Table III.
Cost structure measures classified according to the BSC

Financial perspective	Customer perspective	Internal efficiency	Learning and growth
Profit-to-net-sales ratio	CRM-cost-to-net-sales ratio	Labor-cost-to-net-sales ratio Capital-cost-to-net-sales ratio	D&L-cost-to-net-sales ratio

are classified into the BSC perspectives in Table IV in the same way as corresponding net sales ratios. The effect of a shift in the strategy on the ratio depends on the cost impact factor z and on the relation of the profit-maximizing price to the revenue-maximizing price. Hence, if the shift towards revenue maximization makes the price to diminish at a higher rate than z declines, the sales-volume ratios will increase when the shift takes place. If this does happen, it means that the sales-volume-based productivity ratios will increase and the net-sales-based productivity ratios decrease, when a shift in the strategy is emerged. The cost-structure ratios and the profit-to-net-sales ratio will also deteriorate in this case. Thus, on the condition explained above, financial ratios will deteriorate and the ratios based on non-financial items will improve, due to a shift towards revenue maximization. This kind of situation in practice may deteriorate reliance on performance measures when trying to identify the causal links between non-financial and financial measures.

Illustrative case: Nokia Corporation

Specification of the functions

The empirical results below are based on a specified version of the original model. All the relevant elasticities are assumed constant and that a steady state has been reached. Then, the production function is specified as follows

$$q = fK^{\varepsilon K}L^{\varepsilon L}s^{\varepsilon s}S^{\varepsilon S} = fK^{\varepsilon K}L^{\varepsilon L}s^{\varepsilon s+\varepsilon S}(1/v)^{\varepsilon S} \tag{15}$$

which is based on a constant scale factor f and constant elasticities. For simplicity, it is assumed that $\varepsilon_s = \varepsilon_S = (\varepsilon_s + \varepsilon_S)/2$. For the steady state, S is replaced by s/v where v is the rate of decay.

Finally, it is assumed constant elasticities for the demand function as

$$q = dp^{\varepsilon p}a^{\varepsilon a}A^{\varepsilon A} = dp^{\varepsilon p}a^{\varepsilon a+\varepsilon A}(1/b)^{\varepsilon A} \tag{16}$$

where d is a constant scale factor. Similarly, it is assumed that $\varepsilon_a = \varepsilon_A = (\varepsilon_a + \varepsilon_A)/2$. Because of the steady state, A is replaced by a/b where b is the rate of decay.

Nokia case: data and estimation

The results drawn from the theoretical model will be illustrated here by the case of Nokia Corporation (see www.nokia.com). Nokia is nowadays the world leader in mobile communications, driving the growth and sustainability of the broader mobility industry. Nokia is dedicated to enhancing people's lives and productivity by providing easy-to-use and secure products like mobile phones, and solutions for imaging, games, media, mobile network operators and businesses. In 2003, Nokia achieved net sales of EUR 29.5 billion (USD 36.2 billion). At the end of 2003, Nokia had 16 manufacturing facilities in nine countries around the world and R&D centres in 11 countries at the end of 2003. In addition, Nokia employed approximately 51,000 people.

Financial perspective	Customer perspective	Internal efficiency	Learning and growth
	Sales-to-CRM-cost ratio	Sales-to-labor-cost ratio sales-to-labor ratio Sales-to-capital-cost ratio	Sales-to-D&L-cost ratio

Table IV.
Sales volume ratios classified according to the BSC

The time-series data of Nokia covers the years from 1993 to 2002 (ten years). The data for the estimation are extracted from COMPUSTAT (see www.compustat.com/www/). However, this database did not include figures for Nokia's advertising expense which were extracted from annual reports. The most challenging task in the estimation was to estimate the parameters of the functions (15) and (16). Several estimation experiments (regression analysis and ridge regression) were carried out to choose appropriate estimation methods and independent variables. Because the price level of products is not known, the sales volume in both functions was roughly approximated by net sales (COMPUSTAT item 12) deflated by the producer price index in technology industries in Finland (Statistics Finland, 2004). From 1995 (level 100), this index was decreased to the level 63 in 2003.

