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Forming the Productivity Commission

The Federal Government, as part of its broader micro economic reform agenda, is merging the Bureau of Industry Economics, the Economic Planning Advisory Commission and the Industry Commission to form the Productivity Commission. The three agencies are now co-located in the Treasury portfolio and amalgamation has begun on an administrative basis. While appropriate arrangements are being finalised, the work program of each of the agencies will continue. The relevant legislation will be introduced soon. This report has been produced by the Industry Commission.

PREFACE

The following study was undertaken in support of the Industry Commission's Industry Development Reference into Tourism Accommodation and Training. It comprises a model of a regional hotel market that accounts for the long term nature of hotel investment and an application of the model to examine the growth in the number of rooms available in 4 and 5 star hotels in Sydney from 1987 to 1994.

The Sydney 4 and 5 star hotel market from 1987 to 1994 was chosen for three reasons. First, Sydney is an important domestic and international tourist destination. Second, the lead-up to the Sydney 2000 Olympic games has provided a wealth of information about the Sydney market from which to build and test a model. Third, developments in the Sydney market from 1987 to 1994 were remarkable — the number of 4 and 5 star rooms available approximately doubled from 1988 to 1992 — significantly affecting room rates, occupancy rates and hotel profitability.

In presenting a coherent economic framework, the model will help identify the economic factors that contributed to the rapid growth in the number of 4 and 5 hotel rooms in Sydney from 1987 to 1994. In addition, the general modelling framework is adaptable to other regional markets and to other uses, such as forecasting, taxation issues, labour market issues or the relationship between hotel owners and hotel operators. However, the latter three uses would require a more elaborate specification of hotel operation.

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EXECUTIVE SUMMARY

The Sydney 4 and 5 star hotel market changed substantially from 1987 to 1994. Before and during the Expo and Bicentennial celebrations in 1988, occupancy rates and rooms rates were high. However, from 1988 to 1992, the number of hotel rooms available approximately doubled, depressing both occupancy rates and room rates. This paper examines if economic factors could explain the rapid expansion of supply in the Sydney 4 and 5 star hotel market. It finds that three factors could contribute to an explanation of the rapid increase in the number of 4 and 5 star hotel rooms from 1988 to 1992 relative to demand:

- Forecasts of demand growth based on historic demand growth were stronger than the demand growth that actually occurred.
- The lag between hotel construction and hotel opening precluded an immediate market correction to the unrealised demand forecasts.
- The general investment climate was overly optimistic as seen in the rapid appreciation of real estate values in Sydney and the strong Australia-wide investment in new fixed capital.

These factors must be viewed in the context of the market for 4 and 5 star hotel accommodation. Its characteristics include:

- a demand for hotel rooms that varies across seasons and years and cannot be precisely forecast;
- fixed investments — hotels — that take time to build and are substantial and long-lived and whose profitability depends on uncertain demand and costs conditions in the medium and long term; and
- an operating cost structure, that, given competitive market forces, allows a normal return to the hotel investment only if occupancy rates are high and room rates can earn a premium above operating costs.

These characteristics are embedded in a multi-year model of a hotel market. The model's parameter values are calibrated to the Sydney market. Historical demand functions are constructed in part from monthly ABS data on room rates and the number of rooms available and occupied for Sydney from 1987 to 1994. Forecasts of demand growth after 1994 are obtained from industry publications. Data for hotel construction and operating costs come from industry sources.

The model simulates actual room rates, occupancy rates and room supply in Sydney from 1987 to 1994 best when, by assumption, demand for 4 and 5 star hotel rooms in Sydney is elastic and investors' demand growth forecasts are extrapolated from historical growth rates. Under these demand circumstances, demand forecasts were extremely bullish when the large number of hotels were being built but the actual demand when those hotels opened turned out much weaker. Model results are similar for a wide range of hotel construction cost assumptions, given an assumed elasticity of demand for rooms in 4 and 5 star hotels in Sydney. Model performance is further improved, especially when the demand for rooms in 4 and 5 star hotels in Sydney is elastic, if investors expect future sale prices of hotels to increase in line with the general appreciation of real estate values in Sydney.

A MODEL OF INVESTMENT IN THE SYDNEY 4 AND 5 STAR HOTEL MARKET

This paper investigates the growth in the number of rooms available in the Sydney 4 and 5 star hotel sector from 1987 to 1994 with a focus on the rapid growth in the number of rooms available between 1989 and 1994. In particular, it examines whether economic factors can contribute to an explanation of the growth in the number of 4 and 5 star hotel rooms available in Sydney.

Two classes of competitive market models are developed for the Sydney 4 and 5 star hotel market.[1] The models use different assumptions about the uncertainty of future market conditions. One model assumes certainty; investors know what future market conditions will be and invest accordingly. The other model assumes that future market conditions are uncertain — a more realistic assumption — and investors must forecast future market conditions and decide whether to invest based on past experience and the situation at hand.

A comparison of the projected number of rooms available under these assumptions with the actual number of rooms available sheds light on whether the large increase in the number of 4 and 5 star hotel rooms between 1989 and 1994 may be attributed to accurate forecasts of future market conditions, forecasting errors, or the general investment climate in Sydney and Australia.

The paper is organised into 5 sections. First, the developments in the hotel and motel sector since 1981 are reviewed. Second, the usefulness of previous models of hotel markets is considered. Third, the basic empirical demand and supply factors on which the models are built are presented. Fourth, the models are presented and their projections compared to what was observed in the Sydney 4 and 5 star hotel sector from 1987 to 1994. Fifth, the conclusions are discussed.

1 Review of the hotel market

This section reviews changes in Sydney's 4 and 5 star hotel sector from 1987 to 1994. These are compared with developments in the wider accommodation sector between 1981 and 1994.

[1] The study uses the ABS classification of the Sydney Statistical Division for the Sydney 4 and 5 star market.

1.1 4 and 5 star hotels, Sydney 1987 to 1994

Between 1987 and 1988, the number of 4 and 5 star rooms available and the number of 4 and 5 star rooms occupied grew at similar, moderate rates (see Table 1).[2] Consequently occupancy rates remained stable.

Table 1 Rooms available and rooms occupied, 4 and 5 star establishments in Sydney, 1987 to 1994

	Rooms available		*Rooms occupied*		*Occupancy rate*	*Real takings per room night occupied*	
Year	*Rooms (No.)*	*Change over previous year (%)*	*Rooms (No.)*	*Change over previous year (%)*	*(%)*	*Takings ($)*	*Change over previous year (%)*
1987	6 099	na	4 932	na	81	177	na
1988	6 270	3	5 195	5	83	208	17
1989	7 238	15	5 184	0	72	201	-3
1990	9 263	28	6 128	18	66	184	-9
1991	11 251	21	6 634	8	59	158	-14
1992	13 319	18	7 685	16	58	139	-12
1993	14 193	7	8 878	16	63	129	-7
1994	14 267	1	10 386	17	73	129	0

a The data refers to 4 and 5 star hotels, motels and guest houses (with facilities).
b Takings are expressed in constant 1995 dollars.
na Not available.
Source: Based on data from the ABS Cat. No. 8635.3.

Between 1989 and 1992, the number of rooms available and the number of rooms occupied grew faster than either had in 1988. In addition, the number of rooms available grew faster than the number of rooms occupied: The average number of rooms available almost doubled from 7238 to 13 319 rooms. In contrast, the number of rooms occupied increased by only 48 per cent from 5195 to 7685 rooms over the same period. As a result, occupancy rates had fallen by almost 20 per cent by 1992. Room rates fell by over 30 per cent in the same period.

[2] Since 1987, the ABS has collected data on the number of rooms available, the number of rooms occupied and takings for 4 and 5 star establishments. Four and 5 star establishments can be either hotels, motels or guesthouses (with facilities). Changes in the number of rooms available, the number of rooms occupied and takings per room occupied in these establishments mainly reflect changes in 4 and 5 star hotels because 4 and 5 star hotels make up a significant part of the total 4 and 5 star sector.

In 1993 and 1994 the rates of increase in the number of rooms available slowed to the rate in 1988, while the number of rooms occupied continued to grow strongly. As a result, the occupancy rate in 1994 was similar to that in 1989. Takings per room occupied responded more slowly and remained low in 1994.

1.2 Other sectors and earlier periods

The recent developments in the 4 and 5 star sector can be placed in perspective by comparing supply and demand developments in the 4 and 5 star sector from 1987 to 1994 with those in the 1, 2 and 3 star sector from 1987 to 1994 and with those in the 'licensed hotels' and 'motels' sectors from 1981 to 1988.[3] For instance:

- the experience of the 1, 2 and 3 star sector provides some insight into whether the 4 and 5 star experience from 1989 to 1992 was out of the ordinary, or reflected wider developments in accommodation at the time; and
- the experience of the accommodation sector before 1987 provides an indication of whether similar developments occurred in earlier periods.

The experience of the 4 and 5 star sector is different from that of the 1, 2 and 3 star sector from 1987 to 1994, and from accommodation more generally from 1981 to 1988 (see Figure 1). In particular, no other sector in any time period matches the doubling of the number of rooms available and the large increase in the number of rooms occupied in the 4 and 5 star sector between 1989 and 1992.

Like the 4 and 5 star sector, the 1, 2 and 3 star sector also experienced falling occupancy rates between 1989 and 1992. However the falling occupancy rates in the 1, 2 and 3 star sector are perhaps more a consequence of an unusual fall in demand (see Figure 1, Panel B). The number of 1, 2 and 3 star rooms occupied fell significantly in 1989 and continued to fall until 1991. This was somewhat unusual because the number of rooms occupied typically increased in other accommodation sectors. The number of rooms available in the 1, 2 and 3 star sector grew at a slightly faster rate after 1989, peaking at around 8 per cent in 1992.

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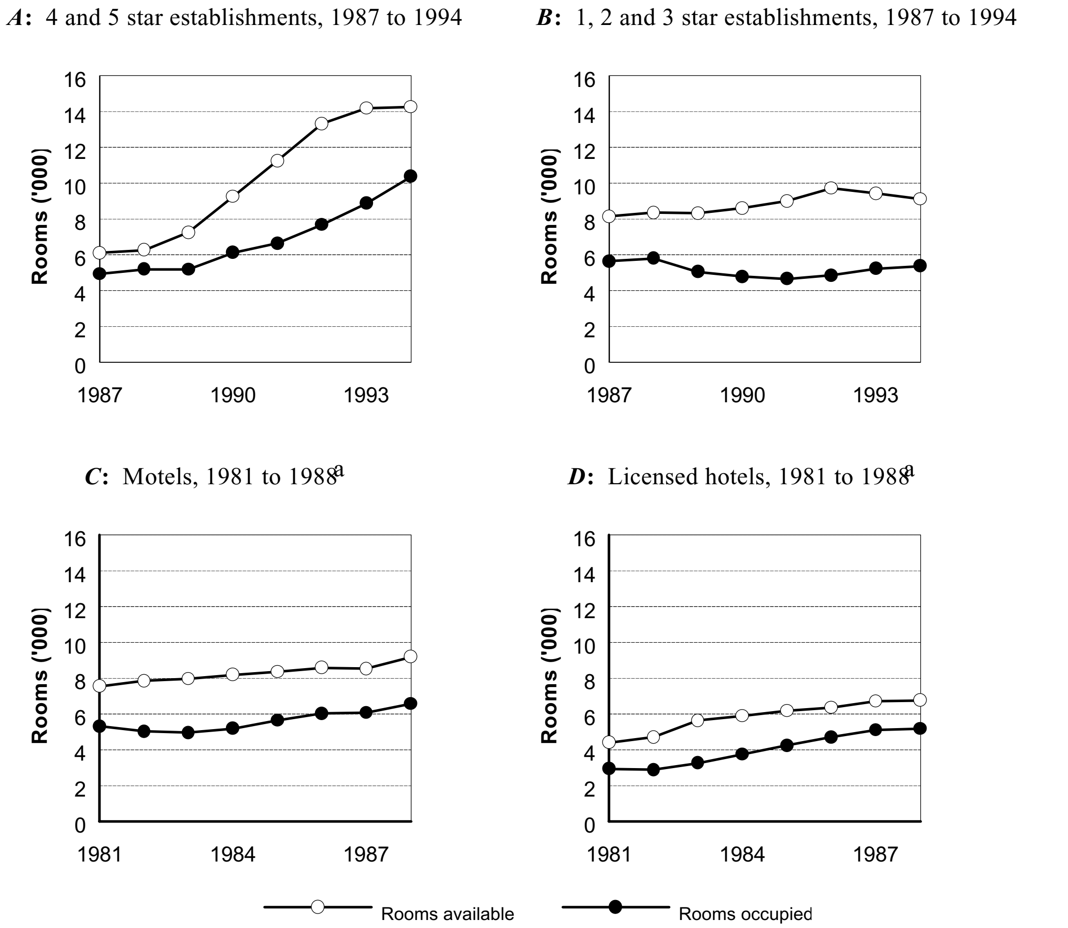
[3] ABS data for establishments by star grading in Sydney begin only in 1987. Prior to 1987, data are classified by 'licensed hotels' and 'motels'. ABS defines licensed hotels as 'hotels which provide tourist accommodation, are licensed to operate a public bar, and provide baths or showers, and toilets in most guest rooms' and motels as 'licensed or unlicensed motels, private hotels, or guest houses which provide tourist accommodation and provide baths or showers, and toilets in most guest rooms, but are not licensed to operate a public bar' (ABS, Cat 8635.0, 1986).

Figure 1 Average yearly number of rooms available and rooms occupied, 1981 to 1994



a The average number of rooms available and the average number of rooms occupied in 1988 are calculated using data from the March and June quarters from that year.

Source: ABS Cat. No. 8635.3.

