Cycles in the sky: Understanding and managing business cycles in the airline market

Martin Liehr[1], Andreas Größler[1]*, Martin Klein[2] and Peter M. Milling[1]

[1] Industrieseminar, Mannheim University, Germany

[2] formerly with Lufthansa German Airlines, now with tiss.com

* Corresponding author:

Andreas Größler

Industrieseminar, Mannheim University, 68131 Mannheim, Germany

phone: +49 621 181-1583, fax: +49 621 181-1579

e-mail: agroe@is.bwl.uni-mannheim.de

Cycles in the sky: Understanding and managing business cycles in the airline market

Abstract

The airline market is a highly cyclical business with relatively poor returns on invested capital. The fluctuations in the market put the carriers under severe economic pressure, and most of them lack of strategies for cycle oriented behavior. The focus of the research conducted at Lufthansa German Airlines is the analysis of fundamental, cycle-generating structures in the airline market and the identification of alternative strategies for effective "cycle-management". The system dynamics approach is combined with a statistical forecasting model—a combination that proved to be valuable for the analysis and management of airline business cycles. The article describes a successful system dynamics study in a complex and fast changing environment. Insights generated during the project work are now going to influence order policies for new commercial aircraft for the carrier.

The evolution of the airline market is characterized by long-term business cycles. Whatever the reasons are for these cycles, they are the major cause for the market's poor profitability and for its low shareholder returns.[1] Since 1970, the airline market has seen two complete cycles. These included severe crises in the early 80s and the early 90s affecting nearly all carriers.[2] In order to gain insights into the dynamics of the cyclical movements and to derive strategies for long-term capacity and fleet planning, we developed a model of the airline market.

After having a closer look at the situation in the airline market, the paper firstly describes the generic, cycle-generating structure of the problem—a negative feedback loop with two delays. This relatively simple dynamic model already provides a first explanation for the business cycles in the airline industry. In a second step, the generic model serves as the basis for the development of a general model of the airline market. The general model helps

- to identify the cycle generating components of the industry and to understand their interactions,
- to analyze different scenarios, and
- to identify key variables and leverages for cyclical management strategies.

The model reproduces historical behavior of the airline market and allows basic estimations of future order trends for commercial aircraft jets.

The project reported herein is a system dynamics study realized for the corporate planning department of Lufthansa German Airlines. It emphasizes the importance of systems thinking and systems simulation in complex and fast changing environments.

Business cycles in the airline market

The evolution of the airline industry is heavily influenced by business cycles. Figure 1 shows the industry's operating profits according to the IATA-member statistics (International Air Transport Association 1998). The figure shows that the industry's cyclical behavior starts to develop after the deregulation of the airline market in the USA. It also depicts some of the major incidences between 1970 and 1998. They are often considered by managers and in literature as the main causes for the cycles, besides the fluctuations in gross domestic product (GDP) of the major industrialized regions of the earth (North America, Europe, Japan).

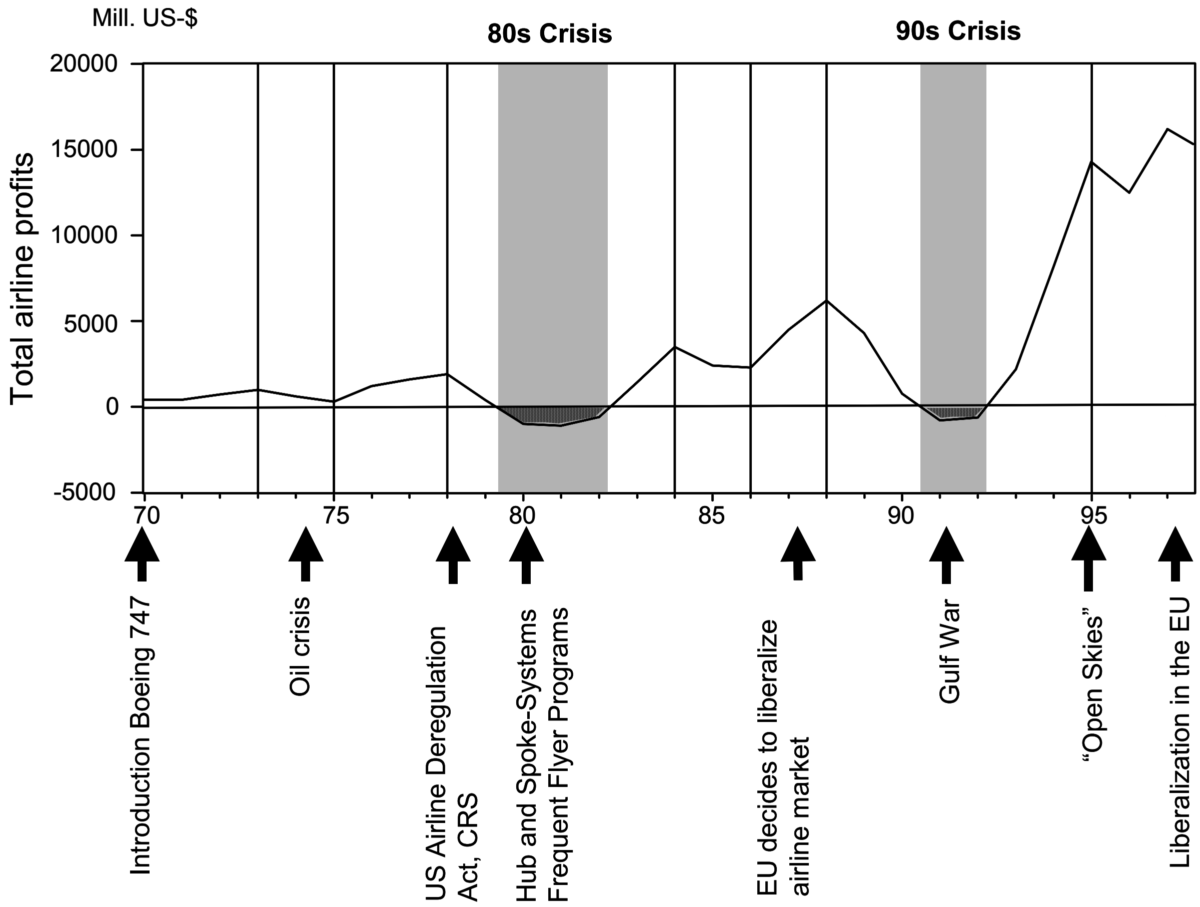

Figure 1: Total profit of all airlines from 1970–1998[3]

