MARKET ANALYSIS AND FORECASTING AS A STRATEGIC BUSINESS TOOL

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I. INTRODUCTION

Pugh-Roberts has developed a number of simulation models to forecast the demand for products in specific markets. These models contain key feedback relationships which create growth, decline, and cycles in demand. They are unique in their integrated representation of macro-economic, micro-economic, and regulatory factors. Their broad scope makes them powerful enough to specifically show the relative importance of industry factors such as manufacturer pricing policies, inventory and production policies, capacity expansion policies, and the timing of new product introduction, in creating or magnifying market cycles. These models are highly valuable because, unlike simple statistical models, they explain the root causes of cyclical behaviour and can therefore more accurately predict the timing and severity of market cycles. As a result, the models provide valuable information regarding:

* timing of "booms" and "busts"
* required production capacity and production rates
* "windows of opportunity" for new product introduction
* relative growth of market segments
* relative importance of growth versus replacement demand
* relative importance of price, availability, and technology in determining demand and market share
* effects of macro-economic, regulatory, and/or political changes on overall demand patterns.

These market models have been used successfully in the aerospace, automobile, computer, container shipping, financial services, industrial coatings, insurance, health care, and mail order retailing industries, so they are quite generally applicable. To illustrate their value versus statistical models, two of the existing aerospace models are examined in detail. With emphasis on the "Macro/Micro" issues, the basic causal structure is described and the importance of feedback is demonstrated with sensitivity tests. General uses, and examples of other potential applications, are also discussed.

II. DESCRIPTION OF THE MODELS

2.1 Causal Structure

Exhibits 1 and 2 show the pattern of order rates for aircraft in the North American helicopter market and the European commercial jet market over the recent historical period. The models produce historically accurate, but different, behaviour in each case. In spite of these differences, the two models have common feedback structures. These are depicted in Exhibit 3. The narrow arrows are ordering cycle feedbacks and the thicker arrows are profitability, regulatory and flight frequency feedbacks.

Starting at the left of Exhibit 3, demand is a function GDP (or one of its derivatives, personal income or corporate profits), population, experience, and fares. GDP and population are exogenous inputs. Experience and fares are computed internally from factors within the rest of the system.

Demand growth is extrapolated by operators to produce a projected demand. Projected demand is converted into a desired fleet based on a "desired utilization rate": for commercial aircraft, this is Revenue Passenger Kilometres per year per aircraft (RPK); for helicopters, this is Flight-Hours per year per aircraft (FH). Desired utilization rate is an exogenous input.

Comparing desired fleet to the existing fleet determines the number of "growth orders". The fraction of growth orders for new aircraft, versus used, depends on: new versus used aircraft prices, delivery delay, technology, and regulations.

