

# Developments In Business Simulation & Experiential Exercises, Volume 20, 1993

## MULTIPLE INDUSTRIES IN COMPUTERIZED GAMING-SIMULATIONS

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### ABSTRACT

A scale-invariant model for incorporating multiple industries into computerized business gaming-simulations such as to match the U.S. Standard Industrial Classification system, while also allowing the instructor to redefine the industries, is presented. Intended to capture the functional character of industries, the model allows for (a) quantitative differences in rates of productivity, of deterioration, of depreciation, and of utilization; (b) qualitative differences in resource requirements; and (c) industrial interdependence. The model should be most suitable for business gaming-simulations designed to cover strategic business issues. Experience with such gaming-simulations may help clarify concepts in business policy and strategy, illuminate the method of competitive analysis, and suggest even better analytical methods.

### INTRODUCTION

Although comparative industrial studies are pervasive in business and economics, and is particularly central to business policy and strategy, computerized business gaming-simulations have generally not allowed either instructors or participants a choice of industries. In most cases, the gaming-simulation is based either on a particular industry or on a generic manufacturing industry. An exception is STRATEGY! (Priesmeyer, 1992), wherein participants are allowed to enter and exit 10 industries. Even so, STRATEGY! does not allow the instructor to redefine the industries.

A multiple-industry business gaming-simulation that allows the instructor to define the industries must capture the essential differences between industries in a small set of instructor-modifiable parameters. The selection of these parameters is crucial, for they limit the issues that can be addressed.

Capital, labor, and material are the elements of industry in Gold's (1991) multiplicative production function. The function specifies that these elements affect output through elasticity parameters that allow for variable returns to scale. The function fits an industrial classification system based on input intensities (i.e., capital intensive, labor intensive, and material intensive). It ignores qualitative differences in inputs, outputs, and processes. It neither accounts for time-dependent losses (output deterioration and resource depreciation) nor for interdependence among industries, factors crucial to the relative profitability of industries. Furthermore, it is unrelated to the U.S. governments Standard Industrial Classification (SIC) system, the basis for many comparative industrial studies of U.S. businesses.

By the SIC system, businesses are assigned to industries based on their "product or group of products produced or distributed, or services rendered" (Office of Management and Budget: 15). Because products and services are tied to production processes, gaming-simulations can be related to the system by modeling production processes, and labeling the products and services to suit.

This paper presents a model of production processes that allow for qualitatively different inputs; that accounts for output deterioration, resource depreciation, and industrial interdependence; and that can be directly matched to the SIC system. The model is mathematically simple, with invariable returns to scale. When properly incorporated into a business gaming-simulation, the model permits the instructor to define any industry by setting a small number of parameters and labeling the products and services.

### THE MODEL

Scale-invariant production processes can be modeled by rates. The rates having the greatest effects on the production process are the productivity rate, deterioration rate, utilization rate, and depreciation rate. The productivity rate is the rate by which a resource's productive capacity depends upon its presence (Equation 1). The deterioration rate is the rate by which the inventoried output diminishes over time (Equation 2). The utilization rate is the rate by which a resource is consumed by production, and the depreciation rate is the rate by which an unconsumed resource is lost over time (Equation 3). Given any number of required resources, actual production will be limited by the minimum of the productive capacities of all resources.

$$\text{Productive capacity}_t = \text{Resource}_{t-1} \times \text{productivity rate.} \quad (1)$$

$$\text{Output Inventory}_t = (\text{Output Inventory}_{t-1} + \text{Production}_t - \text{Sales}_t) \times (1 - \text{deterioration rate}). \quad (2)$$

$$\text{Resource}_t = (\text{Resource}_{t-1} - \text{Production}_t \times \text{utilization rate}) \times (1 - \text{depreciation rate}). \quad (3)$$

The four rates are not completely independent. If the output of one industry is the resource of another, the deterioration rate of the output-to-resource item should generally be the same as its depreciation rate. Moreover, the utilization rate of a production-limiting resource cannot exceed the inverse of its productivity rate, for that would cause the ending level of that resource to have an impossible negative value.<sup>1</sup>

With these relationships, an economy of interdependent industries can be created by designating the outputs of some industries as resources of other industries. A sample instructor's setup table that defines a sample-simulated economy of five cascadingly dependent industries is shown in Table 1.