(source: IATA World Air Transport Statistics; real values)

To understand these cycles, one has to look at the underlying critical factors of success within the airline market. Air traffic as a product is basically a service which is offered to the customer. From this point of view, the air transport market suffers from the typical service industry's problem, namely the inability to store up the product offered to the customer.

In addition, the carriers' core product itself (air transport) is hard to differentiate, especially for airlines that are in the same alliance. Studies have shown that between the various factors which influence the customer's decision for a specific airline the most important are schedule and price.[4]

For business travelers, the schedule is more important than the price of the flight. Due to higher yields in the business travel market, airlines try to attract business travelers. Knowing that these passengers mainly decide according to the schedule, the airline's challenge is to develop and optimize a schedule which is characterized by a high number of destinations and frequent flights to each of these destinations.

On the other hand, the cost structure of a single flight of an airline leads to a contrary situation. Since the biggest part of the overall costs of a flight is induced by the flight itself (direct operating costs), the marginal costs of each additional passenger are low (Doganis 1991, p. 109–111). From this point of view the airline should attempt to fly with a low frequency to a specific destination whilst filling the plane with as many passengers as possible (i.e., seek to maximize the so called seat load factor, SLF). Taking these aspects together, airlines are facing the fact that capacity planning and schedule planning are amongst the most relevant factors for business success.

Given the requirements of the global capital markets, it is necessary for airlines to be able to show substantial growth in order to attract capital (Borgo and Bull-Larsen 1998, p. 56). The business cycles, which have impact on the profitability of the industry, are a subject of growing interest to the companies' management, since the cycles are also observed by professional investors. As long as the inherent causes of these cycles are not understood and adequately managed, the airline industry suffers from a discount in stock prices, compared to other industries. This situation leads to the necessity to be able to understand, explain and manage the business cycles. Through forecasting, simulation and understanding it should be possible to manage cyclical behavior (at least as a single company) and, thus, to be able to keep profit up and outperform the industry.

A statistical forecasting model served as a starting point for our system dynamics study. Based on multivariate regressions it can sufficiently ex-post forecast the rate of change of the delivered aircraft as well as the operating profits (Figure 2). Nevertheless, having reached a linear statistical model that is able to sufficiently ex-post forecast the cycles in the airline industry still does not help to explain the industry's behavior or to find and test alternative strategies. Therefore, it was decided to create a system dynamics model.

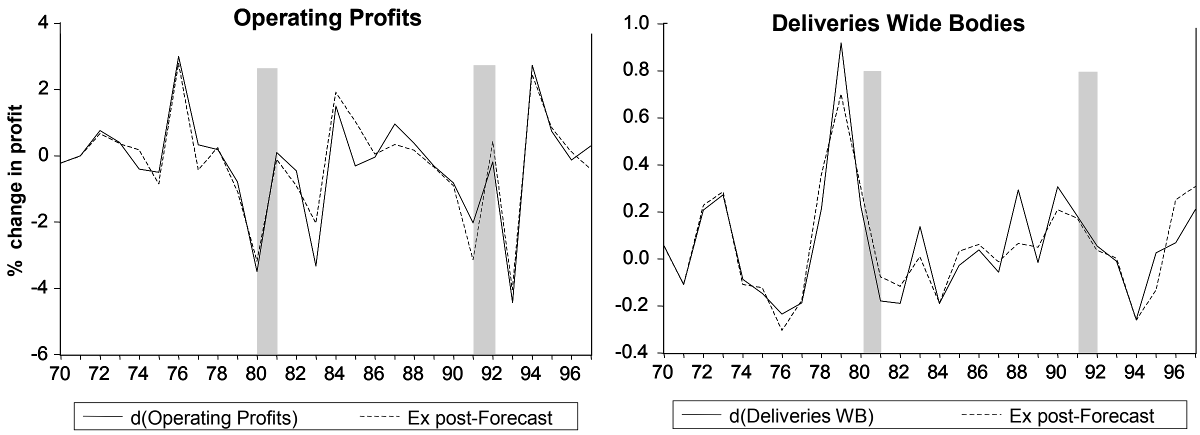

Figure 2: Results of statistical model

By combining the system dynamics and the statistical approaches, we aimed at the integration of two different methods for analyzing and dealing with the fluctuations in the market. This procedure offers the possibility to examine the problem from two complementing perspectives. The integration of both approaches yields several advantages that were especially useful in our project work.

From a methodological point of view, this integration combines the data richness of a statistical model with the precision and insight provided by a system dynamics model (Forrester 1961, p. 57). From a practical point of view, the decision maker needs both: accurate data on future trends as well as understanding of market dynamics and long-term implications of different policies.[5] To fulfill these requirements a combined static-dynamic decision support tool proved to be helpful. Furthermore, the variables that are included in both models can be compared and their respective relevance discussed. By these means, understanding of the underlying model assumptions, their differences and the synergies become clearer. And finally, we found out that presenting and comparing both models resulted in greater acceptance and commitment on the part of the managers. In this article the focus lies on the discussion of the structure and results of the system dynamics model.