There is little evidence to suggest that the large, sustained increase in the number of 4 and 5 star rooms available reflects a general trend in the wider accommodation sector. From the early to mid 1980s, the number of motel rooms available and the number of motel rooms occupied increased at moderate and similar rates (see Figure 1, Panel C). Consequently, occupancy rates were stable. Room rates also held steady. However, sudden large increases in the number of rooms available have occurred in the licensed hotel sector. In 1983 the number of licensed hotel rooms available grew by 20 per cent (see Figure 1, Panel D). Nevertheless, the short-lived growth spurt did not match the large, sustained supply increase seen in the 4 and 5 star sector from 1989 to 1992.

After 1984, the number of rooms occupied in licensed hotels grew significantly faster than it had previously, and continued to grow strongly until 1987. Despite the growth spurt in the number of rooms available in 1983, the number of rooms occupied grew faster than the number of rooms available from 1982 to 1987. Consequently occupancy rates rose. Room rates also increased.

Increased occupancy rates and room rates may suggest latent demand pressure on the number of rooms available in the licensed hotel sector. However the increased occupancy rates and room rates also reflect a structural change in this sector. Between 1982 and 1987 the number of licensed hotels decreased whilst the number of rooms available increased. This suggests that the growth in the number of rooms available occurred mostly through the construction of large (typically higher star graded) hotels replacing smaller (typically lower star graded) hotels. ABS data from 1987 to 1994 show that 4 and 5 star establishments, on average, have more rooms per establishment, higher occupancy rates and higher room rates than 1, 2 and 3 star establishments. Thus the increasing share of 4 and 5 star hotels contributed to increasing average room rates and occupancy rates in the entire licensed hotel sector.

The evidence for a change in composition suggests that the growth in the number of rooms available and in the number of rooms occupied in the licensed hotel sector was largely driven by vigorous growth in the upper end of the sector. This changed the composition of the licensed hotel sector. Therefore, it is difficult to infer whether the number of 4 and 5 star rooms occupied grew faster than the number of 4 and 5 star rooms available and hence possibly placed upward pressure on room rates before 1987. However, if any demand pressure existed in the 4 and 5 star sector, the growth in the number of rooms available in 1989 eased this pressure because occupancy rates and room rates fell after 1988.

In summary, the experience of the 4 and 5 star sector between 1989 and 1992 appears to be unusual. The rapid growth in the number of 4 and 5 star rooms available between 1989 and 1992 is not evident in the 1, 2 and 3 star sector during the same period nor in licensed hotels and motels in earlier periods.

2 Previous studies of demand and supply

There are few previous attempts to analyse demand and supply jointly in a hotel market. The methodologies used in these studies for determining hotel capacity are not well suited for assessing uneven growth in demand and supply. Either they rely on an assumed long-run occupancy rate, hence even growth, or they ignore the dynamics of the industry's investment behaviour.

Carey (1992) reports on studies by Waddell (1977) and Choy (1985). Choy (1985) forecasts visitor arrivals for hotels in a given locality and uses an assumed occupancy rate to determine when investment should occur. The report *The Sydney and Environs Accommodation Supply and Demand Study*, prepared for the NSW Tourism Olympic Forum (hereafter referred to as the Olympic Forum 1994), uses a similar methodology to Choy's to plan for accommodation supply in Sydney.

In these studies, occupancy rates and room rates are assumed to maintain hotel profitability given an expected growth in demand. This in turn presumes stable seasonal and weekly patterns of demand and no trend increase or decrease in hotel operating and construction costs. In reality, the underlying costs and demand patterns change over time, altering the desired level of investment in hotel capacity.

Carey (1992) overcomes some of these drawbacks by using a single year 'peak load pricing' model, which recognises the effects of seasonal demand on investment, room rates and occupancy rates. Rooms added for the peak season may stand idle in the off peak season. Changes in operating costs are also a consideration in her model. Her model explicitly relates the industry's profitability to the seasonal cycle of market demand and to the operating costs of servicing that cyclical demand. Her approach contributes a rigorous theory and empirical methodology for determining optimal hotel capacity. Nevertheless, her model determines investment based on market conditions in only a single year. It overlooks that hotels are long-lived assets and can not explain the dynamic effects of investment decisions.

3 Dynamic models of supply and demand

The following extends previous analysis by recognising the dependence of occupancy rates, room rates, capacity and investment on cost and demand factors that change over time and are not known with certainty. The general modelling approach is presented by Takayama and Judge (1971) and Day (1961). Dynamic models are developed relating supply and demand over a number of years. The models are applied to study developments in the 4 and 5 star hotel sector in Sydney over the period from 1987 to 1994. A mathematical statement of the models is presented in Appendix A.

The models are tested for their ability to explain the observed number of rooms available in the Sydney 4 and 5 star hotel sector from 1987 to 1994 under varying assumptions about the uncertainty of future market conditions. In all cases, the market is assumed to be efficient (that is, competitive and free of distortions). Investment decisions are assumed to be based on real changes in costs and room rates. All model data on room rates and costs are expressed in real terms of 1994 dollars, unless stated otherwise.

3.1 Demand

The demand for hotel accommodation has various sources, including business travellers, domestic holiday-makers and foreign visitors, and derives from those people's decision to travel. The level of business activity, household income, costs of travel (particularly airfares and fuel costs), weather, politics, travel fashions and exchange rates all affect customers' propensity to travel and subsequently their demand for tourist accommodation.

There is a voluminous research on the determinants of travel flows. Examples include Crouch (1995), Divisekera (1995), Crouch (1994), Artus (1972), Kwack (1972), Bechdolt (1973), Gray (1966), and Barry and O'Hagan (1972). The Tourism Forecasting Council (1994) documents the forecasting approaches used in Australia. These studies relate domestic and international travel demand to factors such as income growth, the unemployment rate, exchange rates, transport costs, business activity, population, special events and the relative price of accommodation.

However, because the studies focus on aggregate relationships, for example, tourist expenditure or foreign arrivals and not hotel accommodation, they are useful for analysing broad trends in travelling activity but less useful for predicting demand for accommodation in one regional hotel sector. The latter requires market specific information, including the mix of clients, their origins and other local demand features.

The model decomposes the demand for 4 and 5 star hotel accommodation into two parts: the response of demand to changes in room rates and demand shifting in response to non-price factors such as special events, income changes, the business cycle and seasonal factors.

Price elasticity of demand

The response in demand to a change in price is measured by the price elasticity of demand. For instance, an elasticity of 1 means that a 10 per cent rise in price reduces demand by 10 per cent. Data limitations preclude reliable estimation of the price elasticity of demand for accommodation in Sydney 4 and 5 star hotels.

Empirical estimates of the price elasticity for tourist accommodation range widely from 0.13 to 1.7 (Arbel and Strebel (1983), Carey (1992) and Crouch (1994)). Model specification, estimation technique as well as the choice of data interval all differ in these studies. Most estimates are in the lower end of the range. This agrees with the suggestion that visitors are not too sensitive to changes in room rates because accommodation is only a small part of their overall cost of travel (Bureau of Tourism Research (1995)). However none of these estimates refers to a market that closely resembles the 4 and 5 star market in Sydney. Consequently, this study assumes an elasticity of 0.5 in its core simulations but also evaluates the effects of using larger and smaller demand elasticities.

Demand shifts

There are other determinants of demand beside room rates and they are no less important. They indicate the underlying strength of demand and help determine profitable supply growth.

Annual growth of demand

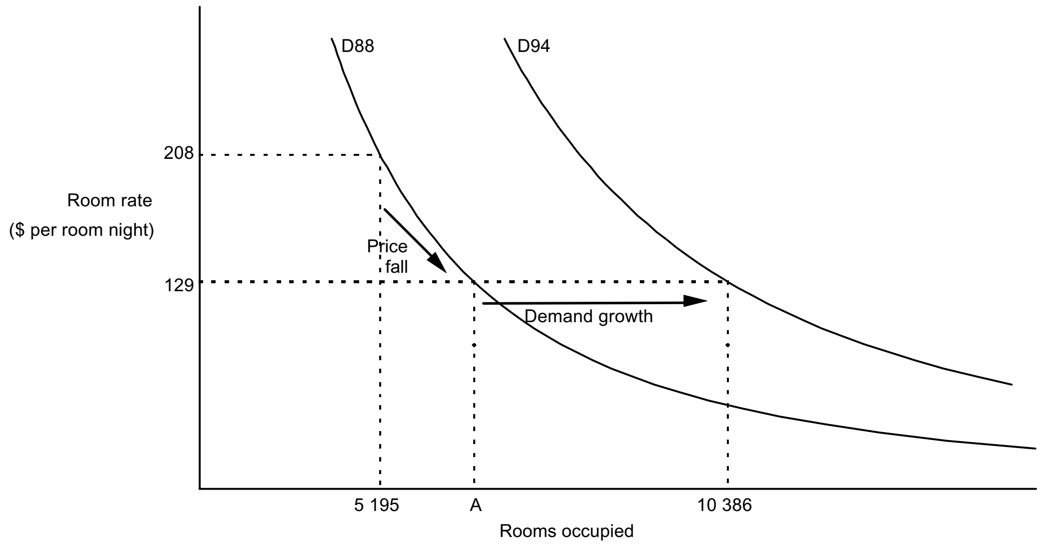
From 1987 to 1994 the trend growth in the number of rooms occupied in Sydney 4 and 5 star hotels was 11.2 per cent a year (see Table 1). However, as room rates on average decreased in real terms from 1988 on, this trend growth in the number of rooms occupied reflects both the stimulating effect of falling room rates and the shifts in demand due to other factors. The contributions of the price reductions and demand growth to the observed growth in the number of rooms occupied depend crucially on the price responsiveness of demand.

The average takings per room occupied and the number of rooms occupied for 1988 and 1994 are taken from Table 1 to illustrate this point. From 1988 to 1994 takings per room occupied fell by 38 per cent while the number of rooms occupied grew by 100 per cent. For a given elasticity of demand it is possible to draw two demand curves, one for 1988 and one for 1994, and to compute the contributions of room rates and demand growth to the growth in the observed number of rooms occupied from 1988 to 1994 (See Figure 2).

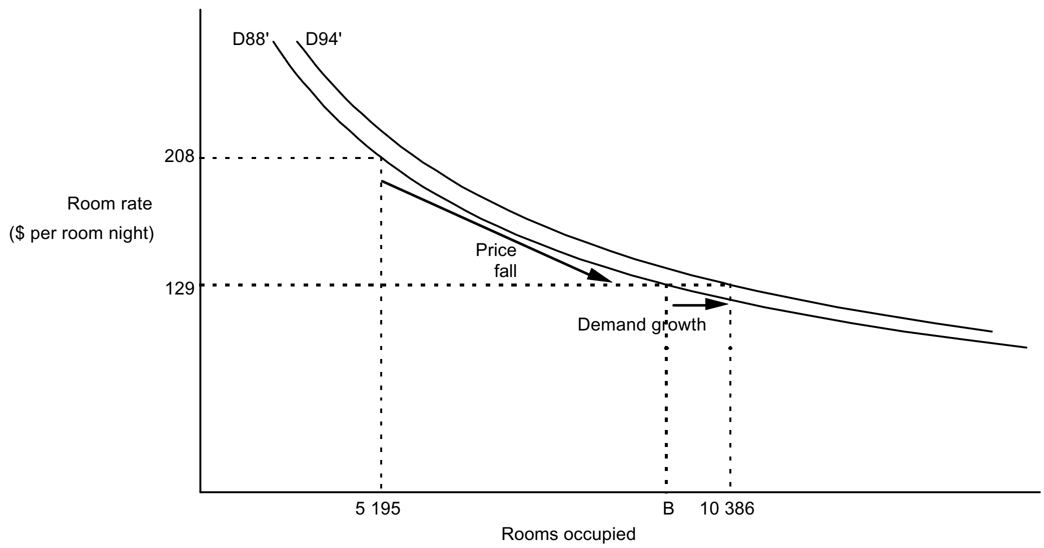
The average demand curves for 1988 and 1994 are given by D88 and D94 if the price elasticity of demand is 0.5 (see Figure 2, panel A). The price effect of the room rate reduction from 208 to 129 dollars per room is represented by a movement down D88 increasing the number of rooms occupied to A. The difference between 10 386 and A is the increase in the number of rooms occupied which is attributable to demand growth, implying an increase in demand of 57 per cent.

Figure 2 The effects of changing room rates and demand growth on the number of rooms occupied

A: Price elasticity of demand = 0.5



B: Price elasticity of demand = 1.25



Source: Data points are based on data from the ABSCat. No. 8635.3.

Similarly, the demand curves for 1988 and 1994 are given by D88' and D94' if the price elasticity of demand is 1.25 (see Figure 2, panel B). Because demand is more responsive to changes in the room rate, the number of rooms occupied grows by more given the same fall in room rates. The price effect of falling room rates accounts for an increase in the number of rooms occupied to B. The demand growth needed to increase the number of rooms occupied from B to 10 386 is just 10 per cent.

This same method of calculating the shift in demand can be applied to the monthly observations of takings per room occupied and number of rooms occupied. The trend increase in demand is estimated to be 7.4 per cent a year from 1987 to 1994 after adjusting the number of occupied rooms for the effect of falling prices given a price elasticity of 0.5.

