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Simulation as a pedagogical tool for managerial decision-making in a transition economy

DL Olson[1]*, MF Shipley[2], M Johnson[2], P Dimitrova[3], I Marchevski[4], I Stoykov[3] and N Yankov[4]

Q1 *[1]University of Nebraska, Lincoln, NE, USA; [2]University of Houston, Downtown, TX, USA; [3]Institute of Economics, Bulgarian Academy of Sciences, Bulgaria; and [4]Tsenov Academy of Economics, Svishtov, Bulgaria*

Eastern European countries are undergoing a transition from centralized economic planning to more open economic systems. A team of Bulgarian and US researchers collaborated to study this problem, using a Bulgarian winery as the focus of their research. The study resulted in development of a business simulation of the winery, with the purpose of generating a pedagogical tool for knowledge acquisition by winery management as well as Bulgarian business students. This paper discusses the concept of simulation as a pedagogical tool, outlines the purposes of this simulation, reviews the development of this model using soft systems approaches, and suggests its applicability for any pedagogical learning situation but more specifically to the general operations of the firm at the microeconomic level of decision-making.
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Introduction

The transition from centralized economic planning to more open economic systems has become vitally important as Bulgaria approaches its year of entry into the European Union community. Towards an initiative to study the implications of decision-making within the Bulgarian firm and to provide a tool for managerial decisions by present and/or future managers, Bulgarian and US researchers collaborated upon developing a Monte Carlo simulation model of an operational Bulgarian winery. In order to develop this model, soft system principles were applied to key functional processes with the purpose of providing a pedagogical tool for knowledge acquisition by winery management as well as Bulgarian business students. Given the ambiguity of information and the lack of data about a process, fuzzy logic distributions were incorporated into the simulation model. This paper uses the concept of simulation as a pedagogical tool, outlines the purposes of simulation and restrictions upon modelling the real world, reviews the development of this model, and suggests its applicability to any pedagogical learning situation but more specifically to the general operations of the firm at the microeconomic level of decision-making.

The evolutionary development of the model was based on soft systems approaches. An initial meeting was held in Svishtov, Bulgaria at the Tsenov Academy of Economics (Tsenov Academy) in May 2002. Participants included about 10 faculty members from the Tsenov Academy, two from the Bulgarian Academy of Sciences (Institute of Economics), faculty from the United States, and students from the representative institutions. The project was directed by the University of Houston, Downtown and funded by NSF Award No. INT-0207141.

Monte Carlo simulation was selected as a tool to provide better understanding of management issues and to allow a systemic broad-based approach to dealing with the constraints inherent in the transitional economy environment. An initial simulation model was developed in an earlier stage of this project, showing the basic flow of information within the firm, and providing choices for key managerial decisions such as pricing, promotion, production capacity, and labour policies. Problems were defined in terms of which types of wine to produce for which markets to provide a local, regional and/or global presence. The simulation model generated results for given inputs on a number of measures, reporting profitability, risk, and market share measures. The original model was reported with multiple criteria analysis (Olson *et al*, 2005), with more detailed focus on the simulation model by Olson *et al* (2006). Subsequent analysis focused on revising the model in the light of initial results, applying soft systems principles, and is the basis for the system reported here. This model can be used in the future in business programmes to yield experimental results of adopting alternative business strategies with respect to price, promotion, quality, and production decisions.

*Correspondence: DL Olson, Department of Management, University of Nebraska, Lincoln, NE 68588-0491, USA.
E-mail: dolso1@unlnotes.unl.edu

Gml : Ver 6.0
Template: Ver 1.1.5

Background

Simulation as a pedagogical tool

Simulation provides a hands-on experience to the participant, whether they are managers in the workplace or students in the classroom. The experiential exercise integrates theory with application, making the learner an active participant in the learning process. A benefit of such interaction is the immediate feedback such that the participant can view the effects of changes on the performance of the overall system (Shannon and Fry, 2003). Simulation-based discovery has been shown to have three main characteristics (richness, low transparency, and interaction), each of which relates to the acquisition and features of intuitive knowledge and which leads to an improvement in learning (Swaak and deJong, 2001). Research indicates enhanced student involvement, improved student achievement and positive student attitudes toward the course as a result of using simulation (Motahar, 1994).