EXHIBIT 1

NORTH AMERICAN HELICOPTER ORDER RATES

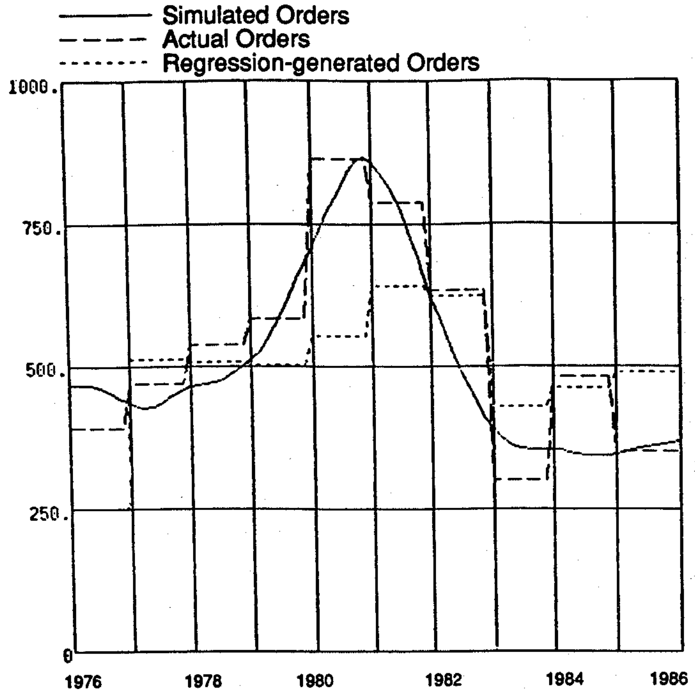


EXHIBIT 2

EUROPEAN JET AIRCRAFT ORDER RATES

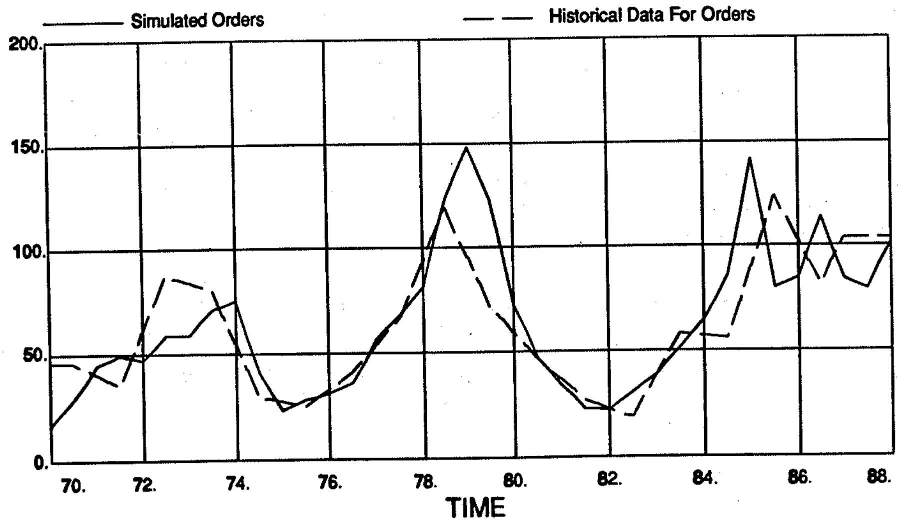
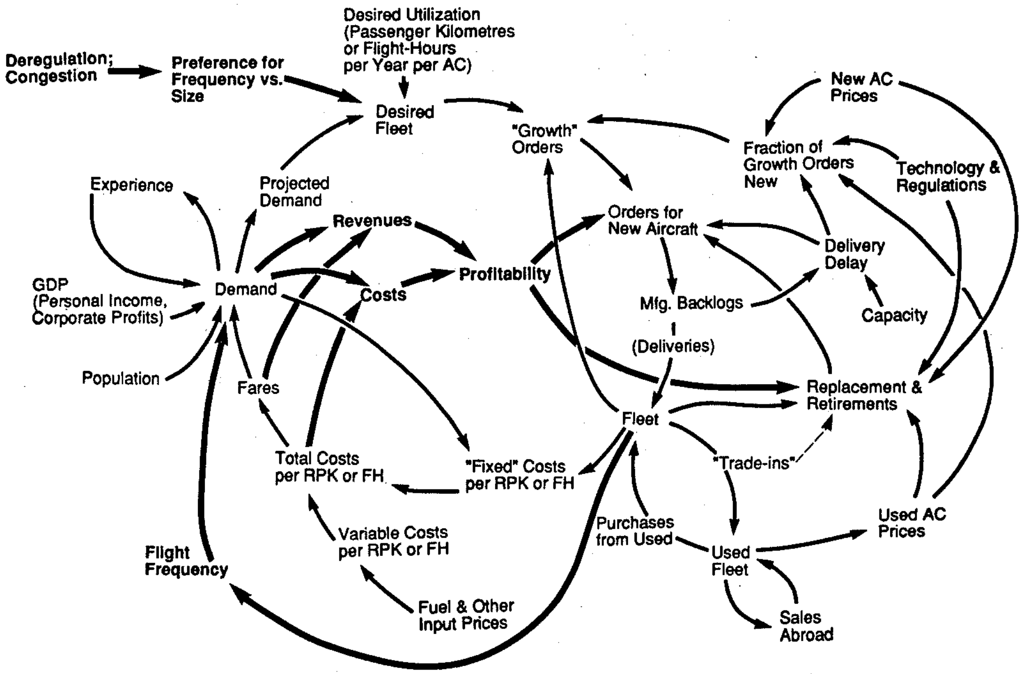


EXHIBIT 3

CAUSAL RELATIONSHIPS IN AIRCRAFT MARKET MODELS



Orders for new aircraft are added to manufacturers backlogs and then delivered after a delivery delay determined by production lead times and capacity. As owners of new aircraft "trade-in", these used aircraft become available for satisfaction of growth demand, or are sold abroad. Finally, after the normal lifetime of the aircraft, it is retired. Replacement and retirements are modulated by relative aircraft prices, technological changes, regulations, and, as discussed below, operator financial condition.