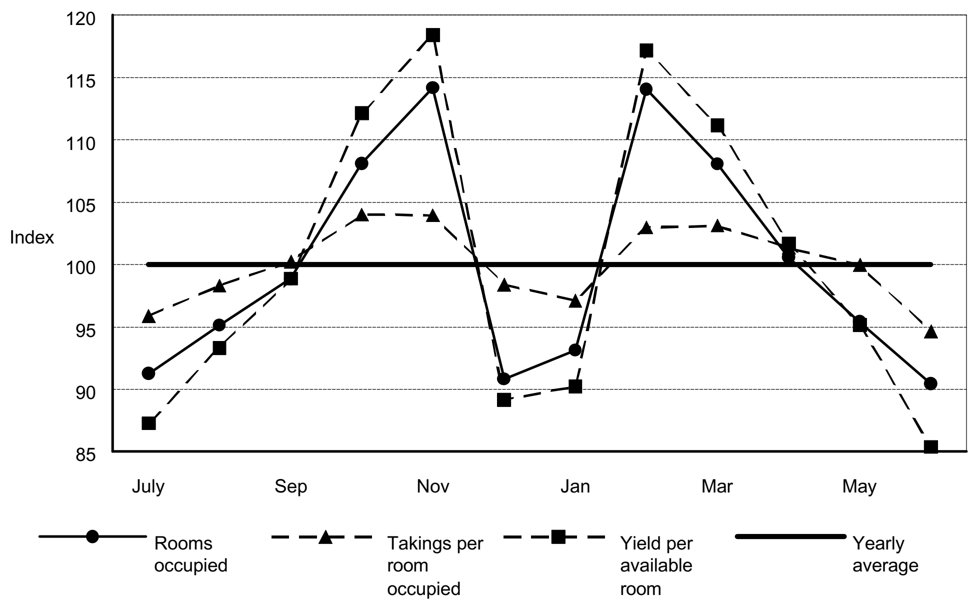
The data limitations that precluded estimating a price elasticity of demand also preclude estimating the relationship between demand shifting factors and the demand for accommodation in Sydney's 4 and 5 star hotels. The models will however estimate the combined effects of various factors which shifted demand during the period from 1987 to 1994. The demand growth after 1994 is that estimated in the Olympic Forum and is assumed to be accurate. In its medium forecast, the Olympic Forum (1994) projects demand to grow at slightly above 7 per cent a year until 1997 and at 4.6 per cent a year after 1997 to 2000.

Seasonal shifts of demand

The seasonal pattern of demand is another factor determining capacity, room rates and occupancy rates. To illustrate the typical pattern, Figure 3 displays the statistical indexes of seasonal shifts in demand for the 4 and 5 star hotel sector in Sydney compiled using the 1987 to 1994 data. The number of rooms occupied is typically highest in February and November and lowest in December – January and June – July. Seasonal swings in the takings per room occupied are less drastic than those in the number of rooms occupied, but the yield per room available shows even greater swings reflecting the combined effects of rooms occupied and takings per room occupied.

Seasonal patterns of demand changed slightly over time although the major peaks and troughs have not shifted dramatically. The models neither analyse the determinants of seasonal variation in demand nor depend on a fixed series of seasonal indexes, such as the one exhibited in Figure 3. Instead, the models use monthly data between 1987 and 1994 and also include changes in the seasonal pattern of demand over the years as part of the demand shifts. As demand shifts after 1994 are extrapolated from trends in previous years, the seasonal pattern of demand for those years will be the same.

Figure 3 Seasonal variation in rooms occupied, takings per room occupied and yield per available room, Sydney 4 and 5 star hotels, 1987 to 1994



Source: Estimates based on ABS Cat. No. 8635.3 data.

In summary, the demand relationship is described by a price elasticity, which is assumed to be constant over time, and a parameter that varies over time and captures yearly growth and seasonal shifts of demand. The models use Cobb-Douglas demand functions for this purpose which are fitted to observed data for the Sydney 4 and 5 star hotel market (see Appendix A for details).

3.2 Supply

In this study, four factors determine the supply of hotel accommodation: the aggregate supply of rooms and operating costs; construction costs; an investment rule; and the initial stock of hotel rooms. The initial stock of hotel rooms is the stock available in 1986.

Aggregate supply and hotel operating costs

Aggregate supply is limited by absolute capacity — the total number of rooms available. However, a practical capacity may be reached before the absolute capacity. This may be because rooms are under repair or because more rooms are occupied on weekdays than on weekends (Olympic Forum 1994). Consequently, monthly data on capacity usage would report a monthly average occupancy rate that is unlikely to reach 100 per cent. A maximum capacity of 93 per cent of all available hotel rooms is taken to summarise these limits. This is the highest monthly occupancy rate ever observed in Sydney's 4 and 5 star hotels from 1987 to 1994.

Hotel operating costs are modelled to change with the number of rooms occupied. The cost function was estimated with four objectives in mind. First, the estimated cost function, in conjunction with the demand function, should predict seasonal patterns of the number of rooms occupied and the takings per room occupied similar to those observed over the period 1987–1994. Second, the cost function should point to the same level of average operating costs per room occupied as that recorded by Horwath Asia Pacific (HAP) (1995) for the 4 and 5 star hotels in Sydney from 1992 to 1994. Third, the cost function is meant to reflect an average hotel in the 4 and 5 star sector. Four star hotels and 5 star hotels have different cost structures. Therefore, as the proportion of 4 star hotels in this sector has increased over the years, the cost function needs to reflect the greater representation of 4 star hotels. Fourth, the operating cost function should change over time to reflect real changes in wages and input prices as experienced by the industry.[4]

The average operating costs per occupied room in Sydney 4 and 5 star hotels as used in the model is drawn from HAP (1995) and was estimated to be 113 dollars per occupied room at 73 per cent occupancy (See Table 2). Standard accounting rules allocate costs to operating "departments" and do not include capital costs.[5] In this study, expenditures on food and beverage were excluded (and not given in Table 2) because a breakdown between guest and non-guest expenditures was not available. In addition, takings do not include revenues from food and beverage sales. Their exclusion is valid if the provision of food and beverage covers its own operating costs, with no return on its physical capital. This assumption is largely supported by the Horwath Asia Pacific data.

4 These components do not account for any technological improvement in operating a hotel, but no evidence was found to suggest there were significant technical efficiency gains in hotel operation.

5 See Hotel Association of New York, Inc (1986) for a detailed description of the costs.

Table 2 Room expenditures, excluding capital costs, for Sydney 4 and 5 star hotels, 1992 to 1994

Operation activity	*Expenditure per occupied room ($)*	*Share of total expenditure (%)*
Room servicing	48	42
Telephone and other minor operating activities	10	9
Administrative and general	21	19
Marketing	15	13
Energy	9	8
Property operation and maintenance	10	9
Total	**113**	**100**

Source: Based on HAP (1995).

Some operating costs vary according to the number of rooms occupied on a given night, such as expenditures on servicing rooms and on electricity. Other operating costs, such as expenditures on marketing and administrative activities, do not vary with the number of rooms occupied but are incurred if the hotel is open. The operating cost function covers both kinds of costs.

The operating cost function needs to adequately reflect the cost structure of hotels as discussed above. It also needs to be a concise statement suitable for modelling purposes. Appendix B presents the details of its estimation using data from ABS and HAP (1995).

To illustrate, the average operating cost per room occupied for each month in 1994 was estimated to be:

$$Average\ \cos t\,(dollars\ per\ room\ occupied = 92.88 + 0.28 \times \left(\frac{rooms\ occupied}{rooms\ available} \times 100 \right)$$

In this equation, the average operating cost depends on the occupancy rate, which is the term in brackets. An increase in the occupancy rate by 1 percentage point would raise the average cost by 28 cents. As the occupancy rate varies according to the monthly demand pattern, the estimated average cost would change from month to month. The cost variation between months would subsequently lead to seasonal variation in the room rate. This demand pattern and cost relationship thus reproduces the correlation between the number of rooms occupied and the takings per room occupied as observed in ABS's monthly data. The other parameter in the equation, shown to be 92.88 for 1994, was estimated so that the average operating cost per room occupied was comparable to the average expenditure per room occupied in HAP (1995). For example, the average cost would be approximately 113 dollars in 1994 when the occupancy rate was 73 per cent, which is consistent with that displayed in Table 2.

The same cost equation applies to other years; but the two parameters then have different values from those used for 1994. The first adjustment in parameter values is related to the changing composition of the 4 and 5 star hotel sector. The parameter values for 1994 reflect the average occupancy rate and the average level of expenditure per occupied room amongst the 4 star hotels and 5 star hotels in that year. The average occupancy rate differs between 4 star hotels and 5 star hotels. Furthermore, 4 star hotels expend less on average on each occupied room, at 91.54 dollars compared to 142.20 dollars by 5 star hotels (HAP (1995)). The composition of the 4 and 5 star sector changed considerably from 1987 to 1994 as the large growth in hotel rooms occurred in 4 star hotels not in 5 star hotels. Consequently, the average level of expenditure in each year is adjusted to show a trend of greater weighting towards the 4 star hotels. The two parameters are thus adjusted to this effect.

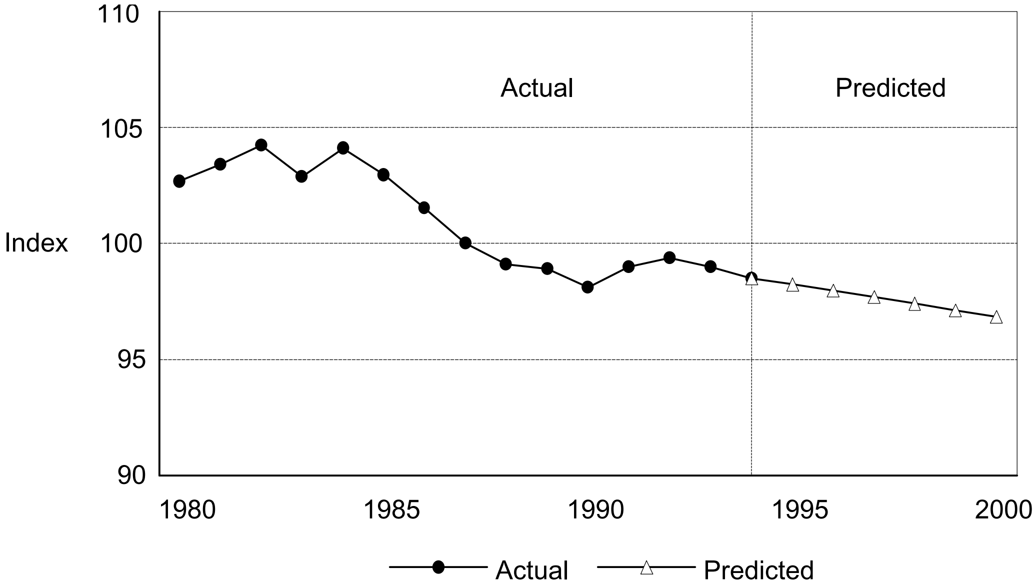
The second adjustment in parameter values reflects real changes in wages and energy prices. Figure 4 shows them as an index, which is a cost share weighting of wages in service industries (the nearest wage index available from ABS relevant to occupations in the hotel industry) and the price of electricity. Labour and energy account for 31.6 and 4.7 per cent respectively of the total operating costs in the 4 and 5 star hotels (HAP (1995)). For other operating inputs, their unit costs are assumed to have changed with general inflation. The compiled index was relatively stable, especially from 1987 to 1994. Yearly changes were small, averaging less than half of a percentage point over the period 1980–1994.

Index values after 1994 are also required. They are generated by extrapolating the trends in and before 1994. The index after 1994 shows a downward trend, mainly reflecting the decline in costs from 1992 to 1994. For modelling the scenario in which prospective investors do not know future costs, they are supposed to make forecasts based on cost trends prior to the time of planning.

Construction costs for Sydney 4 and 5 star hotels

Building new hotels or extending existing ones involves land acquisition, hotel design and construction. The costs of constructing new hotels vary considerably depending on location, star grading and the scale of the project. For example, the Olympic Forum's estimate of the cost of a new 4 star hotel with 400 rooms in Sydney is about 253 000 dollars per room (Olympic Forum 1994). This includes a land cost of 30 000 dollars per room.

Figure 4 Index of actual and projected real operating costs 1980 to 2000[a,b]



a Proxied by a combined index of wages and electricity price, net of inflation.

b The index is calculated with 1987 as the base year (=100).

Source: Based on data from ABS Cat. No. 8635.3 and Horwath Asia Pacific 1995.

In the models, the average construction cost per room refers to the total construction cost of all rooms added to the market during a year divided by the number of new rooms. It is assumed that the average cost would increase with the number of new rooms. This presumes supply constraints in the construction industry. For example, construction projects carried out simultaneously may bid up the costs for one another. As a result, investors who are the last ones to build may pay a higher cost per room than the early investors. The construction cost per room for prospective investors is represented in the models by the marginal cost equation. As the industry's average cost is assumed to rise with the number of new rooms, so its marginal cost must be greater than average cost.

To illustrate, the marginal construction cost in dollars per room in 1994 is:

$$\textit{Marginal cost of construction per room} = 189.95 \times \textit{Number of rooms under construction in the year}$$

The parameter, shown to have a value of 189.95 for 1994, is estimated by taking the Olympic Forum's estimate of 223 000 dollars per room (net of land cost) as the cost for the latest investment in the market where 1 174 new rooms have been built during the year. 1 174 rooms are the average number of 4 and 5 star rooms added per year from 1987 to 1994 in Sydney. At this level of investment, the equation calculates the cost of constructing the newest room to be approximately 223 000 dollars, which is the Olympic Forum's estimate. In the model, if fewer than 1 174 rooms are built, the cost of the newest room will be less than 223 000.

An alternative specification of the cost equation is considered later. In particular, results of models using an assumption of a rising average cost are compared with those of models using an assumption of constant average cost — every hotel room costs 223 000 dollars to build no matter how many are built.

Construction time for the hotel is assumed to be 2 years. This is consistent with the time lag between the trend of commencements of tourism accommodation and the trend of capacity additions as observed from ABS data (see Table 1 and Figure 8).