Organizations, or their decision processes, are characterized by three properties. First, the organization operates on the basis of a variety of inconsistent and ill-defined preferences. Second, it operates on the basis of trial-and-error procedures, the residue of learning from past experience and pragmatic inventions of necessity. Third, the boundaries of the organization are uncertain and changing (Cohen *et al*, 1972). While these properties are applicable to any organization, they are particularly pronounced in firms operating within transitional economies. The model developed must relate decision-making to interpretation of several relatively independent streams with the organization concerned with problems, solutions, participants, and choice opportunities. The simulation model should be specified in terms of these streams. The selected model of a Bulgarian winery addressed the decision processes of pricing, promotion, production capacity, and labour policies in a spreadsheet model including random events caused by nature and competition.

Soft systems methodology

Of primary importance in determining the success of the simulation is having a clear understanding of the goals of the experience prior to beginning it. In order to be used successfully, all participants must understand the goal as acquisition of new knowledge and development of knowledge based on existing skills for managerial decision-making scenarios (Kaufman, 1998). At the initial meeting in 2002, the goal of developing a microeconomic model suited to decision-making within a local winery was accepted by all participants. The Tsenov Academy faculty and students defined the objective of using the simulation model in classroom situations in order to investigate the profitability and overall risk of potential markets. Business students in this Bulgarian school would be able to utilize the model to observe how decisions relating to pricing, promotion, production capacity, and labour policies would change as the winery presumably moved from its restricted market to the free enterprise system. A secondary objective was utilization of the simulation model by actual winery management to see the immediate impact of proposed market expansion.

Thus, the soft systems methodology (SSM) was viewed as highly appropriate for this study, which involved a very unstructured subjective model of a transition economy decision environment. This was driven in part due to the lack of concrete data for a specific business domain. The Bulgarian Academy of Sciences has a great deal of objective data about Bulgarian economic performance, and these were drawn upon for use in the model. However, the model required an understanding of the interrelationship of microeconomic decision-making in a transition economy, and the nature of this domain involves high levels of uncertainty (regardless of being in a transition economy or not). The soft systems method (Checkland, 1984; Mingers and Taylor, 1992; Bennets *et al*, 1998) has been around for some time, with many applications in fields involving subjective modelling. These subjective models have been applied in information systems development (Ledington and Donaldson, 1997; Ormerod, 1998) as well as to models of policy (Rose, 1997). Ultimately, SSM can be used either as a tool for carrying out the systemic intervention or as a tool for making sense of a complex problem, helping organize the overall discussion—it is this latter type of usage that is applied in this paper.

SSM includes a sequence of seven stages leading to understanding of the type of system developed for the Bulgarian winery case (Checkland and Scholes, 1990). The SSM was followed in principle, in that an unstructured problem was defined (Step 1: Unstructured problem situation: Define the problem), and an initial mental picture of the case developed in the simulation modeller's mind (Step 2: Problem situation expressed). The system components of the model were clearly identified (Step 3: Root definition—CATWOE). After determining the goal to be modelling the winery's microeconomic processes in the move to a free-market enterprise, the initial conceptual model was developed (Step 4: Conceptual model—in our case Monte Carlo simulation).

In October 2003, four US faculty participants met with two Tsenov Academy faculty and the two researchers from the Bulgarian Academy of Science. At this meeting, the model was explained in detail, and then revised based upon further explanation and clarification of the winery processes and the firm's goals. All development participants; the winery experts (the two Tsenov Academy faculty), the economic experts (the two Bulgarian Academy of Science participants), and the modellers (the four US faculty) reached a clear understanding of the goal and objectives of

the experience. This activity also led to comparison of the original conceptual model with the real world (Step 5).

Upon completion of this meeting, the US faculty again returned home, and the model was refined (Step 6). Feedback indicates the model adequately represents the Bulgarian winery's microeconomic parameters within its macroeconomic environmental considerations of distribution beyond the local area. The fulfilment of the pedagogical objectives for utilization of the model are mixed. While winery management might find results of interest, it is unlikely that the model will change pre-transitional economic decision-making practices for winery management, because they have developed their own managerial style that is not dependent on tools such as simulation. However, the model's primary pedagogical objective is to aid the learning process of the next generation of managers. As a simulation model for use in Bulgarian business schools, the Bulgarian faculty affirmed the applicability of the model and its intended use in the classroom (Step 7).