As the size of the fleet increases, "fixed" costs per RPK or FH also increase. As demand increases, unit fixed costs decrease. Variable costs depend on intensity of use (which is calculated internally) multiplied by fuel and other input prices, (which are exogenous inputs). The sum of fixed and variable costs equals total cost, which is an important determinant of fares. Fares then feed back to affect demand.

Revenues are determined by demand and fares, while costs depend on demand and total unit costs. Revenues less costs equals profitability. Profitability affects orders for new aircraft, and both replacements and retirements of older aircraft.

Two other important feedbacks are also depicted. The first is a feedback which says that as the size of the fleet increases, flight frequency increases, and this acts to stimulate demand growth. The second is an input which specifies the preference for frequency versus size. This preference determines the size of the fleet required to serve a given level of projected demand. The preference is a function of deregulation and congestion. Deregulation encourages growth in the number of flights; congestion constrains growth in the number of flights.

2.2 Level Of Detail

Within the structure discussed above, the model represents several demand and aircraft categories. The categories are chosen to minimize the number of behaviourally distinct groups. For example, demand in our commercial aviation model is divided among domestic, intra-European and inter-continental. This selection is based on the idea that demand categories should reflect certain average flight characteristics, passenger demographics and competitive factors. The selection of aircraft size categories, of which there are five in the commercial aviation model, is influenced by the product positioning interests of our clients, and by the selection of demand categories (some aircraft are unsuitable for certain applications or may serve specific market segments exceptionally well). Often the number of categories is further limited by the degree of detail in the data. Similar objectives/constraints determined the demand and aircraft categories in the helicopter model.

Categorisation of this kind is important for several reasons:

* Parameterisation is simpler and more "reasonable".
* Cross influences among categories can be explicitly included.
* Distinct markets and market niches are more accurately represented
* Tracking shifts in the distribution of aircraft types is possible.
* Diagnosing and explaining behaviour is simplified.

2.3 A Market Cycle

Before discussing specific examples it is useful to envision how a market cycle could evolve. Again, following through Exhibit 3:

Suppose demand should increase. In the short term, this increase raises load factors, reduces unit costs, and improves operating margins. Reduced costs lead to reduced fares, which further stimulate demand. Operators extrapolate this demand growth into the future and conclude that they need additional aircraft. Because their financial condition has improved, operators are more willing and able to order aircraft. Improved financial condition also stimulates orders through early replacement of existing aircraft.

Given manufacturers' delivery delays, operators experience several years of high load factors before the new aircraft arrive. But when the new aircraft start to enter service, the dynamics start to reverse direction. An increase in the size of the fleet causes costs to rise and margins to decline. As costs rise, so do fares, which in turn slows demand growth.

The combination of slowing demand growth and deteriorating financial condition causes operators to cut back on new aircraft orders. But previously ordered aircraft continue to be delivered, unit costs rise further, fares are increased, and demand growth slows or even becomes negative.

With reduced demand growth, the operators realize they have ordered too many aircraft. Moreover, fares generally lag the increase in unit costs such that, with reduced demand growth, revenues do not increase as fast as costs. Financial condition deteriorates further, operators cut back drastically on new orders, delay orders for replacement aircraft, and delay the retirement of existing aircraft.

Given the backlog of aircraft on order and any overexpansion of capacity, several years of depressed conditions can result before the situation turns around. But once it does, unit costs and fares will begin to fall, demand increase, and another cycle starts.