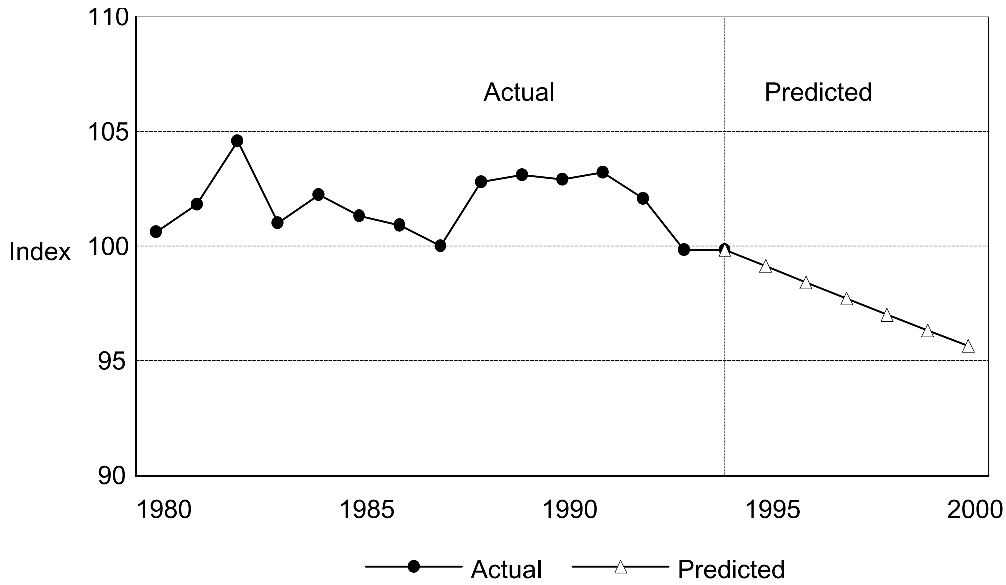
Hotels are long-lived assets. The service life of any hotel will depend on its own characteristics. There is no data series to estimate an average economic life of a hotel. The models assume a service life of 25 years at which time the hotel needs to be extensively renovated, converted or demolished. This assumption is based in part on the accounting rule applied to tourist accommodation that permits a complete write-off of the capital expenditure on the construction of buildings over 25 years. The Building Owners and Managers Association of Australia (BOMA) estimates a range of economic lives from 3 to 30 years for various hotel features with a 'blended' economic life for the hotel of 16 years (BOMA, Sub. 162, p. 2). JLW (1995) records that only 6 per cent of hotels are more than 30 years old, with no mention of whether and when the hotels have been extensively renovated.

The important modelling question is how projected investment changes if the assumed service life of the hotel is increased or decreased. The results of a sensitivity analysis using the certainty model show that projected investment changes by less than 1 per cent if hotel life is increased or decreased by 5 years. Thus, an exact estimate of the average service life would be useful, but it is unlikely to change the modelling results significantly. This is largely because net revenues 20 years after hotel construction become quite small when discounted to their present values at the time of construction.

In the models, the construction cost is estimated net of land cost. The rationale rests on the idea that the land can be sold at the end of the hotel's service life while other physical components are fully depreciated. Consequently, the cost of construction with land cost included must be reduced by the present value of the expected future resale price of the land. For simplicity, the price of the land at a hotel site is assumed to appreciate at 8 per cent per year, the same rate at which the hotel investment is assessed. Under this assumption, the present value of the expected future resale price of the land is the initial land cost and is thus deducted from the total cost of construction.[6]

The unit construction cost is assumed to follow the price index of construction materials in Sydney. The unit construction cost of a hotel in real terms was stable despite some small rises in the 1980s (see Figure 5). Projected unit cost falls after 1994 as a continuation of the yearly declines experienced after 1991.

Figure 5 Actual and projected real construction costs of hotels, 1980 to 2000[a, b]



a Proxied by the price index of construction materials in Sydney, net of consumer price inflation.

b The index is calculated with 1987 as the base year (=100).

Source: Based on data from ABS Cat. No. 8635.3.

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6 Estimating the full cost of land introduces two possible biases: If land value of the hotel is expected to appreciate faster (more slowly) than the risk adjusted market rate of return, the disregard of the above (below) average return from the land investment is an implicit cost increase (decrease) to the total construction cost. Land cost is only 13 per cent of the building costs according to the Olympic Forum's feasibility study. Thus, to attain an equivalent 10 per cent change in the construction cost, land value at the hotel site would need either to rise roughly two times as fast as the market rate of return in each year or to decline to become worthless. Neither case seems to be a common perception amongst the hotel investors. As will be seen later, basic modelling results are not affected by a 10 per cent change in the construction cost. The assumption of the models about land value of the hotel is quite defensible.

The models have a finite planning horizon. Thus, costs and revenues are compared over a span of years that is shorter than the hotel's service life. The cost of construction is adjusted to apply only to those service years within the planning horizon. This is done by first calculating the annuity value of the construction cost with a fixed discount rate. The annuity value, when paid in each year of the service life of the hotel, would repay the principle and interest of a fixed rate loan equal to the construction cost of the hotel. Only the present value of the annuity for those years of service in the planning horizon are included in construction cost.

The discount rate covers the risk free rate plus the risk premium which applies to the uncertainty in the tourism business and includes the return that compensates investors for their entrepreneurial efforts. The models assume a discount rate of 8 per cent in real terms.

For comparison, Olympic Forum (1994) used a nominal rate of 12.75 per cent in its feasibility study. Given the trend inflation of about 5 per cent a year in the past decade, the real rate of return would be 7.75 per cent. The hypothetical investment featured in the investment survey of Macquarie Bank's *Perspectives on Tourism Investment* used an internal rate of return of 15.8 per cent yielding a real rate of 10.8 per cent. Finally, the Commonwealth Department of Finance (1991) recommends using a 8 per cent real discount rate in planning for public work projects. Government-backed investments would probably be considered safer investments than hotels. These comparisons suggest that an 8 per cent discount rate is reasonable but could be low. Other things being equal, a 'low' discount rate leads to more hotel rooms being built than a 'high' discount rate.

An investment rule

A full description of how investment — and room rates and occupancy rates — are determined will be given when the modelling results are discussed in detail below. Nevertheless, some comments about a general investment rule are warranted here. Investment depends on the expected profitability of the planned hotel. Its yearly profits may vary from year to year. But over its lifetime, the new hotels are expected to earn at least the normal rate of return on capital invested including the income to compensate investors for their entrepreneurial efforts.

Under the assumption of certainty, when future demand and cost conditions are known, the model ensures a normal rate of return on the investment in a new hotel. By comparing the model's predicted levels of investment with those actually observed one obtains an indication of the extent to which investors, as typified in the model, knew future demand and cost conditions.

Of more practical relevance is the scenario of uncertain future demand and cost conditions. In this scenario, a normal return on investing in a new hotel is exactly achieved only by chance, for example, if all predictions are correct. But as demand and cost conditions would likely evolve differently from expected, the actual rate of return may well differ from the normal rate of return. The actual rate of return will be higher than the normal rate of return if, for instance, demand grows more strongly than expected and, in hindsight, not enough hotel rooms are provided. In contrast, the actual rate of return will be less than the normal rate if demand grows more slowly than expected and, in hindsight, too many hotel rooms are built.

The models assume that all investors use the same discount rate. This abstracts from the fact that individual investors have different costs of capital depending on the source of finance, loan interest rates, differing structures of equity and debt, and other relevant financial factors. Foreign investors also face risks from exchange rate fluctuations. The models are neutral between whether the hotel owner operates the hotel or leases it to an operator when, in fact, the terms of lease may give the lessee a different set of incentives from those an owner/operator might have. They are also neutral between whether the investor chooses to sell or own the hotel upon its completion. In reality, the investor's decision may be based more on the expectation of finding a willing buyer than on the intention to own and operate or to own and lease the hotel for a profit. The adequacy of these neutrality assumptions is taken up later.

3.3 Pricing constraints

In this study, room rates are assumed to be determined in part by the factors of demand and supply as outlined above. In reality, room rates are also determined by factors such as the influence of wholesalers, marketing strategies and other pricing practices. These factors are difficult to incorporate in the model but are not likely to be the significant determinants of the rate of growth of rooms available. To summarise these factors, two constraints are applied to the model's ability to make large changes in room rates within a year and between years.

In short-run sensitivity simulations without the pricing constraints, the projected room rates fell more rapidly in response to the observed large increases in hotel capacity than the actual market room rates did.[7] The inclusion of the two

[7] The ability to simulate short run market characteristics is important because inaccuracy may lead to a systematic over estimating or under estimating of hotel revenues and hence profits. If the systematic bias continues in the long run, when the number of

pricing constraints in the model helps capture that price ‘stickiness’ and improves the model’s ability to simulate actual room rates, occupancy rates and room yields during the large increases in the number of rooms available observed in Sydney from 1989 to 1993. (See Appendix C for a summary of the short-run sensitivity simulation using the observed number of rooms available from 1987 to 1994.)

The first constraint reflects the fact that uncertainty makes it difficult for hotel operators to know market clearing room rates. Hotel operators, like other business operators, will be careful to limit price increases and decreases when they do not know general demand conditions. If they set their room rates too high compared to their competitors they lose business. If they set them too low compared to their competitors they will keep business but could have had the same, or nearly the same, amount of business at a higher room rate. Also, long term contracts, such as those with tour group wholesalers, would slow the speed at which hotel operators could adjust room rates to current market conditions. Therefore, room rates may adjust only partially after large changes in the number of rooms available. Complete adjustment will take a number of years.

To reflect these considerations, room rates are constrained in the model so that the maximum reduction in room rates from one year to the next (for example, January 1987 to January 1988) is 11.9 per cent. 11.9 per cent was the largest recorded reduction in room rates when comparing the same months in adjacent years from 1987 to 1994.

The second pricing constraint reflects the fact that hotel operators may not be able to raise or lower room rates in precise response to unexpected deviations from typical seasonal patterns. Instead they are likely to set room rates in their pricing schemes that reflect the anticipated seasonal pattern around an average yearly room rate. This limits the deviation of the monthly room rates from the yearly average room rate. The model limits the upward deviation to no more than 10 per cent above the yearly average and the downward deviation to 13 per cent below the yearly average. These were the largest observed price deviations from the respective yearly averages from 1987 to 1994. For comparison, the bounds are twice as large as the average monthly deviation from the yearly room rates as given in Figure 2.

The pricing constraints are left in the long run models, when the number of rooms available is chosen and not fixed. The results confirm that the pricing constraints bind only when large unanticipated changes in cost and demand conditions occur.

rooms available is chosen and not fixed, then the model may systematically project too many or, respectively, too few hotel rooms.

4 Explaining supply and demand

This section presents results of models that attempt to simulate the number of rooms available from 1987 to 1994. Box 1 summarises the basic demand and supply factors used in the two models.

4.1 Investment in Sydney 4 and 5 star hotels under certainty

The certainty model assumes all relevant cost and demand information is available up to the year 2000. The monthly demand functions from 1987 to 1994 are inferred, given an assumed elasticity of demand, from the observed monthly takings per room occupied and number of rooms occupied. The operating cost and construction cost functions change over time according to their respective trends since 1987 (see Figure 4 for operating costs and the compositional change discussion and Figure 5 for construction costs). Demand and cost functions after 1994 are forecast from past demand and cost functions.

Hotel investment, occupancy rates, etc are determined in the model by maximising the net present value of present and future consumer surplus less the net present value of present and future operating and construction costs when all demand and cost functions are known (see Appendix A for a mathematical formulation). This coincides with the outcome of an idealised competitive hotel market under certainty. The net present value is determined by using the interest (cum discount) rate used by the investor; which reflects supply and demand conditions for investment funds. The discount rate of the investor rather than a social discount rate is used in order to obtain the levels of hotel investment, occupancy rates, etc of a competitive hotel market.

Box 1 Summary of market characteristics

The following sketches the important supply and demand assumptions that underlie the models.

Demand factors:

Price elasticity of demand is 0.5 in core simulations.

Yearly growth in demand

> varies by year from 1987 to 1994 but on average it is 7.1 per cent a year given the demand elasticity of 0.5;
>
> is approximately 7 per cent a year from 1995 to 1997; and
>
> is 4 per cent thereafter.

Monthly demand patterns vary from year to year but are approximately those in Figure 3.

Supply factors

The aggregate marginal operating cost is related to the occupancy rate. It reflects the changing composition of the 4 and 5 star hotel sector and any input price or wage-driven cost changes. The resulting average operating cost per room occupied will be approximately that in HAP (1995). By assumption, no gains in technical efficiency are achieved.

The marginal cost of construction increases with each new hotel room so that the marginal cost of building 1174 hotel rooms, the average number of rooms built from 1987 to 1994, is 223 000 dollars in 1994.

The following is a 'rule of thumb' approximation to the actual investment rule given 1994 construction costs. It need not hold in every year but should hold as a rough average over the service life of the hotel. In the rule, the average yearly room rates must cover two costs, the average operating cost per room occupied and the average yearly 'rental' of the new hotel. The 'rental' is calculated as a monthly payment as if the cost of the hotel were 100 per cent financed at the assumed 8 per cent real discount rate over the 25 year life of the hotel.