A system dynamics model to explain the business cycles

The purpose of the model we developed for Lufthansa German Airlines is threefold: we intended

(1) to gain insights into the dynamics of the cyclical movements and to identify the core structure of the problem;

(2) to develop a tool for the analysis of different scenarios, for example, exogenous demand-shocks;

(3) to test alternative policies in order to derive strategies for long-term capacity and fleet planning.

The period of the market's cycle is roughly eight to ten years, which is typical for *Juglar* waves. *Juglar* waves correspond to machine-investment-cycles and are considered as the classical economic cycle (Schumpeter 1939, p. 161). This contributes to the wide spread managers' opinion that the cycles in the airline market are a response to fluctuations in the evolution of the GDP and that they lie beyond the sphere of the industry's influence. As a consequence, there is a lack of cyclical management strategies to smooth the oscillations and to reduce their negative impact on the carriers‘ profitability (Gialloreto 1998, p. 18). However, our research has shown that there is strong evidence that the cycles of the market are endogenously driven. We were able to show that several strategic points of high leverage for the airlines exist, depending on their position in the cycle.

In order to improve understanding and to create a basis for a general model, the underlying structure of airline market cycles will be illustrated in a first step. This generic, cycle-generating structure as described in Figure 3 is a very simple representation of the problem, but it already provides a first explanation for the cyclical phenomenon.

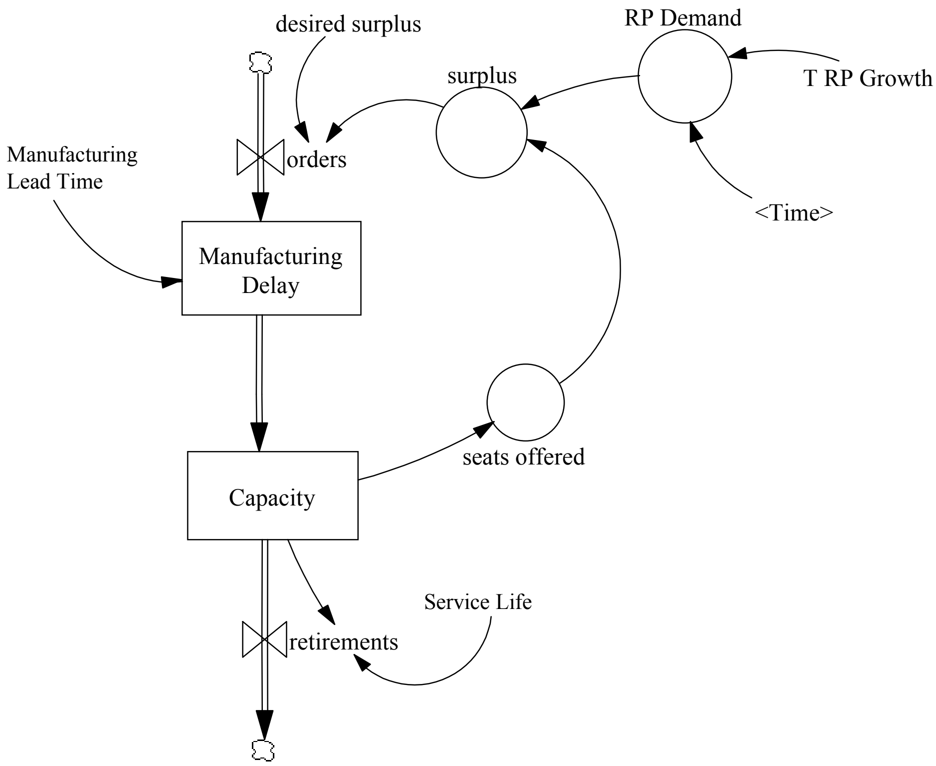

Figure 3: Basic model generating business cycles in the airline market

Figure 3 shows the abstracted micro-structure (Lane and Smart 1996, p. 94–95) of the airline market. It is a negative feedback loop with two delays—a structure that can lead to oscillations (Forrester 1968, p. 2/37). It illustrates the chain of causal relationships in the order loop of the airline industry. The first delay in the structural diagram characterizes the aircraft manufacturer lead-time, the second the delayed recognition of the industry's surplus passenger capacity. The lag between aircraft orders and deliveries is about 18–24 months before new jets increase the market's capacity. The latter is reduced by aircraft retirements. The value of the constant *Service Life* is thirty years, as the great majority of jetliners are definitely retired from passenger service before they reach thirty years of age (Airbus Industry 1998, p. 26).[6] Over-capacity (*surplus*) increases with *seats offered* and declines with higher *RP demand* (RP = revenue passenger; paying passenger). Growing over-capacity (which means lower seat load factors) reduces the number of aircraft ordered depending on the tolerated surplus level (*desired surplus*).

Besides the airline market there are various other cyclical industries and markets, e. g. the paper industry, real estate markets, commodity markets, the shipbuilding industry. It seems interesting to note that the dynamic behavior and core structures of these systems are similar or nearly identical to each other. The description of the aircraft order loop in action is similar to the causes and effects produced by commodity production systems (Meadows 1970) or by delayed inventory systems, as simulated with the Beer-Game (Sterman 1989, pp. 326–331): Airlines strive for high seat load factors to maximize their revenue. Due to aircraft lead-times and delayed recognition of over-capacities, the system starts to oscillate around the desired seat load factor. The basic mechanisms underlying these expansion and contraction movements are the same as those of the economic long wave in production systems (Sterman 1986, pp. 95–96). In fact, our generic model follows a cause and effect logic comparable to the *Kusnets* or *Kontradieff* cycles and exhibits similar dynamic behavior (Mager 1987, pp. 3–4, 18–19). After excess seat-capacity has reached its maximum value, order rates and thus "capital [aircraft] production must remain below the level required for replacement and long run growth until the excess physical ... capital is depreciated" (Sterman 1986, p. 102), a process whose duration depends on the lifetime of the aircraft.