Therefore, the model was tested, and adjusted according to real-world considerations relative to the transitional economic situation and unique, decision-making processes of that environment. While there are valid questions that can be raised about the realism of any simulation for any organizational experience, the model developed in the following section has been adjusted to the operational goals of the winery and the microeconomic environment in which it operates, considering the macroeconomic environment in which it will need to operate. The result from this integration of primary goal and operational objectives is a dynamic system allowing decision makers, whether managers or business students as future managers, to interact and evaluate decision outcomes and alternatives.

Model development

This model developed is a tool to allow participants in the simulation to react to managerial decision-making situations and to observe the impact of their decisions as related to key transformational processes such as (1) market selections for different products, (2) product promotion and pricing based on competition, (3) perceptions of product quality as related to product development and design changes, (4) production functions and capacity including making inventories of grapes, and (5) distribution in selected markets . The model addressed environmental issues of capital replenishment and labour force development. Based on the interrelationships of transformational firm-level and regional environmental issues while considering the national and international export potential, the simulation model determines expected profit, market share, and various levels of cash flow.

Simulation modelling

There are a number of software products available to support simulation modelling. This phase of the research used Excel models that fit the time dimension of our model quite well. Crystal Ball extension of Excel models provides many advanced Monte Carlo simulation modelling features, to enable generation of thousands of sample runs and displaying probabilistic outcomes of the simulation model. The selection of Excel and Crystal Ball was primarily due to the cost constraint upon the Bulgarian users of other software packages. In addition, the model in Crystal Ball was considered very user-friendly for the student and winery management participants in the decision-making, learning experience. Hands-on usage of the simulation was, therefore, enhanced by the software chosen for the Bulgarian winery's simulation model.

Development of the Bulgarian winery's simulation model

The study focused on five different strategic levels, including components of transformational processes and operating within environmental considerations at the regional, national, and international levels. Each of these demand levels involved probabilistic, interrelated demand growth, which could be influenced by firm efforts. The microlevel included local market demand. Competition was found at the mesolevel, including competing firms who made their own promotion and pricing decisions, making these elements probabilistic for the subject firm. The macrolevel included state policies such as taxes and restrictions, as well as probabilistic national market demand. The global level included duties that could be applied, as well as probabilistic export market demand. Table 1 displays these levels and probabilistic model elements.

The structure of the model is monthly operations over a 6-year period. This model time frame covers a period long enough to show the impact of input decisions in the subject

Table 1 Model strategic levels

Level	*Element*	*Probabilistic components*	*Decisions*
FIRM	Bulgarian winery	Crop yield	Pricing, promotion, capital expenditure, Training
MICRO	Regional	Local market demand	
MESO	Industry		Competitive pricing, promotion, capacity
MACRO	National	National market demand	Taxes, restrictions
GLOBAL	International	Export market demand	

winery. It could easily be extended as far as desired. Output measures include profit, cash flow, net present worth, and market share by market. User inputs include promotion and pricing of finished goods, quality related to design change, which in this case is related to growing their own grapes or buying grapes from independent growers, and place, which is related to market selection for local or export distribution.

Promotion is lagged over 3 months, with weights of 0.5 for prior month effort, 0.35 for efforts 2-months prior, and 0.15 for efforts 3-months prior. The primary impact on quality is the source of grapes. Management felt that those grapes grown on their own fields had higher quality control. These grapes would be used first, supplemented by grapes purchased on the open market for any extra production planned. Prices were set by the market. Place decisions allowed management to block marketing wines in either the national or export markets.

Output measures and exogenous variables

The simulation model consisted of time-variant variables in three classes:

(1) *Exogenous* variables representing the environment (demand, market price, competitor promotion, market share possibilities, crop yield);
(2) *Control* variables reflecting managerial decisions (price by product, promotion by product, plant capacity, labour policy), and
(3) *System* variables measuring aspects of the output measures (demands by product, sales by product, market share by product, inventories, bank balance).

The model included feedback. The core variables and their relationships are shown in Figure 1.