'Rule of thumb'

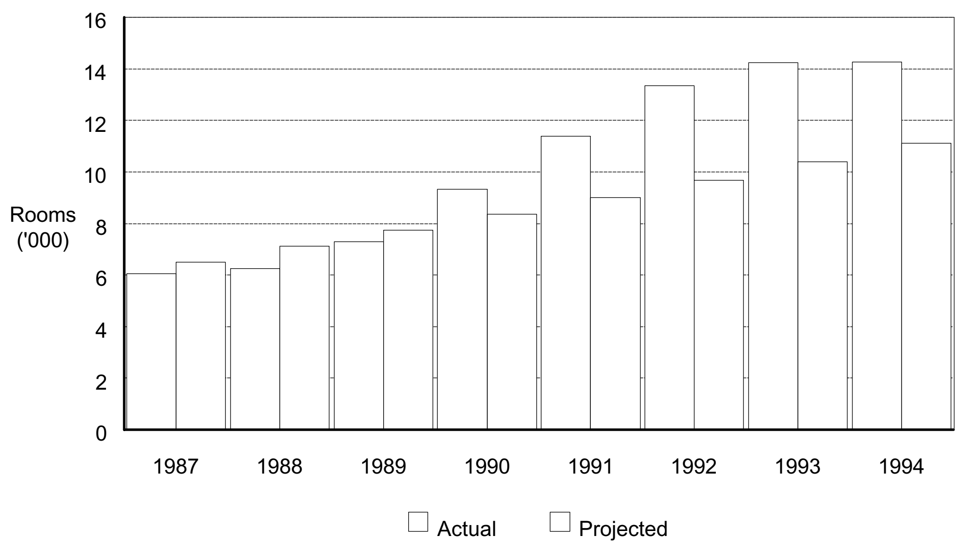
> ave. yearly room rate = (capital rental per room per day / ave. yearly occupancy rate) + ave. cost per room occupied; implying that
>
> ave. yearly room rate = ($53 / ave. yearly occupancy rate) + $109.

At 80 per cent occupancy the average year room rate would be $175. As a point of comparison, Darryl Courtney-O'Connor, Managing Director Touraust Corporation Pty Ltd cited a break even room rate for new 4 and 5 star hotels of 160 to 200 dollars per room at 80 per cent occupancy (Courtney-O'Connor, 1995).

Actual and projected number of rooms available

For the period 1987 to 1989, the model projects numbers of rooms available that are close to, but greater than, the actual number of rooms available (see Figure 6). Explanations for the difference could be that the Bicentenary and Expo brought in more hotel guests in 1988 than were expected when actual investment decisions were taken or that actual construction and operating costs were higher than the model estimates. For the period 1990 to 1993, the actual number of rooms available grew much faster than the model's projected number of rooms available.

Figure 6 Actual and projected rooms available, 1987 to 1994



Source: Actual data, ABS Cat. No. 8635.3.

The difference between the actual and projected number of rooms available also explains, in part, the differences between actual and projected takings per room occupied, occupancy rates and room yield, although price 'stickiness' will also have an impact (see Figure 7).

The greatest difference between actual takings per room occupied and projected takings per room occupied occurred in 1988 when the excess of the projected number of rooms available over the actual number of rooms available was greatest (see Figure 7, Panel A and Figure 6). After 1988, actual takings per room occupied fell slowly toward the projected takings per room occupied as hotel operators slowly adjusted room rates after the large increases in the number of rooms available.

Projected occupancy rates were greater than actual occupancy rates after 1988 (see Figure 7, Panel b) because the actual number of rooms occupied was less than the projected number of rooms occupied and, after 1989, because the actual number of rooms available was more than the projected number of rooms available. The higher actual takings per occupied room, when compared to projected, allowed the actual room yield to remain above the projected room yield until 1990 despite the lower occupancy rates (see Figure 7, Panel c).

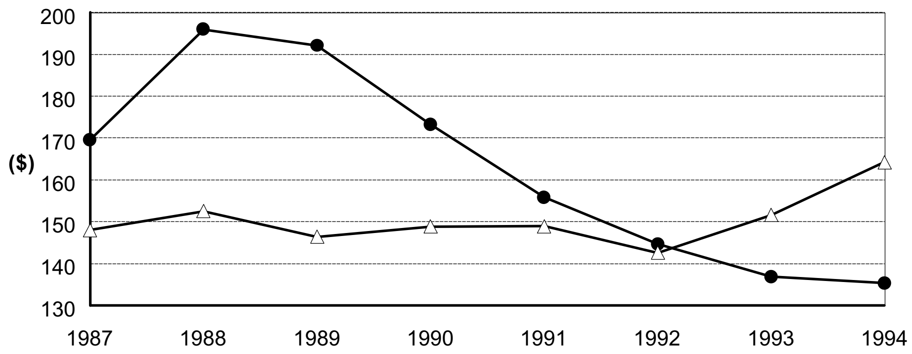
Changes in the projected variables also reflected changes in the underlying demand and cost functions through the simulation period. For example, projected occupancy rates varied over time in response to the pattern of monthly demand in the period. They fell at first because monthly demand patterns had more seasonal variation after 1988. They rose after 1991 in part because the monthly demand patterns had less seasonal variation.

Increased projected takings per room occupied, occupancy rates and room yields in 1994 also reflect how the construction costs of future hotels affect present takings per room occupied, occupancy rates and room yield. The investment rule dictates that the net present value of profits for new hotels must equal their marginal cost of construction. The projected hotels opening in 1994 cost more to build than hotels that are projected to open in 1995 (as indicated in the downward trend of construction costs after 1994 in Figure 5). Consequently the net present value of the profits of a hotel that opens in 1994 will be limited by the lower profits that accrue to the lower cost hotel opening in 1995. By extension, hotel profits in 1994 must be higher so that the hotel opening in 1994 earns normal profits. This occurs through higher room rates, occupancy rates and room yields.

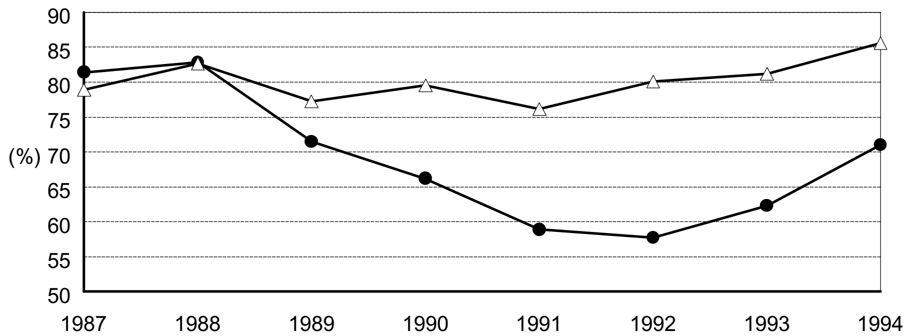
An alternative kind of spike in room rates and occupancy rates can occur when demand increases in one year but falls in subsequent years as might be expected for a special event. The model does not build expensive hotel capacity for one year of high demand. Instead it rations the number of rooms available through higher room rates. In a similar vein, Olympic Forum (1994) believes the Olympic Games will induce comparatively small increase in demand. It suggests that the peak visitation to Sydney would not last much longer than the two to three week duration of the event and would displace the usual clientele that visits Sydney over the same period.

Figure 7 Actual and certainty projected takings per room occupied, occupancy rates and room yields, 1987 to 1994[a]

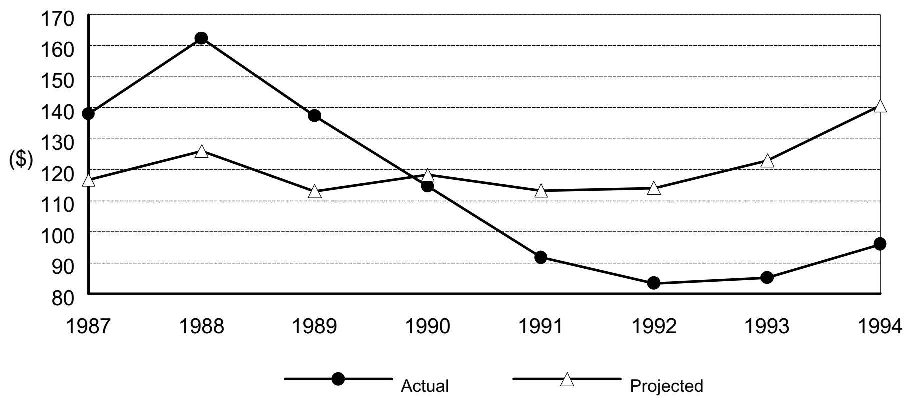
A: Takings per room occupied



B: Occupancy rate



C: Room yield per room available



a Takings per occupied room and room yields are expressed in constant 1994 dollars.

Sensitivity of projected number of rooms available to construction and demand assumptions

The robustness of the certainty model's ability to simulate the actual number of rooms available is tested by altering two assumptions in the model, those pertaining to the elasticity of demand and to the cost of building new hotels. As there is inadequate empirical support for these estimates used in the model it is particularly important to test how changes in these assumptions affect the model's ability to simulate the observed number of rooms available.

The elasticity of demand can be reduced by half to 0.25, making demand less responsive to changes in the room rate. That is, a 10 per cent increase in room rates decreases the number of rooms occupied by 2.5 per cent. Making demand less responsive to changes in the room rate also increases the estimated growth in demand from 1987 to 1994 because the observed reductions in the room rate will lead to smaller increases in the number of rooms occupied. Consequently, demand grows faster to cover the observed increases in the number of rooms occupied for the observed reductions in room rates.[8]

Instead of assuming an increasing marginal cost function of new hotels, the unit cost of building a hotel (excluding land) is assumed to be 220 000 dollars per room no matter how many hotels are built.

Comparing models with identical construction cost assumptions, the models where demand is less responsive to room rate changes tend to have a lower estimated projection error than those where demand is more responsive to room rate changes (see Table 3). This is because the smaller demand elasticity leads to an estimated faster rate of growth in demand from 1987 to 1994 and to more hotels being built to accommodate the faster growing demand. The demand growth effect is less for models with increasing marginal cost of construction, because the marginal cost of construction increases with the number of rooms built. Nevertheless, whatever the demand elasticity assumption, the errors of the models are larger from 1990 to 1994 than from 1987 to 1989.

[8] Although a model with a lower demand elasticity increases the rate of demand growth, it is less able to simulate the observed short-run changes in takings per room, rooms occupied and room yield in the sensitivity tests described above. This is because a lower demand elasticity leads to steeper falls in projected room rates when supply expands faster than demand (as happened in the Sydney 4 and 5 star sector). To correct for this, room rates would have to be even 'stickier' than what is imposed by the pricing constraints above.

Table 3 Estimated projection errors by cost and demand assumption [a]

Year	*Increasing marginal cost of construction and elasticity of demand 0.5*	*Increasing marginal cost of construction and elasticity of demand 0.25*	*Constant marginal cost of construction and elasticity of demand 0.5*	*Constant marginal cost of construction and elasticity of demand 0.25*
	(%)	*(%)*	*(%)*	*(%)*
1987	-8	-8	2	2
1988	-14	-15	-6	-5
1989	-6	-8	10	9
1990	10	8	21	18
1991	21	19	30	24
1992	27	25	38	32
1993	27	24	36	28
1994	22	18	26	19
Ave. error[b]	**10**	**8**	**20**	**16**
Ave. absolute error[b]	**17**	**15**	**21**	**17**

a A negative error implies that the model's projected number of rooms available exceeded the actual number of rooms available.

b Average error is the sum of the yearly errors divided by the number of years. Average absolute error is the sum of the absolute values of the yearly errors divided by the number of years. Stated results may not follow from stated year values due to rounding error.

Comparing projection errors of models with the same elasticity of demand assumption, no construction cost assumption does uniformly better in simulating the actual number of rooms available. Models using the assumption of constant marginal cost do better in 1987 and 1988. Models using the assumption of increasing marginal cost of construction do better from 1989 to 1994, but the error remains quite large after 1991 even though the marginal cost of construction is up to 40 per cent less (see Table 4).

These models depict a broad range of demand and construction cost assumptions. They emphasise the importance of cost and demand conditions in determining the number of rooms available. However they do not offer a complete explanation for the actual number of rooms available from 1987 to 1994 and are systematically wrong in their projections. They simulate the actual number of rooms available from 1987 to 1989 better than they simulate the actual number of rooms available from 1990 to 1994.

Table 4 Estimated marginal cost of hotel construction by cost and demand assumption

Year	*Increasing marginal cost of construction and elasticity of demand 0.5*	*Increasing marginal cost of construction and elasticity of demand 0.25*	*Constant marginal cost of construction and elasticity of demand 0.5*	*Constant marginal cost of construction and elasticity of demand 0.25*
	($ per room)	*($ per room)*	*($ per room)*	*($ per room)*
1987	110 000	115 000	221 000	221 000
1988	113 000	120 000	218 000	218 000
1989	116 000	126 000	225 000	225 000
1990	121 000	133 000	225 000	225 000
1991	125 000	141 000	225 000	225 000
1992	129 000	149 000	227 000	227 000
1993	136 000	159 000	225 000	225 000
1994	138 000	163 000	220 000	220 000

4.2 Investment in Sydney 4 and 5 star hotels under uncertainty

One interpretation of the certainty model is not that hotel operators and investors know future market conditions but that they forecast them well. Thus if simulated outcomes in the certainty model diverge significantly from actual outcomes and the model's other assumptions are plausible then market forecasts are probably not accurate and uncertainty is an important part of the market. In this section, uncertainty and a particular forecasting mechanism are introduced. Hotel operators and investors assess the profitability of a new hotel using forecasts of future market conditions that are based on the current and historical demand and cost conditions at the time of the hotel's construction.

Investors in hotels encounter two major difficulties in predicting future demand and cost conditions. The first is identifying the key factors that influence demand and costs. The second is predicting future demand and cost conditions from those key factors. Both difficulties magnify the uncertainty in investment decisions.

