Capital Investment Cycles: A System Dynamics Modeling Approach to Social Theory Development

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I. Introduction

System dynamics computer modeling has proven to be a powerful analysis tool for engineers, project planners, and policy analysts. Yet its application in the social sciences to date has been surprisingly limited. This paper is an attempt to contribute to the slowly expanding body of work which seeks to amend this gap in social research, such as Hanneman's (1980) *Computer-Assisted Theory Building*. Through the development as much as the actual construction and testing of such models, insights can be gained into general theory development, the dynamics of complex sociological processes, and the impact of social structure on those processes. To this end, a theory of capital investment cycles and their impact upon the built environment of urban areas proposed by David Harvey in "The Urban Process Under Capitalism: A Framework for Analysis", which originally appeared in the March 1978 edition of the *International Journal of Urban and Regional Research*, is constructed as a computer model, utilizing the *Vensim* software. This example demonstrates the applicability of the system dynamics modeling approach to a topic of interest to a broad range of social scientists because of its relevance to urban sociology, economics, industrial and labor studies, public policy, and social theory. Not only does this process provide insights into the dynamics of urban processes within a capitalist social structure, as well as allow for expanding upon some of Harvey's complex and compelling theory, but it also provides a context in which a heightened awareness can be gained regarding what constitutes the construction of satisfactory social theory. Moreover, the process of using a system dynamics model to develop social theory provides a keen contrast to the more common social science practice of progressing directly from theory to statistically testable equation. For while at its core a system dynamics model is still a set of equations, it is a set of equations which possesses properties often lacking in standard regression procedures and which make them a more constructive vehicle for developing or expanding the social theory on which they are based.

II. Harvey's Theory

In "The Urban Process Under Capitalism: A Framework for Analysis", David Harvey describes a theory of capital investment and its impact upon urban areas. Based heavily on the Marxist concepts of the contradictions in capitalism and the dynamics of accumulation, Harvey's model of capital investment encompasses the primary circuit of capital (production), the secondary circuit of capital (the built environment), and the tertiary circuit of capital (social welfare programs). After postulating that crises of over-production in the primary circuit lead to crises of overinvestment in the secondary and tertiary circuits as assets are redirected in efforts to ameliorate primary circuit over-accumulation, Harvey specifically delves into the interplay between capital accumulation and urban processes. Relying on historical data from Thomas (1973) and others as evidence for "long waves" of investment in the built environment, he reviews how flows of investment and labor between Britain and the United States during the nineteenth and twentieth centuries were inter-related and support his hypothesis that capital investment patterns follow regular cycles.

Because Harvey's article is so broad it encompasses the whole of capital investment cycles, only select pieces of his larger model have been reconstructed here. The cyclical interdependency of investments in the production and built environment circuits of capital has been chosen as the focus because it mirrors Harvey's own emphasis on the interaction between investment cycles and urban processes. Over-accumulation of capital in either the primary or secondary circuit of capital shifts the relative productivity of investment in these sectors, with investments moving away from the over-accumulated sector and into the other as over-accumulation drives down the productivity of further investment. As long as institutions such as the state and financial markets function efficiently enough in providing pathways which allow capital to shift from one sector, or circuit, of investment to another, then the investment behavior observed should move, over time, in two opposing sets of waves, with alternating peaks in primary and secondary circuit capital accumulation.

III. Model Construction

As it stands, the model has been developed to explicitly encompass capital in both the primary and secondary circuits, as well as production, the social reproduction of labor and a labor supply, and the inter-related concepts of consumption and perceived demand. It also implicitly incorporates the financial and state entities Harvey posits as essential for moving capital investments from one circuit to the other (See Diagram).

For the sake of simplicity, the money capital available for investment is assumed to flow solely from the production process and price is held constant. The core processes which Harvey has endeavored to explain are not obscured by this distillation, but are brought more clearly into focus. While his description of additional layers of complexity may be a more accurate representation of the complete set of real world processes involved in capital flow dynamics in some respects, the rigor of constructing a complete quantitative system dynamics model forces the theorist to extract from the narrative, to which complexity can be smoothly or roughly grafted with the addition of a few paragraphs, only those elements of the theory which are most essential to understanding the underlying dynamic relationship of the social system being described.

In order to move from Harvey's narrative to a working model, a careful review of Harvey's theory - both regarding his description of causal connections and his actual terminology - was essential. For instance, Harvey includes both the fixed capital of production and the fixed capital of labor reproduction in his conception of the secondary circuit of capital. However, combining categories of built environment capital like this renders quantitative separation of links to the rest of the system a virtual impossibility. In order to differentiate among goods-producing primary circuit capital, goods producing secondary circuit capital, and labor-reproducing secondary circuit capital in which the process of daily living that generates and regenerates the labor supply occurs, primary circuit capital needs to be operationalized as capital dedicated to goods production, which includes both Harvey's initial primary circuit capital of the wage-labor dynamic and fixed capital intended solely for production of goods (machinery, plants, etc.). Secondary circuit capital is defined as, and divided between, the built environment of labor reproduction (housing, schools, etc.) and built environment capital which serves goods production processes (infrastructure, etc.).