Model revision

At the October 2003 meeting in Sophia, the initial model was presented in detail, to include modules on:

- Demand seasonality and monthly labour requirements (vineyard and bottling)
- Bank account
- Demand by product
- Prices (firm policy and market, by product)
- Promotion by product and by market
- Sales by product and by market
- Probability of promotion effect and competitor promotion effects
- Bottling operations (capacities and inventories)

The Tsenov Academy experts identified the need to include five types of product, sold in both national and international markets. These five products, in order of increasing quality, were

(1) Bulk wines (mostly exported),
(2) Table wines,

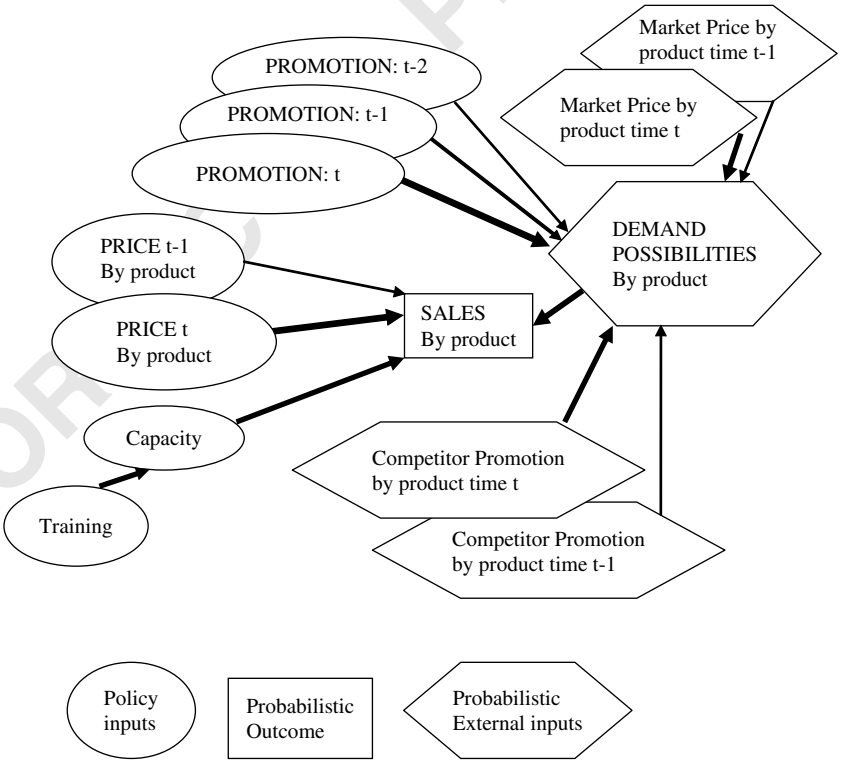

Figure 1 Relationships of model variables.

(3) Brand wines,
(4) Regional wines,
(5) Reserve wines (reserve wine only available in good years).

Tsenov experts also clarified planting requirements for high-quality grapes. For this winery, seeding could be harvested after 4 years. Replanting requirements were beyond the time horizon of the model. Seasonal labour requirements were adjusted. The Bulgarian Academy of Science participants provided objective data on demand, prices, and sales by product. The group as a whole discussed parameter distributions and the fuzziness of the data due to some ambiguity and incompleteness of the information in the expert opinions. Therefore, triangular distributions were used, to reflect low, most likely, and high estimates that were available.

The modeller returned to the US and after a period of about a month, a new model was developed. Results were sent to Tsenov Academy experts, and feedback was gathered about the expected performance of the model. The average profit yielded by the model was checked for reasonability, and was found to be appropriate. The probability of loss for the winery was estimated (to be very low). Rough Bulgarian market shares for each of the five wine products were obtained, as well as rough estimates of export sales by product. The responses were used to further adjust the simulation model.

Simulation results

Simulation model results provide feedback to the managers and/or the students, demonstrating the impact of their policy inputs. The ability of simulations to be replicated is highly useful, as each particular simulation is only one among many possible outcomes. A total of 1000 repetitions of both labour policies using base price and promotion levels were obtained using Crystal Ball. The base run (one of an infinite number of possible policy-decision combinations) yielded measures of five key parameters as displayed in Figure 2. Demand was highly seasonal in both national and export markets, with a slight positive trend. Bank balance can be seen to steadily increase with time. Market share for national product fluctuated, with a large increase in years 2 and 3, returning to initial levels. Export market share was much steadier.