In this study, forecasts of future demand and cost conditions are based on demand and cost conditions in the five most recent years at the time of investment. The forecast method is a weighted average of conditions of the past five years with greater weights placed on the most recent years. These forecasts are 'reasonable' in that if there are underlying demand and cost trends then the forecast will predict those trends on average. The five year average also reduces the influence of one-off demand and cost shocks.

Admittedly, this forecasting method assumes that other information can not improve the forecasts. However, it does use local, market-specific information about demand that is likely to be among the best information available to investors. In addition, future cost trends appear quite predictable as the trends of operating and construction costs were quite stable in real terms (see Figure 4 and Figure 5).

In the model, hotel construction is assumed to commence 2 years before the hotel opens so that the forecasts are for demand and cost conditions 2 years later and beyond. This highlights the information gap in the planning process.

The recursive programming methodology

Like the certainty model, the uncertainty model finds competitive levels of investment, room rates and occupancy rates through a maximisation problem. However it does so based on projected future demand and cost conditions. Consequently, the model runs recursively; each year it repeats the maximisation problem but with updated demand and cost forecasts and with an initial stock of hotel rooms that was determined in the previous year. The recursive program is analogous to investors who reassess the investment climate every year before taking investment decisions.

Construction begins in 1985 for hotels opening in 1987. 1987 is the first year that the model determines the number of rooms available by adding to the number of rooms available in 1986. Demand and cost functions for 1987 and beyond are projected based on present and historical cost and demand functions in 1985. Then, based on these projections, the model finds the expected competitive levels of investment, room rates and occupancy rates for 1987 and beyond given the number of hotel rooms that will be available in 1986. This determines the number of new hotel rooms in 1987. Finally, projected room rates and occupancy rates in 1987 — as opposed to those that are expected — are determined by the actual demand and cost functions for 1987 and the total number of hotel rooms available (the initial stock in 1986 plus the new hotel rooms in 1987). The projected room rates and occupancy rates will differ from the expected occupancy rates and room rates for 1987 if expected demand and cost functions for 1987 differ from the actual demand and cost functions for 1987.

For 1988 the same procedure is repeated with demand and cost functions for 1988 and beyond being projected from present and historical demand and cost functions in 1986 when hotel construction begins for hotels opening in 1988. The assumed capacity in 1987 will be that in 1986 plus the rooms added in the procedure for 1987.

Scenarios for recursive programming models

Demand, operating costs and construction costs are major determinants of hotel investment in the model. Four scenarios are constructed in which future changes in demand, operating costs and construction costs are forecast from their past histories. The demand forecast scenario assumes that only future demand functions are unknown. The operating cost forecast scenario assumes that only future operating cost functions are unknown. The construction cost forecast scenario assumes that only future construction cost functions are unknown. The all forecast scenario assumes that future demand, operating cost and construction cost functions are all unknown.

The operating cost and construction cost scenarios perform better only from 1987 to 1989 when the actual number of rooms available are less than the projected number of rooms available (see Table 5). As a consequence, their average errors exceed that of the certainty model. This suggests two possibilities: Uncertainty about operating and construction is not an important component in improving the model's performance, or the forecasting mechanism is not an adequate approximation of the way investors actually forecast future demand and cost conditions.

In contrast, the demand forecast scenario does improve on the certainty model. Its errors in most years, average error and average absolute error are smaller than those of the certainty model. In addition, it appears to be the dominant influence in the all forecast scenario because the errors of the all forecast scenario overall and from year to year do not differ markedly from those of demand forecast scenario. However, the reduction in the error is small relative to the total error; the errors of the demand forecast model are still large from 1991 to 1994.

Table 5 Errors of projected from actual number of rooms available, 1987 to 1994 (per cent) [a]

		Forecast variable under uncertainty			
Year	*Certainty*	*Demand*	*Operating costs*	*Construction costs*	*All*
	(%)	*(%)*	*(%)*	*(%)*	*(%)*
1987	-8	-5	-6	-7	-5
1988	-14	-12	-11	-13	-11
1989	-6	-7	-4	-5	-7
1990	10	4	11	11	3
1991	21	18	22	22	18
1992	27	24	28	28	24
1993	27	26	28	27	26
1994	22	22	23	22	22
Ave. error[b]	**10**	**9**	**11**	**11**	**9**
Ave. absolute error[b]	**17**	**15**	**17**	**17**	**15**

a A negative number indicates that the projected number of rooms available exceed the actual number of rooms available.

b Average error is the sum of the yearly errors divided by the number of years. Average absolute error is the sum of the absolute values of the yearly errors divided by the number of years. Stated results may not follow from stated year values due to rounding error.

Sensitivity of forecast results to demand elasticity assumptions

In the previous analysis, the price elasticity of demand was assumed to be inelastic (0.5). In this section, the price elasticity of demand is assumed to be elastic (1.25). Thus demand is made more responsive to changes in the room rate — a 10 per cent increase in the room rate reduces the number of rooms occupied by 12.5 per cent.

The results from the certainty model and the four scenarios under uncertainty when demand is price elastic reinforce many of the conclusions drawn from the simulations when demand is price inelastic. The errors of operating and construction cost scenarios do not differ markedly from those of the certainty model (see Table 6). The errors of the all forecast scenario are again most like those of demand forecast scenario. The demand forecast scenario significantly improves on the certainty model overall and especially from 1991 to 1994. However, in contrast to the earlier results, the demand forecast scenario errors in the early years are greater than those of the certainty model.

Table 6 Errors of projected number of rooms available, 1987 to 1994, when demand is more responsive to room rates (per cent)[a,b]

		Forecast variable under uncertainty			
Year	*Certainty*	*Demand*	*Operating costs*	*Construction costs*	*All*
	(%)	*(%)*	*(%)*	*(%)*	*(%)*
1987	-7	-6	-5	-8	-4
1988	-13	-14	-11	-14	-11
1989	-4	-13	-5	-6	-13
1990	13	-12	12	11	-13
1991	24	2	24	23	2
1992	32	12	31	30	12
1993	32	16	32	31	16
1994	29	14	29	28	15
Ave. error[c]	**13**	**0**	**14**	**12**	**1**
Ave. absolute error[c]	**19**	**11**	**19**	**19**	**11**

a Price elasticity of demand is increased to 1.25.
b A negative number indicates that the projected number of rooms available exceed the actual number of rooms available.
c Average error is the sum of the yearly errors divided by the number of years. Average absolute error is the sum of the absolute values of the yearly errors divided by the number of years. Stated results may not follow from stated year values due to rounding error.

Comparing model results for the two demand elasticity assumptions, the certainty model when demand is elastic performs significantly worse in simulating the actual number of rooms available than the certainty model when demand is inelastic (see Tables 5 and 6). This is because the falling room rates from 1988 to 1994 work through a larger price elasticity to capture more of the observed increase in the number of rooms occupied. Consequently, less is left as demand growth.

Demand forecast errors become more important when demand is elastic. Errors in the demand forecast scenario from 1991 to 1994 are less than half those in the certainty scenario from 1991 to 1994 when demand is elastic. In contrast, when demand is inelastic, the errors in the demand forecast scenario from 1991 to 1994 are only somewhat less than those in the certainty scenario from 1991 to 1994. In addition, the average error and the average absolute error when demand is elastic are, respectively, 9 and 4 percentage points less than those when demand is inelastic.

In summary, ignorance of future operating costs and construction costs does not appear to an important explanation for the number of rooms available from 1987 to 1994. Ignorance of future demand — or, more accurately, extrapolating future demand growth from past demand growth — may partly explain the number of rooms available from 1987 to 1994. However it is a significant improvement on the certainty model only if demand is responsive to room rate changes.

4.3 Capital gains expectations and other investment aspects

In the model, a hotel's value is assessed according to its expected future operating profits. An existing hotel's value is the discounted value of its expected future profits. New hotel rooms will be built if the discounted present value of expected future operating profits is greater than the construction cost of the rooms. The valuation method embodies three assumptions:

- that investors are alike and use the same discount rate;
- that investors are indifferent between different financing arrangements; and
- that investors are indifferent between whether they sell the hotel upon completion, own and operate it, or own and lease it.

This section considers the appropriateness of these assumptions in light of evidence that suggests hotel construction in Sydney could also be driven by the general business climate in Australia and the real estate property boom in Sydney.

Hay and Morris (1991) and Mills, Morling and Tease (MMT) (1994, 1995) suggest that factors other than the expected future operating income can influence investment decisions. These include the relative profitability of other investment opportunities, the investment's position in a portfolio of investment, the terms of finance, the investor's over all level of debt and equity, and the business cycle.

MMT emphasise the role financial factors, such as asset prices, the level of debt and cash flows, play in investment decisions. For example, the wider corporate sector relies on both internal and external sources of funds to finance investment activity but internal and external sources of funds may differ in their costs and availability (MMT (1994)).[9] In addition, they argue that cash flows are the dominant source of funding for most companies and indirectly reduce the cost

[9] Externally sourced funds are generally more costly than internally sourced cash flows. There are direct costs — administrative costs and underwriting and legal fees — which raise the price of external funding. In addition, if creditors cannot perfectly distinguish between low risk and high risk investors then they will tend to charge an interest rate more for an average risk investor. Thus low risk investors pay more and high risk investors pay less than they would respectively pay in a perfectly informed market.

of external funds (MMT (1994)). Thus, the increasing cash flows in the mid and late 1980s raised significantly the means to fund investment regardless of the funding source.[10,11]

MMT observe that debt became a more important source of finance overall and suggest that the increased indebtedness was a result of the liberalisation of financial markets (which increased the availability of external funds) and higher cash flows and rising equity prices which increased the perceived collateral of most companies (and lowered the cost of external funds) (MMT (1994)). They argue that the changing financial position of the wider business sector occurred when incentives for general business investment were high — output grew reflecting a strong international recovery and share prices rose reflecting the financial market's confidence in future profitability. Consequently, fixed expenditure in non dwelling construction grew rapidly from 1984 to 1989 (see Figure 8).

The period of increased investment in the economy generally was also seen in the accommodation and restaurant sector nationally and in tourist accommodation in Sydney (see Figure 8). Expenditure in Accommodation, cafes and restaurants Australia wide and Hotel commencements in Sydney mirror the large increase by all private enterprises in Non dwelling construction investment expenditure in the mid and late 1980s.

The similar expenditure patterns suggest that the general business climate may have played a role in spurring hotel investment. Changes in the general economic climate that were particularly relevant to hotel investment in Sydney at the time include:

- changes in the cost and availability of funds in Australia and abroad; and
- substantial increases in commercial property prices up to 1989.

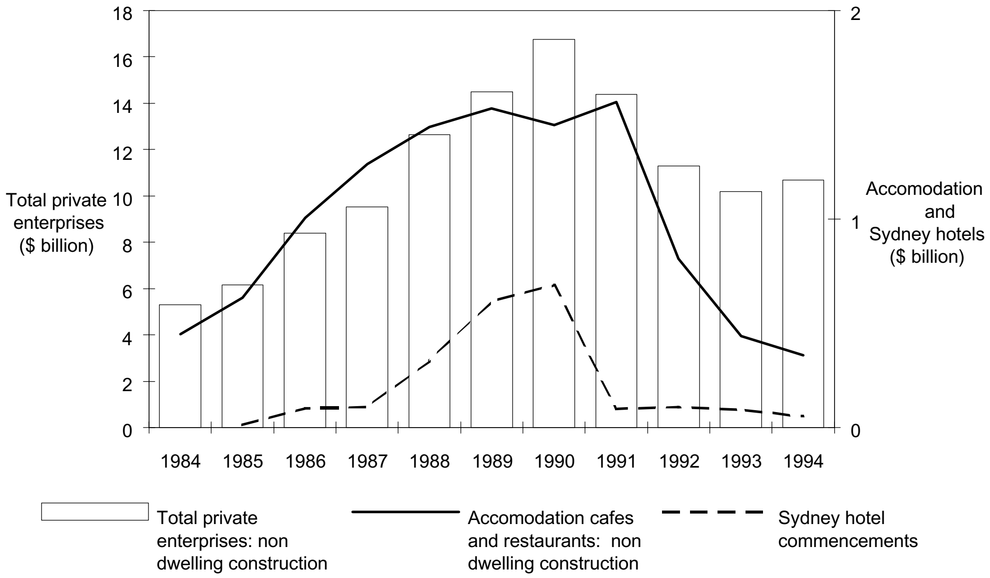
Financial deregulation in Australia and abroad lowered the cost and increased the availability of funds for hotel developments, and finance was readily available in Australia as the major banks and finance companies competed vigorously for increased market share. Similarly, the Tourism Task Force argue that Japanese investors sought foreign investment opportunities in response to falling Japanese interest rates, a strengthening yen, relaxed underwriting

[10] Mills, Morling and Tease (1994) analyse the financial position and investments of a group of 80 large non-financial companies in the All Ordinaries Index. The developments in this subset are used to illustrate developments in the economy more generally at the time.

[11] Higher cash flows indirectly reduce the cost of external finance by increasing the collateral that can be used to back external finance and, consequently, by reducing the information asymmetry risk that external lenders face.

standards for Japan banks, a lack of real estate opportunities in Japan and increased ease in moving Japanese funds offshore (Tourism Task Force (1992)). In addition, it became easier for foreign investors to invest in the Australian tourist sector. Foreign investment restrictions in Australia were relaxed somewhat in July 1986 — the net economic benefits test and the Australian equity requirements for takeovers and new businesses in tourism were suspended (Industry Commission (1995)).

Figure 8 Real gross fixed capital expenditure by industry, Australia 1984 to 1994[a, b]



a Real gross fixed capital expenditure is expressed in constant 1995 dollars. The left hand axis refers to real gross fixed capital expenditure (non dwelling construction) by all private enterprises. The right hand axis refers to real gross fixed capital expenditure (non dwelling construction) in accommodation, cafes and restaurants and Sydney hotel commencements.