IV. Discussion

While social science has thus far made little use of system dynamics models, it has not lacked in quantitative methods for developing and evaluating theories. In particular, social scientists have relied heavily on statistical methodologies. However, though the practice of statistical analysis in social science is replete with hypothesis testing, the social scientists engaging in such analyses will be the first to emphasize that statistical significance holds no special claim to sound theory. Moving back and forth between theory and testable hypothesis has in turn been both a tenuous trek into causal reasoning and a foray into existentialism. Systems thinking and modeling thus have much they can offer the practice of social science by way of strengthening the link between qualitative theory and quantitative equations. The process of building a system dynamics model based on social theory compels clarity in theory conception, as well as variable inclusion and operationalization. And true to its nature, it does not do so in a linear, unidirectional manner, but as an on-going, iterative process which (hopefully) forms the positive feedback loop that every introductory text in social research methods claims initial theory formulation and theory development ought to form. And unlike statistical equation building, it does not so much assume as impose this process. As with any methodology, it produces poor results if practiced poorly. However, its proper practice is in and of itself a theory development structure which much more actively discourages the growth of ill-conceived theory than is that of testing for statistical significance.

For instance, one of the fundamental concepts of system dynamics modeling is the reference mode. What is the observed behavior of the real world system or structure over time? It is this behavior which becomes the guide for developing the theory underlying the model. Statistical estimation is much more concerned with comparing reference modes by examining the covariance of (theoretically) associated concepts. It thus seeks to represent *relationships* with equations, while a good system dynamics model seeks to represent *processes* with equations.

Again, the nature of such modeling, particularly its call for justification of units, pushes its underlying theory toward a conceptual whole. For example, though goods production capital and production may be highly correlated, with the former "explaining" much of the variance in the latter, the causal link from primary circuit capital to production would not be complete without unit production capacity and measures of other relevant types of productivity. Because a good system dynamics model is units-justified, it is conceptually seamless and therefore more apt to be able to represent processes rather than just associative quantitative relationships.

References

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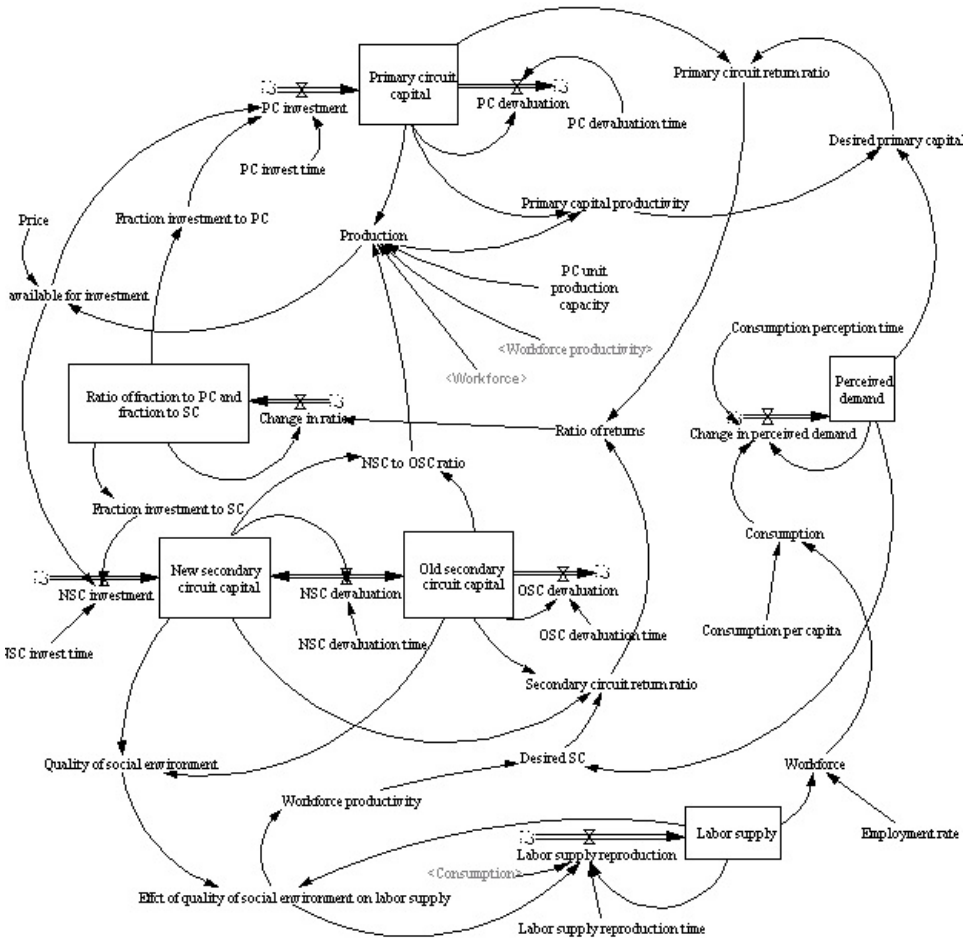
Diagram - Current Model - Circuits of Capital



SC = secondary circuit capital

NSC = new secondary circuit capital

PC = primary circuit capital

OSC = old secondary circuit capital