First, in the production function (15) labor was measured by labor and related expense (COMPUSTAT item 42), capital by property, plant and equipment (item 8), and D&L cost by research and development expenses (item 46). The initial values for elasticities in equation (15) were estimated by the logarithmic-linear ridge regression analysis to analyse the effect of multicollinearity. The coefficient of multiple determination for the production function was 0.971 (adjusted coefficient 0.956). In spite of the good fit, the estimates for the elasticities were used only as initial values. The final values were searched for by computer simulation so that the estimates that best explained the sales volume especially in the last years were selected. The final parameter values were $\varepsilon_K = 0.25$, $\varepsilon_L = 0.50$, and $\varepsilon_s + \varepsilon_S = 1.30$. Moreover, $w = 0.07$, $c = 0.65$, and $v = 0.25$. For these values, the coefficient of multiple determination was 0.990.

Second, the initial parameters of demand function were estimated by the ridge regression explaining the sales volume by the price index and the logarithm of advertising expense (COMPUSTAT item 45), as a proxy of CRM cost. The coefficient of multiple determination was for the model 0.991 (adjusted coefficient 0.988). The final estimates for the elasticities found by the simulation were $\varepsilon_p = -1.35$ and $\varepsilon_a + \varepsilon_A = 0.50$. The price elasticity is somewhat less than the elasticity estimated by Iimi (2003) in his study on the demand for the cellular phone services in the Japanese market. His estimates varied from -1.41 to -2.28. In addition, it is assumed that $b = 0.35$. The final coefficient of multiple determination was 0.998 for these experimental values. Finally, the estimates for f and were chosen such that their relation was 0.000215: 470, which was the best relation found by the simulation.

Results of the case of Nokia

Table V presents a summary of the solutions for the microeconomic model for different values of z (strategy). For the profit-maximization case ($z = 1.00$), the shadow price for demand is clearly the highest. This implies that demand is the most critical factor for Nokia when searching for profit maximization. However, when shifting the strategy towards revenue maximization ($z < 1$), the importance of demand will diminish quickly. When $z = 0.92$, the CRM shadow price exceeds that of demand. For the profit maximization case, the shadows prices of production and D&L are about at the same level. The relative importance of production will however decrease rapidly when the strategy is shifting towards revenue maximization. Thus, its seems that for a technology firm such as Nokia the relative importance of CRM and D&L will increase with the degree of revenue maximization. In the same time, the relative importance of

	Strategy applied: weight of profit z					
	1.0000	*0.9600*	*0.9200*	*0.8800*	*0.8400*	*0.8000*
Financial perspective						
Net sales	32,798	47,726	70,565	1,06,165	1,62,788	2,54,874
Profit/net sales	0.1610	0.1261	0.0881	0.0466	0.0012	-0.0487
Customer perspective						
Price	0.5278	0.3274	0.1990	0.1183	0.0687	0.0388
CRM cost/net sales	0.3436	0.3579	0.3735	0.3905	0.4091	0.4295
Sales volume/CRM cost	5.5142	8.5340	13.4551	21.6480	35.6086	60.0123
Demand shadow price	*0.3909*	*0.2425*	*0.1474*	*0.0876*	*0.0509*	*0.0287*
CRM shadow price	*0.1886*	*0.1811*	*0.1735*	*0.1660*	*0.1584*	*0.1509*
Internal efficiency						
Labor cost/net sales	0.1296	0.1350	0.1409	0.1473	0.1543	0.1620
Sales volume/labor	1.0232	1.5835	2.4967	4.0169	6.6074	11.1356
Capital cost/net sales	0.0648	0.0675	0.0705	0.0737	0.0772	0.0810
Sales volume/capital	19.0023	29.4083	46.3668	74.5995	122.7084	206.8044
Production shadow price	*0.1368*	*0.0849*	*0.0516*	*0.0307*	*0.0178*	*0.0101*
Learning and growth						
D&L cost/net sales	0.3009	0.3135	0.3271	0.3420	0.3582	0.3762
Sales volume/D&L cost	6.2966	9.7448	15.3642	24.7194	40.6608	68.5269
D&L shadow price	*0.1400*	*0.1344*	*0.1288*	*0.1232*	*0.1176*	*0.1120*

Table V.
Performance measures and shadow prices for alternative strategies (experimental values for Nokia)

production and demand will diminish (Figure 1). This implies that also the focus of attention reflected by the design of the BSC, should change when a shift in the strategy towards revenue maximization is made.