Simulations of the basic model reveal that the existence of fluctuations is independent of the development of demand for flights. Figure 4 illustrates the surplus and seat-capacity development at a constant number (*constant RP*) and at linear growth of revenue passenger (*Linear RP*). Note that unit values and time bounds in Figure 4 have been chosen for illustrative reasons, that is, to elucidate the cyclical behavior of the generic structure. For more realistic time bounds and unit values see simulation results of the general model below.

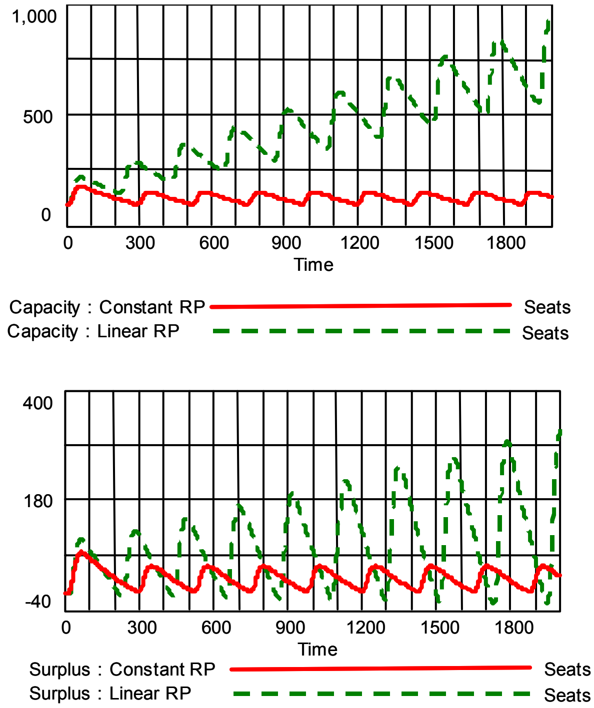

Figure 4: Dynamic behavior of capacity and surplus in the basic model

An enlargement of the generic structure—a price-loop that includes a price setting mechanism and a price-demand function—shows that price management cannot dampen the long-term waves in the market. Different price strategies only affect the amplitude and period of the cycles but not their existence.

The general model of the airline market provides a more realistic and detailed view of the cycle generating elements. It consists of three modules: (1) the airline market as a whole—including all carriers and manufacturers (variables of this module are identified by the letter M), (2) the structure of Lufthansa German Airlines—integrated as a micro module in the airline market (variables of this module are identified by the letter LH) and (3) the competition module, where passengers decide whether or not to fly with Lufthansa German Airlines depending on its competitive situation.

In the following, we will focus on the "macro-module" of the airline market as illustrated in Figure 5. The structure of the Lufthansa specific "micro-module" is similar. However, in order to represent actual decision rules within Lufthansa and not industry averages, some equations and the absolute values of various parameters differ between the two modules. In particular, pricing and capacity planning (e. g., *desired SLF*) are adjusted to Lufthansa's real policies.