TABLE 1  
SAMPLE INSTRUCTOR'S SETUP TABLE

ITEM	Item 0	Item 1	Item 2	Item 3	Item 4
Name	Service	Material	Building	Machine	Food
Deterioration Rate	1.000	0.000	0.000	0.100	0.500
Productivity Rate	1.000	1.000	10.000	5.000	1.000
Utilization Rate	1.000	1.000	0.000	0.000	1.000
Depreciation Rate	1.000	0.000	0.000	0.100	0.500
Requires Item 0	0	1	1	1	1
Requires Item 1	0	0	1	1	1
Requires Item 2	0	0	0	1	1
Requires Item 3	0	0	0	0	1
Requires Item 4	0	0	0	0	0

$$\text{Production}_t = \text{Productive Capacity}_t$$

thus,

$$\text{Resource}_t = \text{Resource}_{t-1} (1 - \text{productivity rate} \times \text{utilization rate}) \times (1 - \text{depreciation rate}).$$

<sup>1</sup> For the production-limiting resource, implying that the product of the productivity and utilization rates must not exceed unity.

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The sample setup table gives a name for each of five items, their associated rates, and the resources required for their production (0, no; 1, yes). The presumption here is that the rates associated with each item are constant across industries. Thus, services depreciate at the rate of 1.000 (100%) a period, irrespective of whether they are used to produce materials, buildings, machines, or food.

Although the sample items have been constructed to match 5 of the SIC system's 11 divisions,<sup>2</sup> and the rates chosen to represent pure cases, the intent is that the instructor should be able to change the labels, rates, and requirements to suit the instructors purposes. Accordingly, if the instructor so chooses, the instructor might set up two industries producing identical outputs with different resources and processes, or two industries producing different outputs with the same resources and processes.

### MODEL APPLICATION

A business gaming-simulation that incorporates the model presented without embellishment would have a very simple production-operations component compared with most total enterprise gaming-simulations traditionally used in courses on business policy and strategy (Keys & Biggs, 1990). Accordingly, it would not be suitable for instructors desiring extensive coverage of production-operations management. But the simplicity of production would enable the gaming-simulation to cover more adequately the strategic issues of entering and leaving industries; of corporate financing; of selecting, compensating, and motivating executives; and of purchasing and product pricing.

A gaming-simulation focused on these strategic issues may be one in which each participant will be allowed to found a limited number of firms each in the participants choice of industry, to finance the firms by selling shares to other participants, and to employ and compensate other participants as executives who will manage purchasing and product pricing. Such a gaming-simulation can include a real market (Thavikulwat, 1990) for executives, for shares, and for industrial inputs and outputs.

### CONCLUSION

This multiple-industry model adds to the body of literature constituting the "science of simulation design and development that Goosen (1981: 41) envisioned over a decade ago. This science may soon develop to the point where concepts in business management will regularly be clarified by their implementation in gaming-simulations. The concept of *service*, for example, generally defined in production-operations management as something that is produced and consumed simultaneously" (Schroeder, 1989), is clarified by the multiple-industry model presented as an item with a 100% deterioration rate, and an identical depreciation rate.

Notwithstanding the widespread use of computerized business gaming-simulations in business courses (Frاند & Britt, 1989), their role in clarifying business concepts remains generally unappreciated. Thus, for example, in the report on doctoral education commissioned in 1988 by the Executive Committee of the Business Policy and Planning Division of the Academy of Management (Summer, et al., 1990), no mention is made of gaming-simulations at all, even though gaming-simulations are used in almost 50% of business policy courses (Faria, 1990).

Moreover, gaming-simulations may be the ideal setting for studying the adequacy of analytical methods. Over the last decade, probably

the most popular of analytical methods in business policy and strategy has been Porters (1980) *competitive analysis*. Because the method brings out differences among industries, it is inapplicable to business gaming-simulations with only a single industry. Even so, how a participant might apply competitive analysis to realize superior results in a multi-industry business gaming-simulation remains unclear.

As all drugs have side effects, all analytical methods require effort. The effort of applying Porters method may cause mental fatigue sufficient to thwart insight. Observations of participants as they contend with a multi-industry gaming-simulation based on a model such as the one proposed here may illuminate Porters method, and suggest even better ones.

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<sup>2</sup> The five matching divisions are (a) services; (b) mining; (c) construction; (d) manufacturing; and (e) agriculture, forestry, and fishing, respectively. The six remaining divisions are (a) transportation, communications, electric, gas, and sanitary services; (b) wholesale trade; (c) retail trade; (d) finance, insurance, and real estate; (e) public administration; and (f) nonclassifiable establishments.