ENDOGENOUS GENERATION OF STRUCTURAL CHANGE IN SYSTEM DYNAMICS MODELS:

An Illustration From a Corporate Context

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ABSTRACT

System Dynamics models have been used extensively for depicting the dynamic behavior which arises from a given underlying feedback structure. In a typical application, a feedback structure is specified, numerical values for model parameters are specified, and then a base-run simulation is conducted. Following the establishment of a Base Case, initial conditions, table functions, constants, policy variables and exogenous inputs are altered; with the resulting impact on model behavior noted and analyzed.

Although such a process has yielded numerous insights, and will continue to do so, it is seriously limited in its ability to contribute to an understanding of a system's evolutionary potential. Social systems, at all levels, are capable of exhibiting evolutionary behavior. Such behavior often manifests as an abrupt change in behavior mode. In some cases, the structural "reorganization" underlying the appearance of new behavior modes can be represented as "shifts in dominance" among a pre-existing set of feedback relationships. The non-linearity causing dominance to shift from an underlying positive feedback loop to a negative feedback loop, yielding the logistic growth curve, is well-known among system dynamicists as one such example. However, not all of the structural changes underlying evolutionary behavior can be characterized as "shifts in dominance". Indeed, more frequently such changes represent the activation of new feedback relationships; implying the introduction of new state variables, with their associated rates of flow.

Modelers using other methodologies [1][2] recently have begun to attack the problem of endogenously generating evolutionary structural change. Particularly in Europe, the term "self-organizing" has been used to characterize the models which seek this end. Not surprisingly, the characteristic features of the behavior generated by "self-organizing" models differs in a number of ways from what is currently typical behavior of System Dynamics models. For example, while the behavior of most system dynamics models is characteristically insensitive to the choice of initial condition values, the behavior "self-organizing" models tends to be critically dependent on the specification of initial conditions. It is not uncommon to see both the equilibrium settling point and the stability properties of "self-organizing" representations altered by varying initial condition values. To cite another example, a System Dynamicist likely would be very surprised to see instability arise -- without exogenous perturbation -- after a model's behavior had proceeded through its transient response and seemingly settled into a steady state. Yet such behavior regularly emerges from "self-organizing" models [3]; and, the real-world supplies numerous additional examples.

System Dynamicists will broaden significantly the range and importance of the issues that they can address if attention is focused on the endogenous generation of structural change. The proposed paper will use a corporate model to illustrate the mechanics of endogenizing structural change in a system dynamics model. The model will simulate the evolution of a firm from its beginnings -- as a handful of entrepreneurs, organized around a single product -- to its steady state - conclusion as a large, functionally-specialized and product-diversified corporation. The model is capable of generating a number of evolutionary trajectories; indicating that the steady state, and progression thereto, depends in part, upon: initial conditions, parameter values, and the particular

set of "natural selective" forces that are operating in the firm's environment.

[1] Dendrinos, Demitrios, "Catastrophe Theory in Urban and Transport Analysis", DOT/RSPA/DPB-25/80/20, 1980.

[2] Allen, Peter, et al., The Dynamics of Urban Education, Volume 1, U.S. DOT, RSPA, 1978.

[3] Day, Richard, "The Emergence from Classical Economic Growth," Modeling Research Group Paper #8014, University of Southern California, 1979. c