Table V also shows the values for the performance measures discussed above. The financial cost structure measures will slowly, but continuously, increase when the strategy is shifted towards revenue maximization. The deterioration of the cost

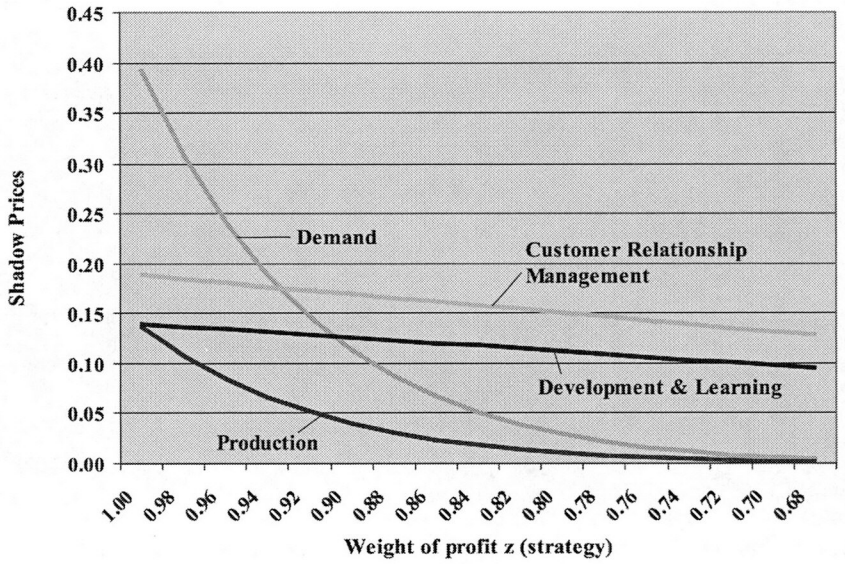

Figure 1.
Shadow prices for alternative values of z (strategies) in the case of Nokia

structure means that the profit-to-net-sales ratio will diminish at the same time. However, the sales volume ratios that are productivity measures, will improve rapidly with the shift in the strategy (Figure 2). For example, when $z = 1.00$ (profit maximization), the sales-volume-to-labor ratio is 1.02 but it more than doubles to 2.50 when the strategy is shifted towards revenue maximization so that $z = 0.92$. Thus, when a technology firm such as Nokia is shifting its strategy more towards revenue maximization, the productivity measures will improve but, at the same time, the financial performance measures (cost structure and profitability ratios) will deteriorate. When shifting from profit maximization towards revenue maximization, these movements in performance measures give a confusing message that while improving non-financial performance, a decline in financial performance is resulted.

Discussion of the case of Nokia

In practice, a shift in the strategy from profit maximization towards revenue maximization means that the firm is going to (try to) sell more at a lower selling price. The new strategy may improve productivity through economies to scale but impair financial performance due to the decrease in selling price. For the new strategy, which gives weight on revenue maximization, demand and production are not as critical factors as for the profit maximization. For the profit-maximizing firm it is important that demand and production will stay at the optimal level, which gives rise for demand and production-oriented performance measurement systems. However, for a revenue-maximizing firm it is more important to focus on customer relationship management and development and learning.

During the last ten years, Nokia has carried out a strategy that resulted in a strong market share and in a very good profitability. Nokia left old businesses and increasingly focused on telecommunications. Ten years ago, Nokia

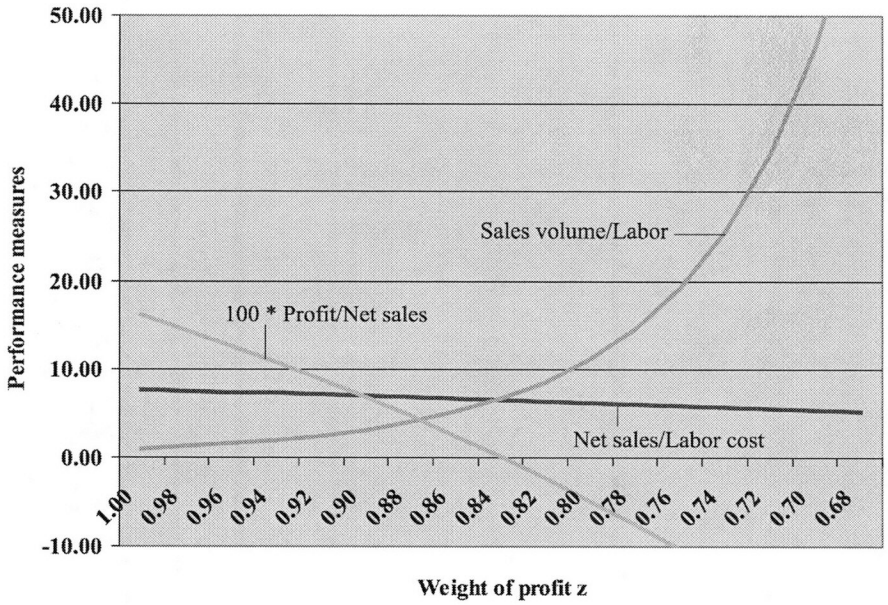

Figure 2.
Labor productivity and profitability for alternative strategies in the case of Nokia