III. VALUE ADDED BY A MICRO/MACRO MODEL

Models containing macroeconomic and microeconomic (industry) relationships add value over purely statistical macro-models in two ways. First, they are better able to predict and explain the timing and severity of industry cycles; and second, they offer sufficient detail in specific market segments to be valuable for strategic decision-making (for example, capacity planning, product targeting, competitive positioning). The predictive value added is illustrated with two examples in this section. The strategic value added is discussed in section IV.

3.1 Example 1 - The U.S. Helicopter Market[1]

GNP and oil prices are important factors in determining the demand for helicopters: GNP, as a measure of economic activity, is indicative of long term demand; oil prices drive offshore oil exploration and production, which is a major market for helicopter services. Perhaps a simple least squares regression employing GNP and/or oil price could explain the changes in helicopter sales. We tried various combinations of GNP and oil price as the basis for a simple regression and found the best to be a "two factor" model: Helicopter Sales = f[GNP Growth lagged one year, Oil Price Growth lagged one year].

Regression produces a correlation coefficient (R^2) with the data of 0.4, which does not inspire great confidence. The time series output of this regression is shown on Exhibit 1. (We use R^2 here because it is sufficient for illustrative purposes. A more rigourous statistical test such as the Theil statistic, which separately measures phase correlation, standard deviation and mean errors, would reinforce the conclusions drawn here.)

The output of the simulation model (Exhibit 1) was subjected to the same statistical test. The correlation coefficient in this case was 0.84. This much higher correlation coefficient coupled with the obvious "visual" correspondence indicates significant explanatory power. Since GNP and oil price are the key macro-economic inputs to the dynamic simulation model, the difference in correlation coefficients is a measure of the "value added" by the more complex structure of the dynamic model. Some of the industry specific factors accounting for the dynamic model's superior performance are:

* Operators tend to extrapolate demand trends several years ahead when formulating their investment plans.
* Helicopter manufacturers accept used helicopters as trade-ins and agree to be the financiers of last resort.
* Advancing helicopter technology encourages replacement sales.
* Operator profitability reduces the intensity of use and increases the rate of retirements.
* Helicopter aviation experience further stimulates demand for helicopter services.

The existence of feedbacks that seem to have an overriding influence on aircraft sales suggests that behaviour might be somewhat insensitive to changes in the basic economic inputs. If this is so then it might have been possible to predict the collapse in the helicopter market.

To see whether the collapse in sales could have been anticipated, we resimulated with different economic inputs starting in 1980. We substituted two GNP scenarios: 1) continued steady growth in GNP at 3.5% per year; and 2) a business cycle that declines less in 1981-82 and recovers much more strongly during 1983-85 than, in fact, was the case. As seen in Exhibit 4 the basic pattern of collapse and stagnation occurs, even when one assumes a steadily growing economy. Diagnosis reveals that the principal causes are on the supply side and not from a major change in the final demand for helicopter services. The collapse is primarily the result of overexpansion of the helicopter fleet in the 1976-80 period, and is only secondarily affected by the economic recession of 1982. Even if planners in the industry had been far too optimistic about GNP in 1980, they could have seen the collapse coming.

The same is true for alternative oil price "forecasts". We tried three scenarios: 1) oil price remains constant through 1986 at the 1980 price level; 2) oil price rises significantly during the following year (to its actual 1981 peak), and then remains constant through 1986; and 3) oil price peaks in 1981 but then declines, but by only half as much as was actually the case. As seen in Exhibit 5 the differences in the essential collapse and stagnation pattern are quite small. This reinforces the conclusion that the "supply side" dynamics determine the basic behaviour, and that the market collapse was predictable!

3.2 Example 2 - Commercial Aircraft in Europe

Orders for commercial aircraft were historically very cyclical. Referring back to Exhibit 2, the correspondence between simulation and what actually happened is quite remarkable. Again, it could be supposed that some very simple economic inputs could explain this behaviour, but as in the first example this is not really the case. Exhibit 6 shows a comparison between three simulations of the same model.

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[1]Henry Weil and Richard Park helped to develop this example.