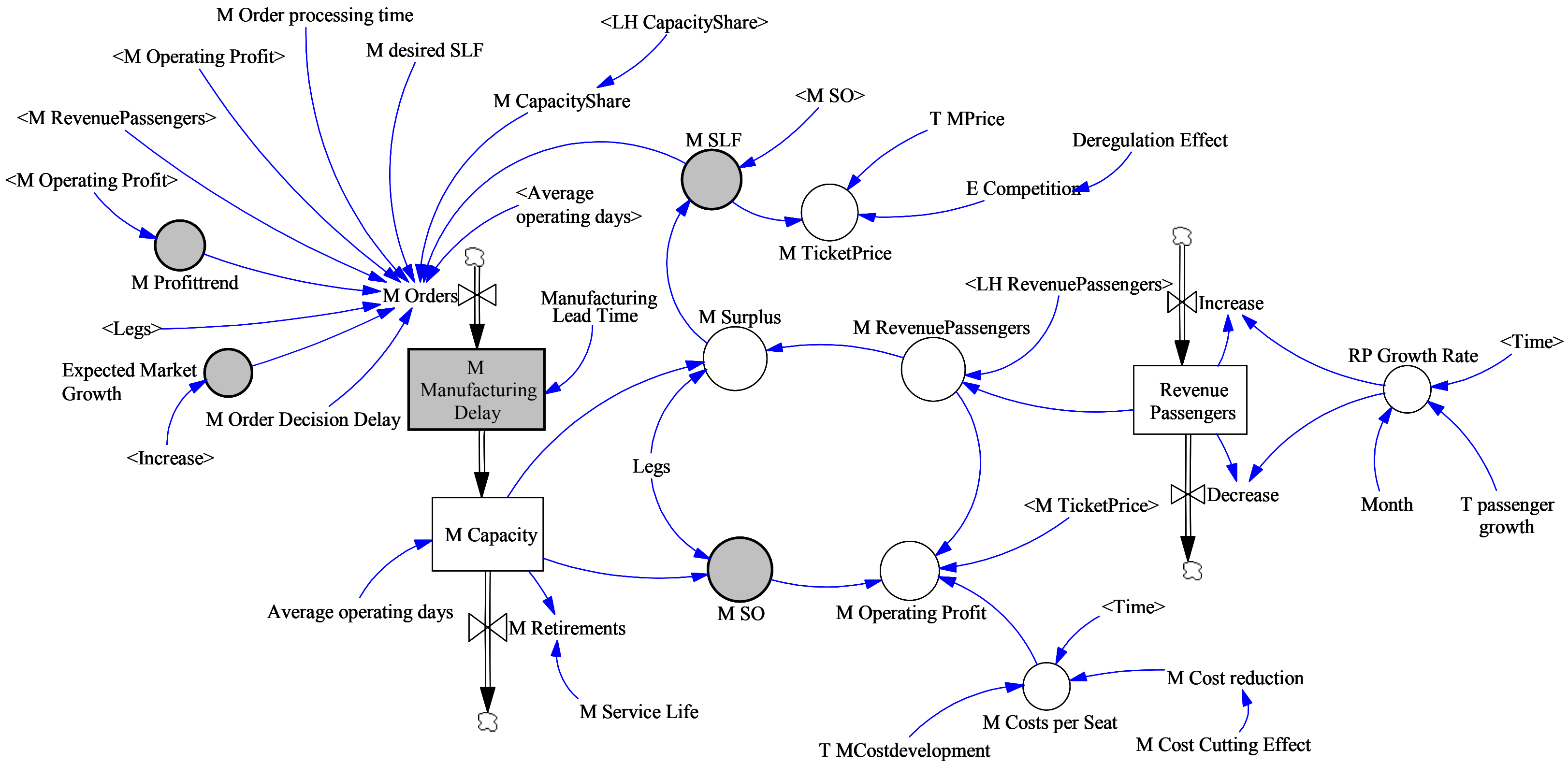

Figure 5: The macro module of the airline market model

The level-rate diagram displays a demand section (*Revenue Passengers*), a price section (*M Ticket Price*), a cost section (*M Costs per Seat*) and a capacity section (*M Capacity*), the latter aggregating all the capacity level variables used in fleet planning. The order variable (*M Orders*) is a key element in the general model. The decision to buy new aircraft depends on several variables including, among others, the passenger growth forecast (*Expected Market Growth*) and *Legs* (number of daily take-offs of one aircraft). Since carriers tend to wait and see if their profitability is sustained before committing to new orders (Skinner and Stock 1998, p. 54), the model considers a variable that describes the mid-term development of operating profits (*M Profittrend*).

The general model is the result of various consultations of experts who helped to identify the relations between the key variables and to define the system's boundaries. "Corporate system modeling policy sessions" for knowledge elicitation (Hall, Aitchison and Kocay 1994, pp. 344–345)—group discussions and open interviews with the help of causal-loop diagrams, system flow diagrams and simulation results—proved to be conducive to an effective model building process.

Various tests for model validity have been made. At different stages of development, the model was presented to groups of experts or single managers in order to discuss the clearness and correctness of its assumptions. The various opinions and experiences of the employees at Lufthansa German Airlines were helpful for accomplishing the boundary adequacy and structure assessment tests (Sterman 2000, p 861–866). The access to a vast database made it possible to conduct sound parameter tests and to compare the finished model to past behavior.[7] As already observed in other studies before, the presentation of successful behavior reproduction tests (such as conformity, duplication, prediction) contributed to the acceptance of the model and its results among managers, especially those who were not involved in the conceptual modeling phase.

Leverage points for corporate planning in the airline market

Without intensive calibration, the model presented above reproduces historical behavior of the airline market satisfactorily. The characteristics of cyclical variables and the two crises of the airline market in the early ´80s and ´90s can be duplicated by model simulations. Compare, for example, actual orders from 1970 until 1998 and data generated by the simulation model (Figure 6).[8] Although the historical and simulated graphs differ on a point by point base, the dynamic, cyclical behavior is obviously and intuitively the same. Furthermore, nearly 92 % of the error between actual historical data and simulated behavior is caused by unequal covariance. This can be supposed to be the effect of noise in the historical data series and, therefore, is not due to a systematic error in the simulation model (Sterman 1984).

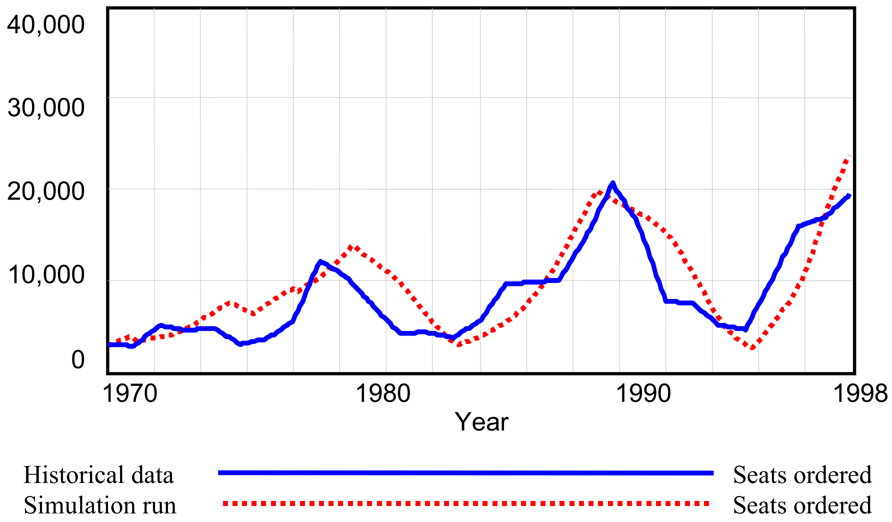

Figure 6: Comparison of historical and simulated data for orders of new aircraft jets (airline market)

Note in particular the level of similarity to results of a simulation presented by Lyneis (1998, p. 11). In contrast to Lyneis, however, we do not aim to provide numerically precise predictions of the future airline market. We rather aim at identifying endogenous factors that are responsible for cyclical behavior in this market. Furthermore, our intention is to improve the system to achieve more stable results. With these two goals, we followed Morecroft's (1988, p. 312) approach and built a model to " 'prime' policymakers for debate." It is our contention that a structurally parsimonious model which replicates data sufficiently generates more acceptance towards system dynamics modeling than a bigger model.[9] Nevertheless, although the model presented here also allows basic estimations of future order trends for commercial jet aircraft, for this goal a more enlarged model seems to be more appropriate. (See Lyneis 1999 for a discussion about the use of models with different degree of detail.) In the project described herein, however, the statistical forecast model briefly described above was used for the purpose of prognoses.