(Telecommunications) had three core processes (product process, customer commitment process, and management and support processes) and the performance of these processes was measured from four perspectives (Kosonen, 1995). These perspectives were customer satisfaction (correct time to market, price vs performance and features, field reliability, delivery accuracy and lead time), operative efficiency (cycle time, first time pass yield, cost efficiency, working capital in days), people involvement (target setting and understanding, communication, empowerment, team-work), and strong market position and good profitability (market share, growth, net profit, return on investment). These perspectives are quite comparable with the ones of the BSC. However, development and learning perspective is replaced by people involvement, which focuses more on social interaction than development.

In the recent years, the fast growth of Nokia has slowed down and profitability has not been as good as before. Consequently, Nokia has changed its strategy to maintain a strong market position, even on the cost of profitability. This kind of shift factually means a shift towards revenue maximization. For example, in 2002 Nokia's overall profitability and market position were still excellent (Nokia Press Release, 23 January 2003). Nokia's net sales decreased by 4 per cent but operating profit increased by 3 per cent. In this stage, CEO Jorma Ollila still largely emphasized demand-focused and production-focused efficiency as critical success factors: "During 2002, we again succeeded in translating our strong brand, product offering, industry-leading execution and operational efficiency into highly profitable results". However, market environment was becoming more challenging and a shift in the strategy was necessary to maintain strong market position.

The shift in the strategy can be read from the statement given by Ollila one and half years later (Nokia Press Release, 15 July 2004). Ollila states that Nokia will continue to use pricing (price declines) selectively and aim to strengthen the competitiveness of the product portfolio in order to increase its market share in the market. He continues that Nokia expects the profitability to continue to come under pressure. Year 2004 was not good for Nokia. Net sales decreased 1 per cent and operating profit decreased 14 per cent due to price decline. At the same time, Nokia Mobile device volume however reached a record of 207.7 units. This volume increased 16 per cent whereas the number of employees in Nokia grew only 8 per cent. In Nokia Phones, the number of personnel came down 7 per cent. A half-year later Ollila reports a change in the strategic priorities set by Nokia (Nokia Press Release, 27 January 2005): "The past year was demanding for Nokia. In response, we set five top priorities in the areas of customer relations, product offering, R&D efficiency, demand-supply management and the ability to offer end-to-end solutions". Thus the strategic priorities have shifted towards CRM and D&L as a response to the shift in the strategy. The main lesson is that also the focus of the BSC should be shifted into the same direction.

Summary

This study analysed the theoretical foundations of the BSC with the aid of a simple dynamic microeconomic model. The model reflected the characteristics of knowledge-based modern companies as outlined by Kaplan and Norton (2001) when justifying the applicability of the BSC. The idea was, first, to show how the critical areas of management change, when the strategy is shifted towards revenue maximization. The importance of the areas was measured by the shadow prices of

the constraints in the model. The theoretical analysis showed that all the shadow prices decline, when the strategy is shifted towards revenue maximization. However, the shadow prices of demand and production decline at a higher rate than those of CRM and D&L stocks. The illustrative case of Nokia Corporation showed that the lines of the shadow prices may intersect with a rather low tension towards revenue maximization. In recent years, this kind of strategic shift can be observed in the market behaviour of Nokia. This factually implies that for a modern company, that is shifting its strategy, the importance of the management areas (production, demand, CRM, and D&L) may change which should be taken into account when designing the BSC. The BSC should be elastic with respect to the shifts in the strategy.

The second idea was analyse the behaviour of performance measures in a company that is shifting its strategy. Theoretically, it was shown that net-sales-based (financial) performance measures tend to decrease when revenue maximization takes place. However, in the same time, sales-volume-based (non-financial) performance measures will increase at a rate faster than that of decline in financial performance measures. Numerical experiments of Nokia Corporation showed that the financial and non-financial performance measures rapidly will go in opposite directions, when a shift in strategy towards revenue maximization takes place. The recent shift in the strategy of Nokia shows that in that kind of situation an increase in productivity is strongly associated with a simultaneous decline in profitability. This result implies that the behaviour of performance measures may give a confusing signal to the management about their causal relationships when the strategy is not stable. This kind of confusing signal may impair reliance on performance measures.

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