EXHIBIT 4

HELICOPTER ORDER RATES FOR VARIOUS GNP SCENARIOS

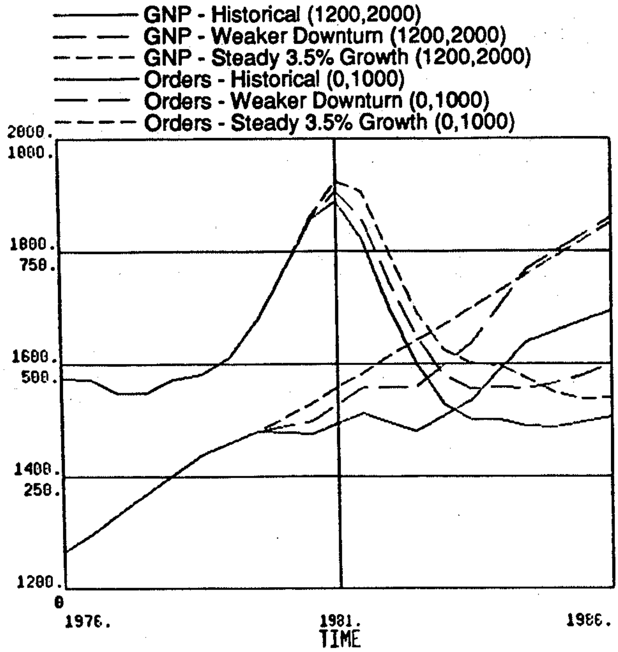
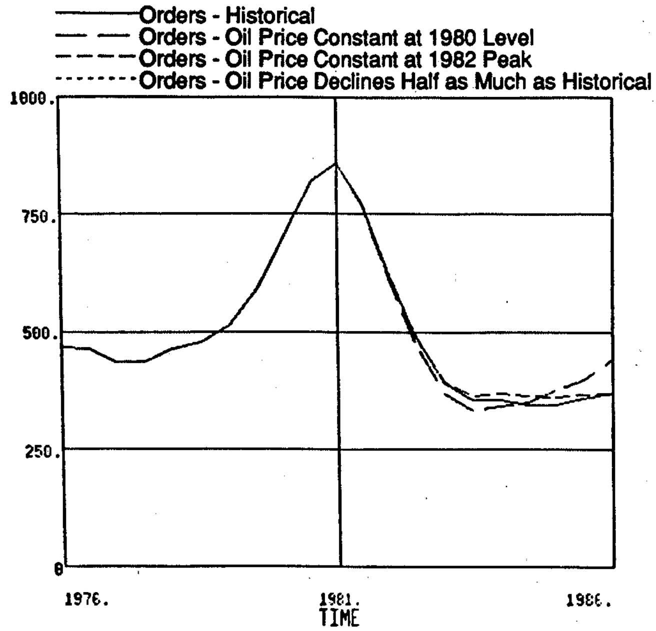


EXHIBIT 5

HELICOPTER ORDER RATES FOR VARIOUS OIL PRICE SCENARIOS



The first is exactly the same as the simulation results shown in Exhibit 2. The second shows what would have happened if the key economic inputs had been smooth; these include GDP, fuel price, inflation and interest rates. Clearly the basic cyclical behaviour is the same -- much as we would expect given the conclusions drawn from example 1.

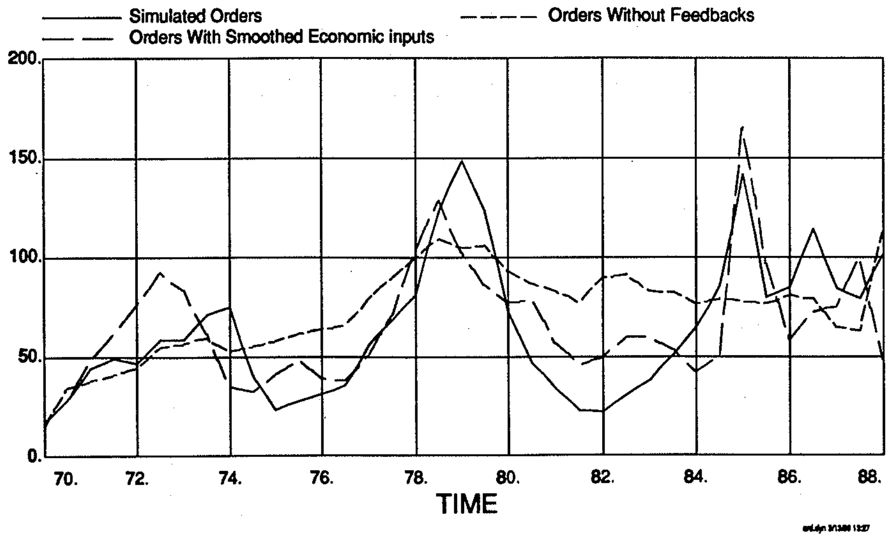
The third simulation shows what would have happened if all cyclical economic inputs remained but some key feedbacks are removed. In particular, we removed the influence of airline operating margin on orders, the influence of changes in delivery delay on projected demand, the influence of aircraft "launch" announcements on orders, and the influence of changing fares (fares still follow the general trend experienced in history but they are not as volatile). This results in a drastically different pattern of behaviour. The overall quantity of aircraft ordered is about the same, but none of the severe peaks and valleys in the order pattern are evident.