The type of performance result provided to users is demonstrated in the following figures. Figure 3 shows the results of 1000 replications of ending bank balance over the 6-year period. The average balance here was positive, with a mean of 4 912 156 Lev (1 Lev approximately \$0.50) after 6 years. Figure 3 shows no results in 1000 trials of losing the entire 100 000 Lev bankroll for the base case. This reflects a highly profitable business environment, which was confirmed with the winery experts. The most optimistic of the 1000 outcomes would yield an ending balance of over 17 million Lev, while the worst outcome was a final balance of

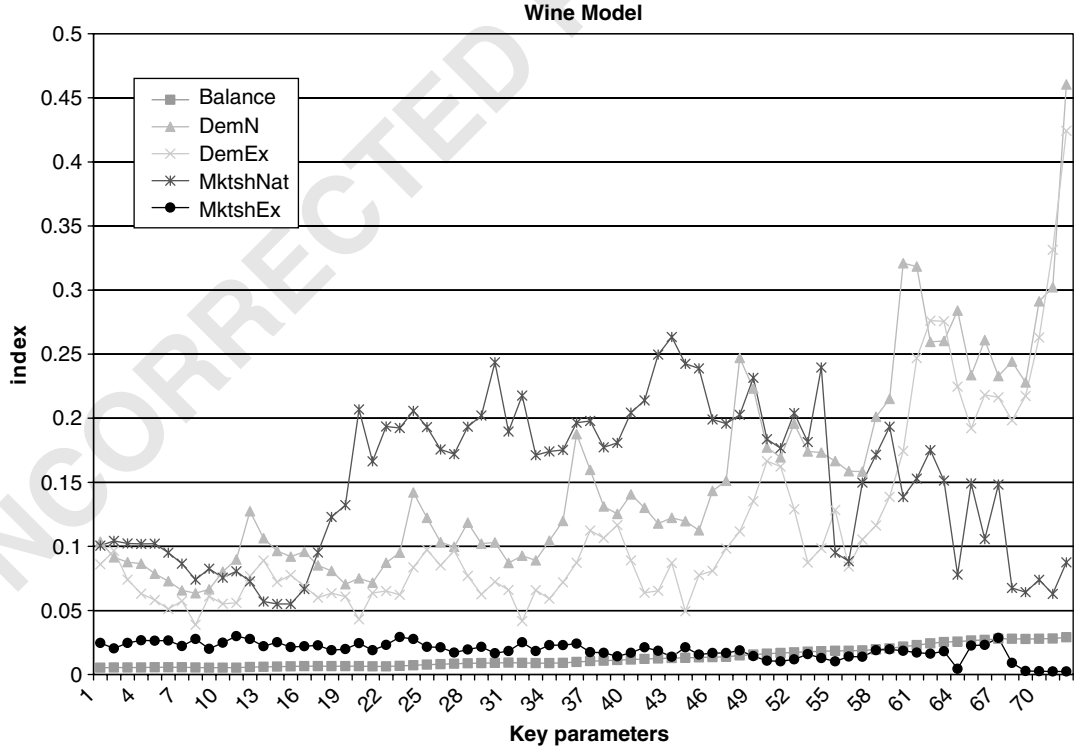

Figure 2 Base run output measures for 72 months.