Source: ABS Cat. No. 5221.0, ABS Cat. No. 8752.0 and unpublished data.

Hotel investors may have also been influenced by developments in the property market. The Tourism Council Australia (sub 57) and the Department of Tourism (sub 89) argued in their respective submissions that expectations of capital gains were significant drivers of hotel investment in the 1980s. The Department of Tourism argued:

> In the late 1980s a number of highly geared investors developed expensive inner city hotels and new resorts principally as property or real estate investments, with

> operational income perceived as a secondary objective or even having no significance in the decision-making process. (sub 89, p. 23)

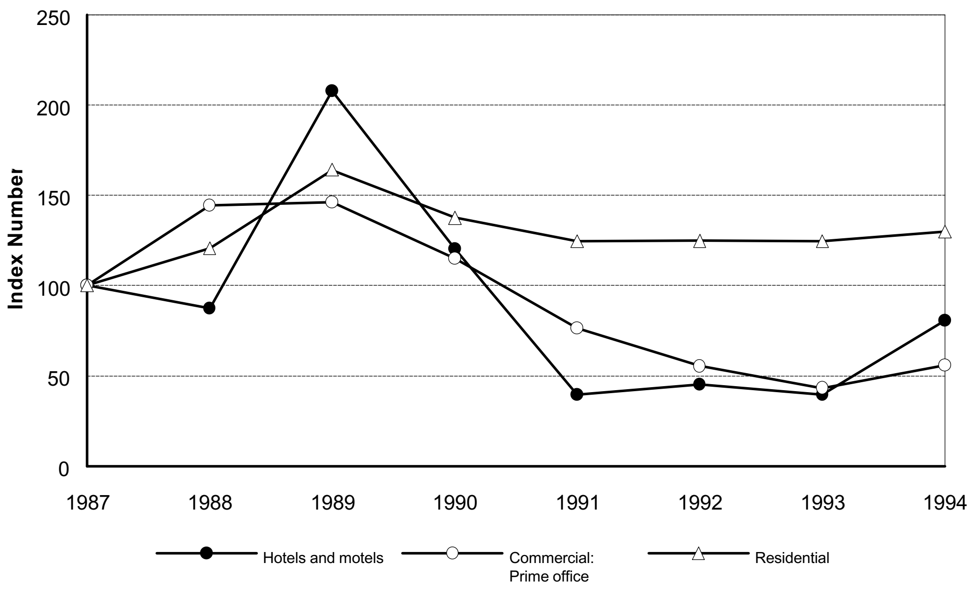
In Sydney, the magnitude of the changes in residential, commercial and hotel and motel prices varies dramatically between 1987 and 1994 (see Figure 9). However, the general patterns in property prices are similar. For example, real commercial and residential property prices increased by around 50 per cent from 1987 to 1989. In the same period, the real sale price of hotels and motels (expressed in terms of dollars per room) doubled. Caution must be used in interpreting the magnitude of changes in the sale price of hotels and motels because there are fewer sales relative to the total market size and a wide range of establishments included.

The property boom in 1988 and 1989 may have created an environment of extreme optimism amongst investors concerning future property values. In particular, new hotel construction may have occurred in anticipation of future high sale prices and some capital gain, even if any calculated expected future profits from operating hotels were small.

In order to examine whether asset valuation could have affected hotel investments, the model is modified to allow for expected capital gains at the end of the planning horizon. The anticipated capital gains from hotel investment are formulated as a proportion of the cost of construction and subtracted from the cost of construction as an increase in the salvage value of the hotel. The proportion follows a real price index of commercial property compiled by the Reserve Bank of Australia. Thus investors adjust the planning cost of investment according to the latest change in property prices, as observed when hotel construction begins — two years before the hotel opens. This procedure leads to effective reductions in the cost of investment planned between 1989 and 1992 by about 21 per cent, 35 per cent, 44 per cent and 29 per cent respectively.

The capital gains scenario is built into the all forecast scenario in which demand, operating costs and construction costs are forecast. A demand sensitivity comparison is done, one with a price elasticity of demand of 0.5, the other with a price elasticity of demand of 1.25.

Figure 9 Real property prices, Sydney 1987 to 1994[a]



a The hotels and motels property price index is based on the average sale price per room for hotels and motels sold in the calender year. The commercial property price index is based on the average midpoint dollar rate per square metre of prime office space over the calender year. The residential property price index is based on the median nominal house price over the financial year.
Real hotel and motel property and commercial propertyprices are expressed in constant dollars using the implicit capital expenditure (non dwelling construction) price deflator from ABS National Accounts. Residential property prices are expressed in constant dollars using the implicit private final consumption price deflator from ABS National Accounts.

Sources: ABS Cat. No. 5206 various issues, Colliers Jardine (1995), REIA 'Market Facts' and Olympic Forum (1994) p.112.

The addition of capital gains expectations to the all forecast scenario improves the ability of the model to simulate the actual number of rooms available after 1991 (see Table 7). When demand is unresponsive to changes in the room rate, there is still a large error between the model's projected number of rooms available and the actual number of rooms available. However, when demand is responsive to changes in the room rate, the resulting error is small and, in contrast to other simulations, is smaller after 1990 than before 1990.

Table 7 Difference between actual and projected values wit h and without capital gains (per cent) [a]

	Price elasticity assumption			
	Price elasticity 0.5		*Price elasticity 1.25*	
Year	*All forecast*[b]	*Capital gains*[c]	*All forecast*[b]	*Capital gains*[c]
	(%)	*(%)*	*(%)*	*(%)*
1987	-5	-5	-4	-4
1988	-11	-11	-11	-11
1989	-7	-8	-13	-15
1990	3	1	-13	-20
1991	18	14	2	-6
1992	24	21	12	5
1993	26	23	16	9
1994	22	20	15	8
Ave. error[d]	**9**	**7**	**1**	**-4**
Ave. absolute error[d]	**15**	**13**	**11**	**10**

a A negative number indicates that the projected number of rooms available exceed the actual number of rooms available.
b All forecast is that demand, operating costs and construction costs are forecast.
c Capital gains is All forecast plus capital gains expectations from 1987 to 1991.
d Average error is the sum of the yearly errors divided by the number of years. Average absolute error is the sum of the absolute values of the yearly errors divided by the number of years. Stated results may not follow from stated year values due to rounding error.

For a given demand elasticity, the errors between the all forecast scenario and the capital gains scenario do not differ in 1987 and 1988 because capital gains expectations affect hotel openings only after 1988. The capital gains scenario has larger errors in 1989 and 1990 than the all forecast scenario for unresponsive demand and larger errors from 1989 to 1991 than the all forecast scenario for responsive demand. The anticipation of capital gains increases construction. Therefore the capital gains effect in 1991, when demand is elastic, is sufficient to change a positive error in the all forecast scenario into a negative error in the capital gains scenario. The average absolute error is smaller when capital gains expectations are introduced into the model.

These results and the sensitivity results from the uncertainty scenarios all emphasise the importance of the price elasticity of demand in determining whether forecast errors, especially demand forecast errors, and the anticipation of capital gains can contribute to an explanation for the number of rooms available from 1989 to 1994. The larger the price elasticity of demand, the better can models utilising the anticipation of capital gains and demand forecast errors simulate the number of rooms available from 1989 to 1994.

5 Summary

This study has examined what economic factors contributed to investment in new 4 and 5 star hotels in Sydney from 1987 to 1994 — and especially from 1989 to 1994 when the supply of 4 and 5 star hotel rooms doubled and occupancy rates and room rates fell. It finds that three factors may have been significant contributors: First, forecasts of demand growth based on historic demand growth were higher than the demand growth that actually occurred. Second, the lag between hotel construction and hotel opening precluded an immediate market correction to the mistaken demand forecasts. Third, the general investment climate was overly optimistic as seen in the rapid appreciation of real estate values in Sydney and the strong Australia-wide investment in new fixed capital.

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Appendix A Mathematical representation of the model

There are two ways of solving a dynamic peak load problem which is based on a spatial inter-temporal equilibrium framework as described in Takayama and Judge (1971). The first one treats it as a profit maximisation problem for a generic firm in a competitive market. The other involves maximising an objective function which is the area beneath the market demand curve less the sum of short-run and long-run costs, subject to the market clearing conditions. Takayama and Judge (1971) have shown that these two models would result in the same competitive equilibrium solution. Chao (1982) also demonstrates that under some general conditions the numerical solution of an inter-temporal competitive equilibrium model would be virtually identical to that of welfare optimisation model. In the light of these findings, the model is specified as a welfare optimisation problem for the hotel industry:

Maximise NSW

$$= \sum_{t=1}^{T}\sum_{m=1}^{12}\left(\frac{1}{1+\ }\right)^{t} d_m\left[\frac{\ _{t,m}}{1+\ }\cdot\left(Y_{t,m}^{1+\ }\ -1\right)\right]$$

$$-\sum_{t=1}^{T}\sum_{m=1}^{12}\sum_{o=1}^{7}\left(\frac{1}{1+\ }\right)^{t} d_m\left[O_o\cdot RO_{t,m,o}\cdot OC_{t,o}\right]$$

$$-\sum_{t=1}^{T}\left(\frac{1}{1+\ }\right)^{t}\left[\sum_{j=1}^{T+1-t}\frac{crf}{(1+\ )^{j}}\cdot I_t\cdot IC_t\right].$$

Subject to

$$Y_{t,m} = \sum_{o=1}^{7} O_o\cdot RO_{t,m,o};$$

$$\sum_{o=1}^{7} RO_{t,m,o} \le K_0 + \sum_{i=1}^{t} I_i;$$

$$\ _{t+1,m}\cdot Y_{t+1,m}\ \ \ge \frac{1}{1.135}\cdot\ \ _{t,m}\cdot Y_{t,m}\ \ ;$$

$$\ _{t,m}\cdot Y_{t,m}\ \ \ge 0.884\cdot\frac{1}{12}\cdot\sum_{m=1}^{12}\ \ _{t,m}\cdot Y_{t,m}\ \ ;$$

$$\ _{t,m}\cdot Y_{t,m}\ \ \le 1.098\cdot\frac{1}{12}\cdot\sum_{m=1}^{12}\ \ _{t,m}\cdot Y_{t,m}\ \ ;$$

where

NSW = present value sum of the consumer surplus less operating and construction costs;

T = number of years in the planning horizon

= discount rate;

$_{t,m}$ = constant term of a Cobb Douglas average daily demand function for month m in year t;

= reciprocal of the price elasticity;

$Y_{t,m}$ = average daily demand of rooms occupied in month m of year i;

d_m = number of days in month m;

O_o = end point of the oth segment of the occupancy rate, values 0.4, 0.5, ..., 0.9, 0.93;

$RO_{t,m,o}$ = average daily supply of rooms served in month m of year i in association with occupancy rate o ;

$OC_{t,o}$ = average operating cost per room night in year t at occupancy rate O_o ;

crf = capital recovery factor;

IC_t = average investment cost per new room;

I_t = number of new rooms completed in year t;

K_0 = initial stock of rooms.

Demand

The first term in the objective function measures the discounted present value sum of consumer surplus from consumption of hotel accommodation over the T-year planning period. It is based on a Cobb Douglas demand function given in its inverse form:

$$P_{t,m} = \;_{t,m} \cdot Y_{t,m}^{\;-} \qquad \text{(A.1)}$$

The price elasticity of demand and therefore its reciprocal β are assumed to be fixed. Its value is chosen on the basis of other empirical studies. Given β, the parameter $\alpha_{t,m}$ is computed using the corresponding data on takings per room occupied and the number of rooms occupied as $_{t,m} = P_{t,m} / Y_{t,m}^{\;-}$. Consequently, $\alpha_{t,m}$ varies over time with the observed takings per room occupied and number of rooms occupied. It reflects the seasonal pattern of demand as well as the combined effect of all factors affecting growth in demand except the room rate. The demand equation does not spell out the individual effects of respective factors. To accommodate a β-value greater than 1 when demand is inelastic, the area under the market demand curve up to a demand of $Y_{t,m}$ is approximated as:

$$\int_1^{Y_{t,m}} \left(\;_{t,m} \times y_{t,m}^{-} \right) dy_{t,m} = \frac{\;_{t,m}}{1-} \times \left(Y_{t,m}^{1-} - 1 \right) \qquad \text{(A.2)}$$

Operating costs

The second term in the objective function measures the discounted value of the total operating costs. The model incorporates a short-run marginal operating cost function using a relationship between average hotel operating costs and the occupancy rate. Using empirical data on hotel operating costs and occupancy, a regression analysis suggests that the marginal operating cost of servicing rooms rises with the occupancy rate. The average operating cost of servicing rooms is given by:

$$OC_{t,m} = {}_1 \cdot c_t \cdot k_t + 0.5 \cdot {}_2 \cdot k_t \cdot V_{t,m} \qquad \text{(A.3)}$$

where

γ_1 and γ_2 are parameters;

k_t is a real price index of costs over time; For

$V_{t,m}$ is the occupancy rate; and

c_t is a cost index reflecting the composition of the 4 and 5 star sector.

example, the average operating cost of servicing rooms in 1987 would have index values of 1, reflecting the base year. Equation (A.3) would then be

$$OC_{1987,\,m} = 77.34 + 0.415 \cdot V_{1987,\,m} \qquad \text{(A.4)}$$

The operating cost function is approximated in a piece wise linear fashion with the model allocating the total number of rooms available amongst any of the possible occupancy rates. This is done to speed up the solution algorithm although it does inject a small imprecision to the model solution.

Investment and Investment costs

New investment augments the hotel capacity at the beginning of a year. The model assumes no demolition nor natural depreciation of the existing hotel stock. This does not affect the general results because the aggregate supply in the relevant market sector did not fall from 1987 to 1994.