To be fair, in removing the above feedbacks we have eliminated some of the economic influences at the same time. So it may be inappropriate to conclude that the internal dynamics of the aircraft market have a vastly stronger influence on the pattern of aircraft orders than economic inputs. Nevertheless, it seems clear that the internal dynamics are more important.

These examples of specific output from two of our aircraft models demonstrate that factors internal to an industry can be very important determinants of industry cycles. Furthermore, since the strength of relationships and selection of time constants is validated with historical data, essential behaviour is valid well past the historical period -- especially when external factors remain relatively stable. In fact, the larger the influence of internal factors, the more reliable forecasts are. This is the value-added: robust predictive power.

EXHIBIT 6

JET AIRCRAFT ORDER RATE SENSITIVITY TESTS



IV. USES OF THE MODELS

The overall objective in developing and using these market models is to support strategy formulation and planning. These models allow companies: (1) to gain an understanding of the mechanisms at work in a market; (2) to produce forecasts; and (3) to explore the sensitivity of forecasts to changes in assumptions. As a result, they are extremely useful for exploring planning issues that involve timing and/or market targeting. Examples of such issues for various potential users are:

Manufacturers:

* Product design -- addressing needs of emerging markets
* Product introduction -- timing during market upswings
* Product upgrades -- focusing on expanding markets, timing during market upswings
* Product phase out -- winding down production of potentially unattractive or obsolete products.
* Sales support -- convincing customers that a product is designed to address their future needs
* Capacity investments -- preparing for overall demand
* Production planning -- preparing for demand cycles
* Workforce policies -- having trained labour available when it is likely to be needed
* Subcontracting policies -- efficient division of fixed and variable costs depending on market cyclicality

Operators:

* Fleet acquisition -- before peaks in demand/order cycles and/or anticipating fleet mix shifts
* Fleet sales -- when used prices are relatively high and/or anticipating fleet mix shifts
* Fleet retirements -- early in market lulls
* Purchasing strategies -- predicting the availability of new versus used aircraft
* Maintenance strategies -- timing major maintenance before market upswings to minimize downtime during periods of intense use
* Pricing policies -- impact on market cyclicality/growth

Investors:

* Buying low and selling high -- investing before market turns up, selling before market peaks.
* Speculating on delivery positions.

Although the examples listed here refer to the aircraft industry, these same issues are important in other markets as well. Some examples are:

* Offshore oil exploration and drilling equipment
* Farm equipment
* Ocean-going tankers and bulk carriers
* Commercial transportation equipment
* Construction equipment
* Automobiles and components
* Suppliers of raw materials or subcontracted products to any of these
* Insurance industry

In summary, these results show that feedback models have very significant advantages over statistical models using equivalent economic inputs. Nevertheless, as in any modeling approach, there are certain caveats. All models are an abstraction of the real system and therefore cannot account for "everything". In particular, although the general period and amplitude of market swings is very accurately predicted in these models, precise timing and severity of market swings often depends on external events. Therefore, this element of uncertainty must be addressed with sensitivity tests.

The primary purpose of these models is to support overall strategic planning, especially where timing and market targeting are important. In this role these models have proven their value in many markets. But apart for overall planning, a rich variety of other roles has emerged. These include consensus building, competitive positioning, sales support, production/capacity planning, product design, management training and investment support.