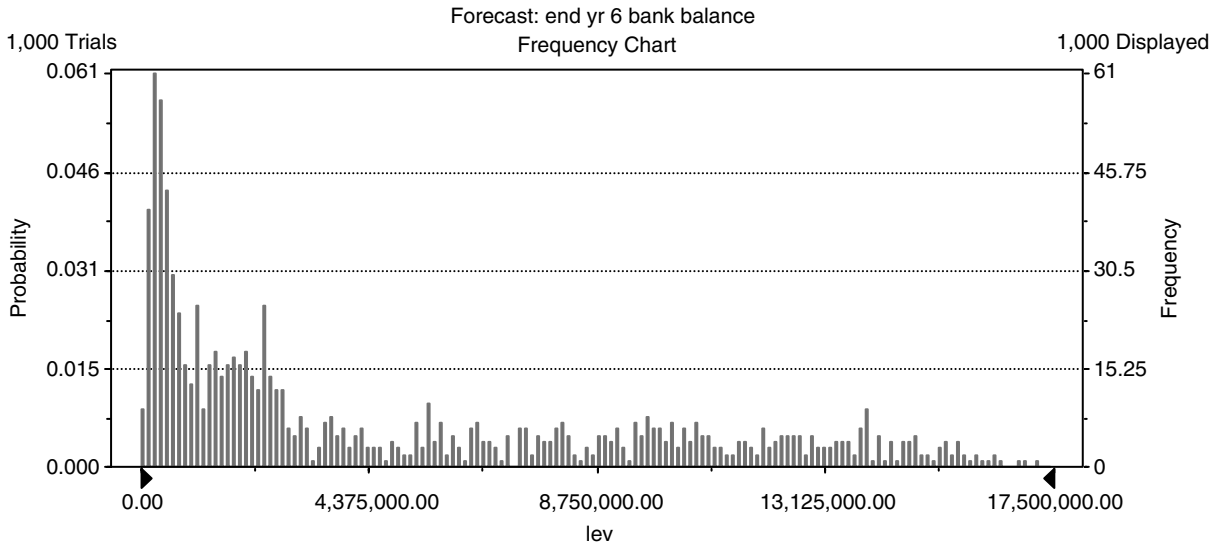

Figure 3 End bank balance.

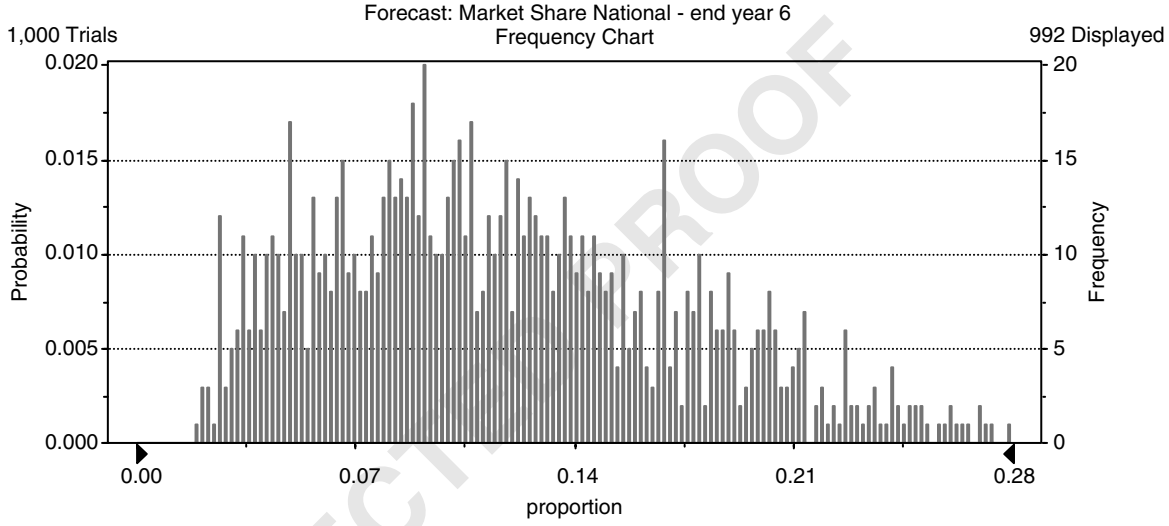

Figure 4 Market share in Bulgaria—base case.

123 960 Lev. The base case clearly involves the opportunity for profit, with low risk.

Other response variable results can similarly be displayed. Market share for wine sold within Bulgaria was reported by the simulation, as well as the total number of bottles exported. Figure 4 shows the market share obtained nationally.

At this stage, the simulation has been used primarily to validate the model. Changing the price and promotion to various levels yielded the results in Table 2.

Case 1 showed a safe operation, near maximum demand (at base promotion rates) for export wines, which had first priority on sales. Increasing local prices (Case 2) had a slightly negative impact on profit, through decreased market share. Export demand was modelled to be a function of price, and the price increases in Case 3 decreased exports and lowered profit. Increasing prices of both products (Case 4) decreased profitability even more. Case 5 left prices at their base levels, and adjusted promotion budgets, diverting export promotion budget to national markets. This resulted in the lowest levels of profit, but had a very high probability of avoiding bankruptcy. The market share for national products jumped to almost 40% of the market, at the expense of export sales. Case 6 reversed the promotion budget, still at the base level total, but emphasizing export markets. This had a very high profitability average. National market share dropped to 1%, more than doubling export sales. Case 7 doubled the promotion budget for both