Furthermore, different scenarios, exogenous changes in demand for instance, can be analyzed. For example, see Figure 7 which depicts results for the basis simulation run in comparison to a simulation run where effects of the Gulf War are not included (technically, the demand table function was changed). The cycles in the simulated markets only differ in amplitude, not in their principal appearance. We interpret this result as another indication that the cycles in the airline industry are mainly caused endogenously. Exogenous factors only determine the amplitude of the cycles, but they are not responsible for the general cyclical behavior of the system.

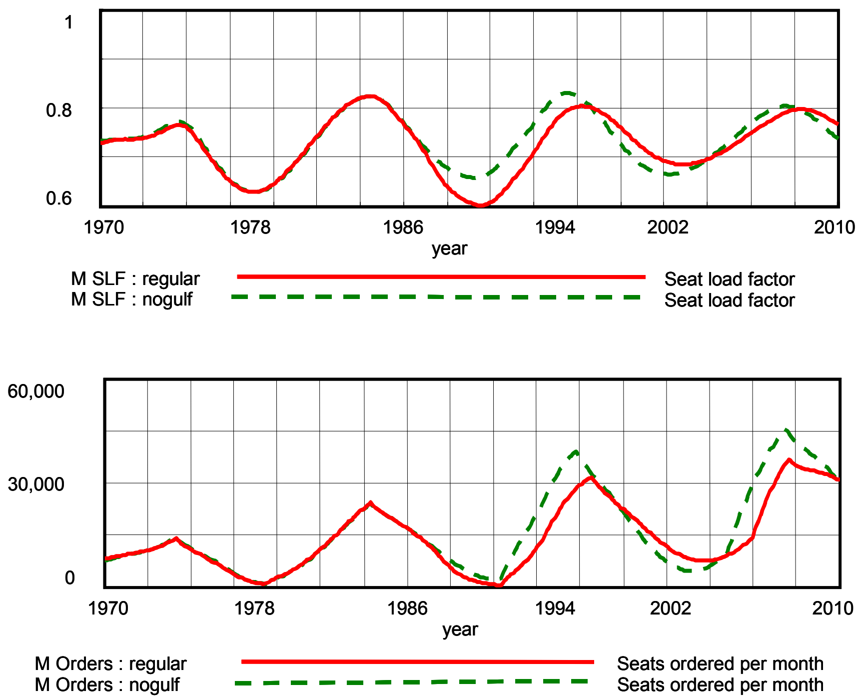

Figure 7: Comparison of seat load factor and orders with and without Gulf War (airline market)

The model presented in this paper helped to identify key variables and leverages for cyclical management strategies. Decision makers learnt that the cyclical behavior of industry's performance is to a significant degree caused by their decision rules and not by exogenous factors. The points shown in Figure 8 were identified as possibilities to stabilize the system. In fact each variable of our generic structure has a high impact on the overall behavior of the cycles in the airline market.

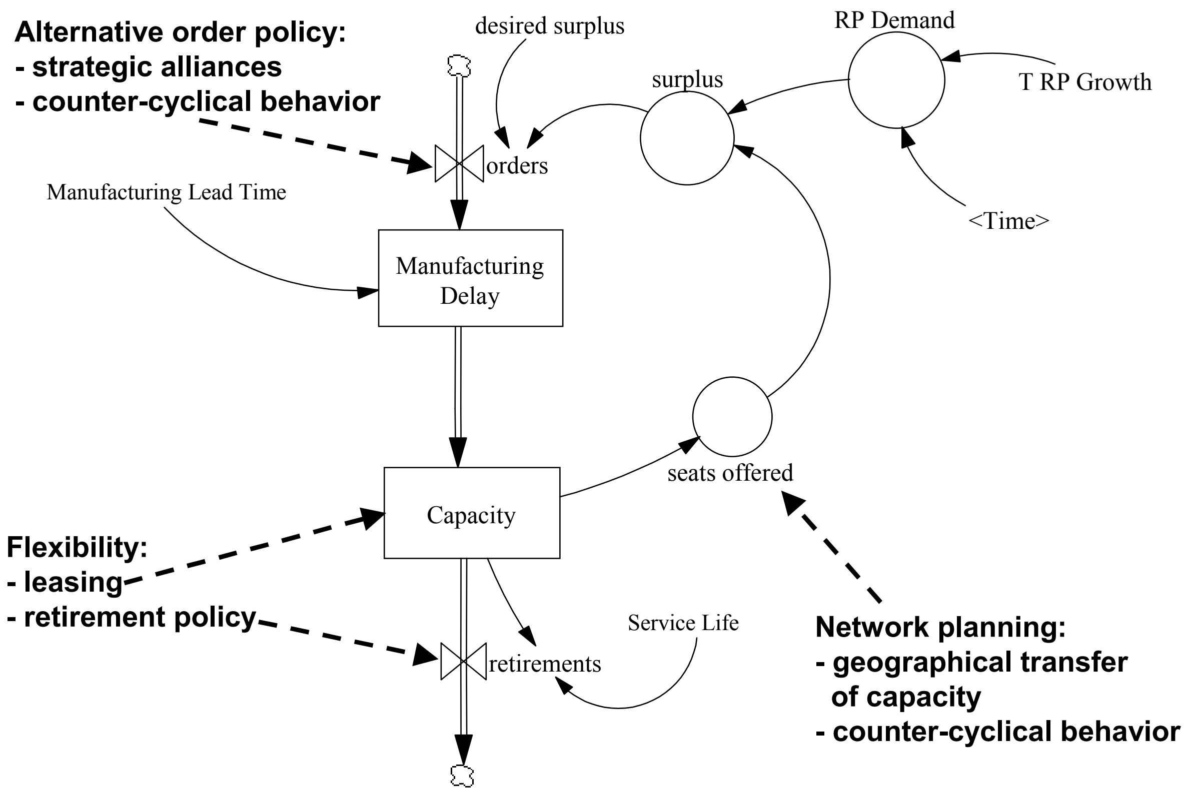

Figure 8: Leverage points to stabilize cyclical behavior in the airline market

The implementation of stabilizing policies leads to structural changes at each leverage point which will be discussed in the following:

