Analysis of Business Cycles in the U.S. Machine Tool Industry

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Cyclicality is a well-known phenomenon in many capital goods industries. It is especially pronounced in the machine tool industry where peak-to-peak variations in incoming orders often exceed 100% of mean sales. While extreme cyclicality in the machine tool industry and its resulting problems are well documented (Bowen et al. 1989; Dertouzos, Lester and Solow 1989; Neary 1993), the underlying causes and the potential levers to reduce it are so far not well understood.

Our work focuses on building an understanding of cyclicality in the machine tool industry. Through the formulation of a system dynamics model of the machine tool industry the structure leading to cyclicality is made more apparent. It then proceeds to discern possible measures for influencing and altering the cyclicality.

First, a review of the situation in the U.S., Japan and Germany as the leading machine tool markets suggests that, while a variety of reasons for the diverging performance of national machine tool industries can be identified, recent developments in the machine tool markets are primarily reflecting changes in macroeconomic conditions rather than changes in national competitiveness. Analysis of data on the U.S. machine tool industry over the past 30 years suggests that serious swings in product orders and production in the machine tool market represent normality rather than an aberration (AMT 1993). Extreme cyclicality is both a characteristic of the machine tool industry and one of its most significant problems (Eglau 1994).

Gaining a better understanding of the structure leading to cyclicality is the first step in devising better ways of dealing with the problem of cyclicality. We use the system dynamics approach to explain the structure causing the extreme cyclicality observed in the real world, proceeding from the formulation of a dynamic hypothesis to the development of a formal model and then to its use for an industry analysis (Forrester 1994).

The first step in the development of the model is the formulation of a hypothesis about the structure causing cyclicality. It is hypothesized that huge variations in orders to the machine tool industry are the result of relatively small changes in Gross Domestic Product which are amplified along the supply chain of capital, resulting in huge variations in orders to the machine tool industry. This phenomenon of order amplification along the supply chain is similar to that observed in the classic "beer distribution game" (Sterman 1989). However, its underlying factors are different in this case.

The building of a model based on this hypothesis proceeds in two steps. First, building on a well-established system dynamics model of a generic company (Mass 1975; Lyneis 1980), this model is modified and extended to describe the machine tool industry structure including both machine tool producers and customers. The resulting model is able to reproduce much of the cyclical behavior observed in the real world in which machine tool companies operate.

The factors most influencing the intensity of cycles in the machine tool industry are sought from this model using sensitivity analysis. In this way the model is able to identify levers which could be used for reduction of cycles in the industry. This analysis proceeds in two parts, focusing first on the machine tool industry itself, and then on the customers of the machine tool industry.

The first analysis reveals that the machine tool industry itself has only one significant lever to reduce variations in incoming orders. A policy of accumulating backlogs in times of high demand can reduce the degree of variation in incoming orders to the industry. The U.S. machine tool industry followed this policy until the early 1980's. However, this lever disappeared with the entry of foreign competition into the U.S. market in the 1980's. Today companies or national industries following a policy of accumulating backlogs would find themselves losing market share to competing companies or national economies. In summary, model simulations show that variations in orders to the machine tool industry are not the result of poor adaptation of the industry or ill adjustment. The problematic behavior is created externally.

Using the car industry as an example in the second part of the analysis it is shown that the most significant levers to influence cyclicality all lie with the customers of the machine tool industry. A multitude of policy and parameter changes in the car industry have a huge effect on the severity of cycles observed in the machine tool industry. These huge effects are thus originally set into motion by the customers demands.

Analogous to the benefits recently achieved in the car industry through coordination and cooperation along the parts supply chain between car manufacturers and parts suppliers to the car industry, an approach focusing on the supply chain of capital could significantly improve conditions for the machine tool industry. The analysis results provide a strong argument to promote cooperation between builders and users of machine tools. As machine tools are of strategic importance to the manufacturing sector of a national economy this approach could yield significant externalities.

While cooperation with its customers seems to be the machine tool industry's main lever for dealing with the problem of cyclicality the efficiency of three alternative approaches should be tested. First, the machine tool industry could follow a counter cyclical ordering policy when ordering machine tools for its own use. Secondly, individual companies could develop product-portfolios specifically aimed at reducing cyclicality. One approach could be providing products to industries with business cycles largely independent of the general business cycle, e.g., aircraft manufacturers. Another approach could be a shift of machine tool builders' product portfolios towards an increased share of less cycle-prone machine tool-related industrial services. Thirdly, improved forecasting of machine tool demand would allow the industry to better cope with cyclicality in incoming orders. One possibility to improve forecasting of demand could be the development of forecasting models based on the model presented in this paper. The development of a management simulator is suggested in order to disseminate the results of this study to industrial decision makers.

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