Table 2 Simulation output measures

Price	*Promotion*	*μ profit*	*Min profit*	*Max profit*	*Pr{>600K} profit*	*Market share Nat'l*	*Bottles export*
1 Base	Base	4 872 676	−15 520	17 145 866	0.790	0.12	1 425 049
2 Nat'l + 20%	Base	4 749 643	−16 725	17 140 957	0.752	0.05	1 435 034
3 Export + 20%	Base	2 161 780	136 411	17 833 035	0.605	0.14	682 644
4 Both + 20%	Base	2 003 576	126 323	17 611 301	0.443	0.07	688 531
5 Base	National	912 447	132 289	1 203 225	0.990	0.39	292 015
6 Base	Export	16 213 083	181 608	19 349 210	0.984	0.01	3 560 453
7 Base	Both up	16 251 717	93 712	19 318 158	0.985	0.05	3 532 730

markets, yielding the highest average profit. Additional runs vastly increasing promotional budgets found a decline in profitability due to logistic response of export market to excessive promotion budgets. (After a given increase in promotional budget, few additional sales were obtained but expenses were higher.)

The above set of runs provided a baseline of results. The average profitability was judged by the winery experts to be within reason, as well as having a high probability of profitability. Since experiments with prices and promotion such as those modelled had not been conducted (or at least results of such experiments were not known), the faculty involved could only subjectively judge the outcomes obtained. Note that the promotional shifts reported here were very slight. Increasing export promotion 10-fold yielded much higher export sales (and much higher profit). Owing to a maximum export demand in the model, extravagant increases in promotion would be counter-productive, and would decrease profitability as promotion expenses would increase with no additional sales.

Conclusions

This paper presents the process of the development of a simulation tool to structure a decision-making soft systems model based upon input from Bulgarian collaborators and winery experts over a period of development beginning in 2002. Bulgarian experts were used to validate the model, its input parameters, and its output relative to evolving economic conditions. Our focus was on the decision-making process and realistic portrayal of the economy, with the intent of supporting pedagogy in the training of present and future managers. Students (and managers) in the transitional economy can use the simulation to study market forces and recognize the impact of pricing, promotion, and capital expenditure at the firm level; competitive pricing, promotion, and capacity at the industry level; and governmental restrictions at the national level. In most cases within the transitional Bulgarian economy, promotion had not been used, competitive pricing had not been studied, and goals for distribution beyond the local level were not in place even though the winery desired to broaden their market to regional, national, and international markets. Thus, students in the transitional economy could be exposed to the what-if process, whereby the unknown aspects of pricing, promotion, distribution, and other factors can be tested with relevance to profit and market share.

SSM contributions to the project are as follows:

(1) Problem definition of an unstructured transitional economy environment led to selection of a simulation model to reflect dynamic and interacting firm-level operational and strategic decisions over time.
(2) Intensive sessions uncovered system components. While rich pictures were not used, the interactive discussion of winery management involving Tsenov experts, Bulgarian researchers with objective data, and US faculty modellers, all supported by graduate students, led to description of the complexities involved in decision-making (capacity planning, production, pricing, promotion, and quality) in a Bulgarian winery.
(3) Root definitions were developed through construction of the simulation model, reflecting the interactive decisions.
(4) The model was constructed.
(5) An initial check of the model was conducted in Sophia in 2003, and was refined.
(6) A pedagogical tool for business students and management training has been developed.
(7) Testing of the simulation was performed and the results were assessed as realistic for the winery in question. Step 7 has been performed in a microenvironment but the pedagogical aspect in a classroom environment by Bulgarian students awaits incorporation into the Tsenov Academy's faculty curriculum.

The simulation presented has the benefit of being developed and refined from the collaborators' first meeting in 2002 and throughout the subsequent years. Aspects of this collaboration add strength to the simulation's ability to model the transitional economy by refining the model's parameters using objective data from the Bulgarian Institute of Economics and adjusting the model structure based on expert opinion about the specific winery's operations, products, and goals. As changes occur within the economic environment, the simulation may require modifications to remain a pedagogical tool for the real-world as Bulgaria advances closer to entry into the European Union.

The value of the project is thus the teamwork involved, the problem-structuring method, and the overall modelling

through strategic levels to the simulated performance of the winery's operational decision-making processes. All of these results suggest a model useful for engaging transitional economy managers and business students in a dialogue about strategic processes, firm performance, industry structure, and competitive advantage from which learning about free-market economies might arise.

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