Aircraft ordering: As already shown in the model description above, policies for aircraft orders are a key element in the cycle generating structure of the airline market. Growing slower in capacity than your competitor means losing market share (Skinner and Stock 1998, p. 54). Hence, the intense competition for regional and global market share is mainly decided by capacity management. With the underlying structure of the market, this leads to the emergence of capacity surpluses. In this situation counter-cyclical ordering yields several advantages for a single carrier, most of all lower prices and shorter lead times for aircraft, which result in quicker reaction times. Realizing counter-cyclical order policies however is far from being a trivial task, both in reality and in the system dynamics model. An organizational prerequisite for management to engage in counter-cyclical strategies could be the foundation of an independent organizational unit that controls and manages all assets (aircraft) of the company. This concept—being currently discussed at German Lufthansa Airlines—creates the flexibility and independence needed for counter-cyclical asset management. The objective is to ensure a quasi continuous inflow and outflow of aircraft, regardless of fluctuations in the market. This includes leasing over-capacities to other airlines.

Strategic alliances offer another opportunity for an effective cycle management in the ordering process. The growing sizes of alliances represent an important leverage to smooth oscillations in certain regions or even in the whole market. For its members, alliances increase transparency, e. g. of information about current and future seat capacities. They offer the chance to coordinate the quantity of seats ordered.

Network planning: "Open Skies"—the liberalization and deregulation of the airline market—made it possible for carriers to shift capacities from regions with low demand to those with higher demand. This practice could be observed in 1998 during the financial crises in the Asian region, when capacities were transferred from inside Asia to the Pacific and Atlantic regions (McMullan and Moreno 1998, p. 4). Hence, in the short term network planning can be used as an instrument to react to unforeseen demand shifts (Hallerström and Melgaard 1995, p. 50). Over-capacities can be decreased to a certain degree. To simulate this ad-hoc strategy the system dynamics model must be extended to represent different regions, with different demand patterns and capacities.

Flexibility: Adding flexibility to existing capacities is another very important leverage in cycle management. The alternatives we discussed with Lufthansa German Airlines are leasing and retirement policies. These require an increase in average life span of the fleet. The idea behind the strategy is to keep a certain percentage (10%–15%) of older aircraft in the fleet which are operated in case of a shortage in deliveries or seats offered; in downturns this part of the fleet is quickly retired, at low costs. This policy opens margins and flexibility for fleet planning. Simulation runs have shown that in periods of recession over-capacities can be reduced and thus oscillations dampened. However, such a quick relief requires a counter-cyclical order policy that ensures an adequate level of capacities when the market turns around. The last example shows that managing the business cycles in the airline market is often a combination of strategies using the different leverage points shown in Figure 8.

Figure 9 depicts the dynamic consequences of a more flexible fleet, which is achieved by leasing a substantial number of airplanes. Leasing airplanes stabilizes Lufthansa's key operational variables. For the market as a whole it has to be considered, however, that this approach only works if the leasing companies are able to work with stable demand and order policies. Leasing will not have a positive effect if the leasing companies just reproduce behavior formerly shown by airlines. They need to apply stabilizing order policies as shown above.

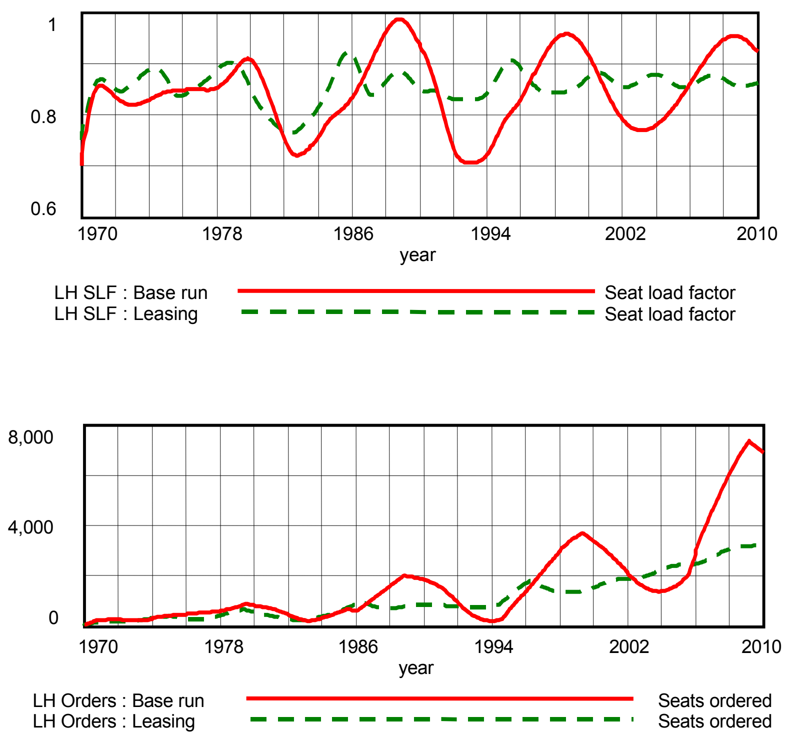

Figure 9: Consequences of leasing airplanes on seat load factor and orders (Lufthansa)

Summary

The cyclical behavior observed in the airline industry is endogenously generated, just as it was frequently found in other industries. Particularly in contrast to a common belief in the industry (Beckett et al. 1997, p. 9-14), our analysis suggests that business cycles are not caused by fluctuation in World-GDP. Our simple system dynamics model can replicate historical data sufficiently well. The model shows long-term trends in the overall system development, creates understanding and offers a way for testing alternative strategies. Leverage points to stabilize the system's behavior were identified in the process of aircraft ordering, in network planning and in adding flexibility to existing capacities, especially leasing and retiring policies. The simulation study extended and enriched insights gained from statistical analyses with explanations of the observed situation and the opportunity to formulate alternative strategies for cycle management.