The last term in the objective function represents the cost of investment. It is estimated in two steps. The construction cost for new rooms is first derived. Then the construction costs are adjusted for its ‘salvage value’ — the value of the hotel at the end of the planning horizon. The first adjustment is the value of the land underneath the hotel at the end of the planning horizon. This value is then discounted back to the time of hotel construction. For simplicity, the following assumes that the current price of the land is the best estimate of the discounted future value of the land.

The second adjustment is for the service years of the hotel that remain at the end of the planning horizon. For example, a hotel built in the last year of the planning horizon still has 24 years of service remaining. The construction costs are scaled down so that the hotel recovers only that portion of the construction costs that apply in the years from hotel opening to the end of the planning horizon. This is done through a 'capital recovery factor' *crf*.

The *crf* is the fraction of construction costs that when paid in a series of annual payments from hotel opening to the end of the hotel's service life would have a present value equal to the lump sum cost of investment. It depends on the discount rate and the service life of the hotel. Thus if the discount rate, δ, is 0.08 and the hotel has a service life, *L*, of 25 years, the capital recovery factor *crf* is:

$$crf = \frac{}{1-\frac{1}{(1+\ )^{L}}} = \frac{.08}{1-\frac{1}{(1.08)^{25}}} = 0.094 \qquad \text{(A.5)}$$

Finally, the salvage value is subtracted from the cost of construction leaving only those annual payments that apply from the time the hotel opens to the end of the planning horizon. Thus, the fraction of the construction costs that apply to the cost of construction made in year t with a T year planning horizon is the left hand side of equation (A.6), and, for example, that apply to the cost of construction in year 3 of a 14 year planning horizon is the right hand side of equation (A.6).

$$\sum_{j=1}^{T+1-t} \frac{crf}{(1+\ )^{j}} = \sum_{j=1}^{12} \frac{crf}{(1.08)^{j}} \qquad \text{(A.6)}$$

In modelling the construction cost of hotel investment, the marginal cost of construction increases linearly with the level of hotel construction undertaken in the year. Since the marginal cost is assumed to be linear, the average cost function will be linear too:

$$IC_t = \ \cdot h_t \cdot I_t \qquad \text{(A.6)}$$

where

is a parameter;

h_t is a price factor based on a real price index of construction materials in Sydney;

I_t is the level of investment in year t.

Accordingly the total cost of investment is equal to $IC_t \cdot I_t$.

There is no reliable information to infer the value of the parameter . Neither are there sufficient time series data for the Sydney market to estimate it econometrically. A crude method is thus used, which equates the marginal cost in the base year to an estimate of the development cost per room as assessed by the Olympic Forum.

Market clearing condition

The first constraint equation in the model is the market clearing condition. It equates the number of rooms occupied to the number of rooms served, which is expressed as the sum of the rooms available at different occupancy rates weighted by their respective occupancy rates.

The second constraint, a weak inequality, states that the industry cannot serve more rooms than it has rooms available. The number of rooms available is the sum of its capacity from the pre-planning level K_0 and the new rooms built in the intervening years. The model assumes no disinvestment. Therefore, $I_t \geq 0$ for all t.

Since data confirm that the market as a whole never attains full occupancy throughout a month, a ceiling is thus set for the occupancy rate at 93 per cent, which is the highest monthly occupancy rate ever recorded during the study period. As a result, the last segment of O_o has an upper end point at 0.93 and the effective supply of room nights is only 93 per cent of the total capacity

Pricing constraints

Three pricing constraints are applied in the model to account for the observed deviation of hotel operators from a practice of marginal cost pricing. These constraints would take effect when there are large unexpected changes in the number of rooms available or in demand.

Partial adjustment of the market room rate

The third constraint in the model describes a partial adjustment mechanism of the market room rate. It stipulates that the maximum rate of decline in the room rate over the previous year is 12 per cent.

Seasonal variation of the market room rate

The fourth and fifth constraints govern the deviation of the room rate in any month from the yearly average. They set an upper and a lower bound respectively within which the room rate can adjust to the changing condition of demand between seasons. The lower bound of 12 per cent and the upper bound of 10 per cent from the yearly average are set on the basis of historical observations.

Models with certainty and uncertainty

The certainty and uncertainty models differ in three respects. First, the planning horizon for the certainty model is 14 years, while the planning horizon for the uncertainty model is 8 years. Second, the certainty model uses the 'actual' demand and cost functions in its maximisation problem, while the uncertainty model uses projections of demand and cost functions based on past and present demand and cost functions. Third, the certainty model solves its maximisation problem in 'one-shot' while the uncertainty model must solve a sequence of 8 recursive maximisation problems.

Under the certainty assumption, the model employs a planning horizon of 14 years from 1987 to 2000. It replicates a 'one-shot' investment planning process in which all relevant cost and demand functions are known. Proxy data are generated for the years after 1994 by taking a weighted average of the growth rates in the five most recent years. Thus, for an unknown data point of x in year t, its growth rate from the previous year is defined as:

$$\hat{\dot{x}}_t = \cdot \dot{x}_{t-1} + {}^{2} \cdot \dot{x}_{t-2} + {}^{3} \cdot \dot{x}_{t-3} + {}^{4} \cdot \dot{x}_{t-4} + {}^{5} \cdot \dot{x}_{t-5} \qquad \text{(A.7)}$$

where

is 0.51 so that the powered coefficients sum to unity.

This process puts more weight on growth rates in more recent years. If there is an underlying trend in growth rates then this forecast will be correct on average. For example, the parameter $\alpha_{t,m}$ for the years after 1994 is calculated using the proxy data on $P_{t,m}$ and $Y_{t,m}$. The projected annual growth rate figures for $Y_{t,m}$ were taken from the Olympic Forum. The proxy growth rate on $P_{t,m}$ is derived by extrapolating from the annual growth rates of price in earlier years. The resulting proxy growth rates of price and quantity are then applied to their levels in 1994 respectively. As a consequence, the proxy data series of $\alpha_{t,m}$ would exhibit the same seasonal pattern as in 1994. Other proxy data on costs are prepared similarly.

Under uncertainty, the planning consists of a recursive sequence of maximisation problems in which the future values of parameters are projected from past information. The resulting investment decision will prove to be sub-optimal afterwards if planning parameters are not accurate. The projected costs and demand are updated in each iteration to reflect the availability of new information as time proceeds and the investment decisions taken in the previous year. The planned investment for the first year of the planning period adds to the capacity and makes up the initial capital stock prior to the subsequent iteration.

The model forecasts future demand and cost conditions from past demand and cost conditions based on the two year construction lag. This reflects the information gap that planning data must be projected using information available when hotel construction commences. Forecasting from past and present conditions is favoured in the model mainly for its computational ease, although it implicitly assumes that other data cannot improve the forecast. (But the capital stock in the year before the hotel opens is known because the newly invested rooms would be under construction.) The annual growth rate for an unknown data point of x in year t is forecast as:

$$\hat{\dot{x}}_i = \mu \cdot \hat{\dot{x}}_{i-1} + \mu^2 \cdot \hat{\dot{x}}_{i-2} + \mu^3 \cdot \dot{x}_{i-3} + \mu^4 \cdot \dot{x}_{i-4} + \mu^5 \cdot \dot{x}_{i-5} \qquad \text{(A.8)}$$

Naturally, hotel investors can not perform these calculations for distant time periods as the forecasts would become increasingly unreliable. However they may believe that the hotel will earn a normal rate of return in the years beyond the planning horizon. The model thus adopts a planning horizon of only eight years and assumes that the hotel earns a normal rate of return in years beyond the planning horizon. The choice of an eight year horizon allows the planning of investment in 1993 and 1994 to encompass the Olympic Games to be held in 2000.

Computation of market equilibrium

The objective function and various constraint equations as described above formulate an inter-temporal optimisation model of investment and output. The model structure is non linear; the number of variables and parameters is large. This non linear optimisation problem is solved numerically by the reduced gradient routine GAMS/MINOS5 as documented in Brooke, Kendrick and Meeraus (1992).

Appendix B Estimation of the operating cost function

The operating cost function is estimated in three steps. First, the supply relationship between rooms occupied and takings per room occupied is statistically estimated from the relationship identified in an error correction model for rooms occupied, rooms available and takings per room occupied. Second, two operating cost functions are fitted to the average expenditure per room occupied for 4 star hotels and for 5 star hotels in HAP (1995) using this supply relationship. Third, the two operating cost functions are aggregated given the composition of 4 and 5 star hotels in each year.

Estimating an operating cost function from seasonal variations in rooms occupied and takings per room occupied assumes that seasonal price differences, on average, reflect the incremental costs of hotel operation. It also has the advantage that the seasonal patterns of rooms occupied and takings per room occupied in the model will be largely consistent with observed seasonal patterns of rooms occupied and takings per room occupied. Useful units for the coefficient estimates are obtained by setting the units of the indexes to the average real takings per occupied room and rooms occupied of the 1987 to 1994 ABS data base of Sydney 4 and 5 star hotels. The high R-square shows that 96.6 per cent of the seasonal variation in takings per room occupied can be accounted for by the variation in the number of rooms occupied. The small but statistically significant coefficient on rooms occupied suggests that takings per room occupied increases with the number of rooms occupied (see Table B1).

Table B1 Average seasonal relationship between takings per room occupied and the number of rooms occupied

Regression Statistics			
R-Square	0.966		
		Coefficient	*Standard Error*
Estimate			
Intercept		109.40[a]	2.35
Number of rooms occupied		0.0053[a]	0.0003

a Average monthly indexes of takings per room occupied were regressed on the average monthly indexes of rooms occupied, after centring the indexes on the average takings per room and rooms occupied observed from 1987 to 1994. The estimates are statistically different from zero at 95 per cent.

Source: Based on data from ABS Cat. No. 8635.3.

The regression estimates are used to compute marginal operating cost functions for 4 and 5 star hotels in two steps. First, the coefficient on the number of rooms occupied is converted into a coefficient on the occupancy rate by multiplying the coefficient by the average number of rooms available recorded in the ABS data for Sydney 4 and 5 star hotels, 1987 to 1994. Second, the intercept parameters for the average operating cost functions for 4 star and, respectively, 5 star hotels are calculated so that the estimated average cost per room occupied for the average number of room nights and rooms available for 4 star and, respectively, 5 star hotels in HAP (1995) data equals the average expenditure per occupied room for 4 star and, respectively, 5 star hotels in HAP (1995) data (see Table B2).

Table B2 Marginal operating cost function of 4 and 5 star hotel rooms for 1994

	Average operating cost per occupied room	*Aggregate supply as a function of the occupancy rate*	
	($1994)	*Intercept*	*Slope*
4 star	91.54	74.20	0.56
5 star	142.20	125.91	0.56
Average[a]	109.81	92.88	0.56

a Averages use composition of all 4 and 5star hotels and not those in Horwath Asia Pacific (1995).

Source: Based on Horwath Asia Pacific (1995) and regression estimates above.

The marginal operating cost function for the average 4 and 5 star hotel in the ABS data is then the weighted average of the marginal cost functions for 4 star and, respectively, 5 star hotels. The weights are given by their respective share in the number of rooms available in the ABS data. The estimated cost per room occupied for the average 4 and 5 star hotel is somewhat less than that in Horwath Asia Pacific (1995) because ABS data record a higher concentration of 4 star hotels than the Horwath data.

The composition of the 4 and 5 star sector changed considerably from 1987 to 1994. The large growth in hotel rooms was in 4 star hotels not 5 star hotels. Expenditures per room occupied for 4 star hotels are significantly lower than those for 5 star hotels (see Table B2). Consequently, the changing composition of the 4 and 5 star hotel sector toward 4 star hotels would reduce the marginal operating cost of the average 4 and 5 star hotel over time. The composition of 4 and 5 star hotels after 1994 is assumed to be that of 1994.

Appendix C Model validity and sensitivity analysis

The ability of the model to predict the short run characteristics of the market was tested by a simulation using the certainty model which fixed capacity in each year to that which was observed from 1987 to 1994. The pricing constraints also applied. The model captures the seasonal pattern of prices and occupancy rates and the turning points in the data. The correlation coefficients between the projected values and the actual values for room rates, occupancy rates and room yields are 0.86, 0.95 and 0.96, respectively.[12]

Projected occupancy rates overestimated actual occupancy rates by 4.8 percentage points on average. Projected room rates underestimated room rates by $15.41 on average. The two biases counteract one another when calculating the room yield; projected room yields underestimated actual room yields by $5.42 on average (see Figure C1). This bias, if it existed in the long run, would be equivalent to an increase in the cost of hotel construction of 23 000 dollars per room for a model which projected room yields exactly. This is around 10 per cent of the construction cost used to calibrate the marginal construction cost function in the model. As seen above, the basic modelling results are little affected by this magnitude of change in construction costs.

Despite the pricing constraints, the main source of bias between projected and actual values in all variables is the period from 1988 to 1991, when room rates fell more slowly than what the model projects. This suggests that rooms rates within a year may be linked through something in addition to marginal operating costs that is stronger than maximum and minimum bounds away from the yearly average. For example, a pricing constraint that imposed seasonal pricing patterns *ex ante* improves short-run predictions and leads to slightly larger growth rates in rooms available but does not significantly reduce the difference between projected and actual values from 1990 to 1994.

Alternatively, a larger price elasticity also predicts short-run changes better. As discussed earlier this increases the difference between projected and actual values from 1990 to 1994 in the certainty model but decreases the difference between projected and actual values when demand must be forecast or if there are expectations of capital gains.

[12] A value of 1 is a perfect match.

Figure C1 Actual and projected room yields, 1987 to 1994 (dollars per available room per day)