Future project work will be on the implementation of such improved order and network policies. Another area of interest is to extend the system dynamics model in order to achieve more precise financial statements.

References

Airbus Industry. 1998. *Global Market Forecast 1998–2017*, Blagnac.

Borgo A. and T. Bull-Larsen. 1998. Losses: What Losses? *Airline Business* 14/1998: 54–59.

Beckett, T., H. Hartmann, D. Myrddin-Evans and C. Tarry. 1997. *Lufthansa*. Dresdner Kleinwort Benson Research. Frankfurt am Main.

Doganis, R. 1991. *Flying Off Course: the Economics of International Airlines*, 2nd edition. Harper Collins Academic. London.

Forrester, J. W. 1961. *Industrial Dynamics*. MIT Press. Cambridge, Massachusetts.

—. 1968. *Principles of Systems*, MIT Press. Cambridge, Massachusetts.

Gialloreto, L. 1998. The Innovation Gap: a Cooperative Solution? *Aviation Strategy* 06/1998: 18–21.

Hall, R. I., P. W. Aitchison and W. L. Kocay. 1994. Causal Policy Maps of Managers: Formal Methods for Knowledge Elicitation and Analysis. *System Dynamics Review* 10(4): 337–360.

Hallerström, N. and J. Melgaard. 1995. Going Round in Cycles. *Airfinance Journal* 03/1995: 47–52.

International Air Transport Association. 1998. *World Air Transport Statistics*. Montreal, Genf, London.

Lane, D.C. and C. Smart. 1996. Reinterpreting 'Generic Structure': Evolution, Application and Limitations of a Concept. *System Dynamics Review* 12(2): 87–120.

Lyneis, J. M. 1998. System Dynamics in Business Forecasting: A Case Study of the Commercial Jet Aircraft Industry. *CD-ROM Proceedings of the 1998 System Dynamics Conference*, ed. System Dynamics Society. Quebec City.

—. 1999. System Dynamics for Business Strategy: a Phased Approach. *System Dynamics Review* 15(1): 37–70.

—. 2000. System Dynamics for Market Forecasting and Structural Analysis. *System Dynamics Review* 16(1): 3–25.

Mager, N. H. 1987. *The Kontradieff Waves*. New York. Praeger.

Meadows, D. 1970. *Dynamics of Commodity Production Cycles*. Wright-Allen Press. Cambridge, Massachusetts.

McMullan, K. and N. Moreno. 1998. Market Outlook: a Mass of Conflicting Images. *Aviation Strategy* 08/1998: 2–6.

Morecroft, J. D. W. 1988. System Dynamics and Microworlds for Policymakers. *European Journal of Operational Research* 35: 301–320.

Schumpeter, J. 1939. *Business Cycles. A Theoretical, Historical and Statistical Analysis of the Capitalist Process*. McGraw-Hill. London/New York.

Skinner, S. and E. Stock. 1998. Masters of the Cycle. *Airline Business* 04/1998: 54–59.

Sterman, J. D. 1984. Appropriate Summary Statistics for Evaluating the Historical Fit of System Dynamics Models. *Dynamica* 10(Part II, Winter): 51–66.

—. 1986. The Economic Long Wave: Theory and Evidence. *System Dynamics Review* 2(2): 87–125.

—. 1989. Modeling Managerial Behavior: Misperceptions of Feedback in a Dynamic Decision Making Experiment. *Management Science* 35(3): 321–339.

—. 2000. *Business Dynamics: Systems Thinking and Modeling for a Complex World*. Mc Graw-Hill, Boston.

Notes

1. The average return on invested capital was 6 % between 1992 and 1997 compared to 9–10 % cost of capital in the industry (Borgo and Bull-Larsen 1998, p. 54).
2. For aircraft orders business cycles can be traced back to the early 50s (Airbus Industries, internal information)
3. The first part of this study was conducted in 1998/99 and, therefore, only data until 1998 could be taken into account.
4. This and all further data without reference are results from investigations of Lufthansa's corporate planning department.

5. Because of their importance, forecast scenarios for particular decisions (e. g., aircraft orders) should also be grounded on more than one model and/or methodology. Comparing the results of a statistical forecasting model with those of a detailed and calibrated system dynamics model (Lyneis 2000) probably yields a sounder basis for policy debates than confining the analysis to one approach.
6. Until recently the great majority of commercial jet aircraft have been purchased to accommodate traffic growth or for strategic reasons (e. g., roll overs). With the first Boeing 747 built in the early 70s, the need to replace older aircraft becomes more and more important for all carriers. Our model takes this fact into consideration (*retirements*).
7. It is important to note that the historical data of airline capacities (by regions or worldwide) rest to a significant degree on estimations, because the competing carriers only communicate the type of aircraft they have ordered, but not their actual seat capacity. In contrast to other studies Lufthansa German Airlines has decided to use the more precise "seat variable" (not number of aircraft) as an indicator for capacities. For this reason the system dynamics model uses seats as a unit of capacity.
8. Source of historical order data: Airbus Industries 1998 (total aircraft market).
9. Replication of historical data is only one step in assuring model validity (Sterman 1984, p. 52). Its heuristic power for clients buying into system dynamics, however, should not be underestimated.