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A COMPARISON OF MODELS FOR CONSTRUCTION CYCLES

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Introduction

This paper follows on from the earlier paper in this session and seeks to compare the office market model already presented (MacFarlane, 1999) which follows very closely the office market models developed by Wheaton (1987), and an alternative model developed by the author and presented at the last PRRES Conference (MacFarlane, 1998). Differences in the models will be highlighted and the strengths and weaknesses of the two models identified.

Data for the Australian metropolitan office markets of Sydney and Melbourne (CBD plus suburban office markets pooled for each city) will be examined. This is in contrast to the earlier paper in which only the CBD office markets were considered but is a little more like Wheaton (1987) who considered the entire US office market as one entity. These markets were particularly selected to demonstrate some of the weaknesses of the models. The data, courtesy of BIS Shrapnel, is annual data from 1970 to 1997 including demand and supply of office stock, office workforce numbers and rental data.

Models of the Office Market

For comparison, it is necessary to present the two basic models under consideration. Since the Wheaton model has already been presented in the earlier paper, it is given here without discussion. The same notation is used for both models, viz.:

S(t)	stock of space at time t	
C(t)	construction commenced during period t	(Wheaton)
E(t)	office employment in period t	
R(t)	real rental rate for new space at time t	
OS(t)	occupied space at time t	
A(t)	net absorption of space during period t	
V(t)	vacancy rate at time t	
V*	structural (or equilibrium) vacancy rate	
CM(t)	construction completed during period t	(Author)
D(t)	space removed from the market during period t	

Wheaton Model:

$$A(t) = OS(t) - OS(t-1) \qquad \text{(A1)} \qquad \text{Demand}$$

$$OS(t) = S(t) * (1 - V(t)) \qquad \text{(A2)} \qquad \text{Vacancy}$$

$$S(t) = S(t-1) + C(t-a1) \qquad \text{(A3)} \qquad \text{Supply}$$

$$A(t) = a2 * F1[E(t), R(t), E(t)/E(t-1)] - a2 * OS(t-1) \qquad \text{(A4)}$$

$$C(t) = F2[R(t), V(t), S(t), E(t)/E(t-1)] \qquad \text{(A5)}$$

$$[R(t) - R(t-1)] / R(t-1) = F_3[V(t) - V^*] \qquad \text{(A6)}$$

and, as previously discussed, equation A6 allows rents to be expressed as a function of vacancy rates, allowing the elimination of rents (and replacement by vacancy rates where required) from equations A4 and A5. The first 3 equations, A1 to A3 are largely definitions of Absorption, Vacancy Rate and Net Supply, respectively, with the critical interplay of factors expressed in the final 3 equations (A4 to A6). The forms of the equations A4 and A5 (after elimination of rent, R(t)) are linear with some lagged variables included. The coefficients of this model are then estimated by linear regression as in the earlier paper. This is no simple matter as the use of lagged variables requires a considerable amount of experimentation to determine the most appropriate models.

A suitable set of initial data, together with estimates or projections of office employment, E(t), is then sufficient to implement the series of difference equations A1 to A5 to produce forecasts of office market conditions into the future.

The model developed by the author is similar to the above but differs in the final equations which specify the interaction of the factors. It is derived from work on construction cycles (Barras, 1983) and market equilibrium/disequilibrium (Hendershott, 1996) and is of the general multiplier-accelerator type (Samuelson, 1939; Kuznets, 1930), viz.:

$A(t)$	=	$OS(t) - OS(t-1)$	(B1)	Demand
$OS(t)$	=	$S(t) * (1 - V(t))$	(B2)	Vacancy
$S(t)$	=	$(1 - a3) * S(t-1) + CM(t)$	(B3)	Supply
$A(t)$	=	$OS(t-1) * [a3 + a4 * ((E(t)/E(t-1))-1)]$	(B4)	Absorption
$CM(t+a1)$	=	$[a5 + a6 * (V^* - V(t))] * S(t)$	(B5)	Construction

The main differences in this set of equations as opposed to the Wheaton model are:

- equation B3 includes an allowance for the removal of office stock from the market in each period. This may be due to redevelopment, refurbishment or obsolescence and may reappear in the market (as a larger or smaller amount of space) at a later date via construction (equations B3 and B5). This equation includes the completions in the current period rather than the commencements in a prior period as for Wheaton.

- equation B4 is simpler than in the Wheaton model and provides that net absorption is a function of current demand and employment growth. It does not include any lagged variables and considers absorption as a rate of increase rather than in absolute terms. It is non-linear.

- equation B5 is a construction adjustment equation which says that the rate of construction increases as the vacancy rate falls This construction will appear some a1 periods later as completions courtesy of equation 3. It is not necessary that construction actually start at this time but rather the consideration and planning of a project relates to factors current at this time. Equation B5 is non-linear.

- This creates just one lagged situation in the set of equations B1 to B5 which is simpler (but perhaps not as realistic) as the Wheaton equations which allow for a construction period and a further lag for the impact of changes in vacancy rates (and possibly other factors).

Data

The models were applied to the data for office markets in Sydney and Melbourne (1970 to 1997). Figures 1 to 3 provide an overview of the office markets with respect to absorption, net additions and vacancy rates respectively.

It is worth noting - as this is one possible cause of later difficulties with the models - that there were periods in the early 70s and again in the late 80s and early 90s when the new supply coming onto the market was in excess of 10% of current stock, the highest levels being a 12.2% increase in Sydney in 1990 and a 14.4% increase in Melbourne in 1991. These high levels of construction were maintained for a number of years. Such high levels of construction are clearly well out of step with general economic growth (at best 5-6%) and had a major impact on supply vacancy rates.

Results

This paper will not consider the fitting of the models in any detail. The methods to do so are covered in the references but is worthwhile mentioning again that the inclusion of lags into several of the equations means that the fitting is not straightforward and a process of judicious “trial and error” is required to find the “best” equation - with the judgement being largely made on the comparison of R^2 values and signs of the coefficients.

Wheaton Model

The results of fitting the Wheaton model (A) to the data are as follows:

Table 1: Regression Equations of Net Absorption (Equation A4)

Independent Variables	Dependent Variable (Net Absorption) Sydney	Melbourne
Intercept	-2174 (-3.14) [1]	-562.4 (-1.09)
E(t) employment	5.685 (2.05)	11.36 (3.68)
V(t-lag) vacancy	1348 (3.11)	-1071 (-4.41)
lag	2	4
OS(t-1) coeff a2	-.1978 (-2.05)	-.3090 (-3.60)
E(t-lag)/E(t-1-lag) employment growth	1689 (2.13)	173.9 (0.30)
lag	0	0
N obs	25	26
R2	.59	.66

[1] t Statistics in parentheses

Table 2: Regression Equations of Construction (Equation A5)

Independent Variables	Dependent Variable (Net New Supply) Sydney	Melbourne
Intercept	-970.7 (-1.32)	-3351 (-5.02)
V(t-lag) vacancy	-2306 (-4.93)	-2990 (-8.18)
lag	2	2
S(t-1)	.00364 (0.24)	.0372 (2.56)
E(t-lag)/E(t-1-lag) employment growth	1346 (1.89)	3532 (5.51)
lag	1	0
N obs	24	24
R2	.65	.81

[1] t Statistics in parentheses

The "best" estimate of the construction period is a1 = 2 years for both cities.

In general, the fits are better than in the earlier paper (MacFarlane, 1999) which may well reflect the fact that CBD office markets are closely interlinked with their suburban office counterparts and consideration of the CBD office market in isolation omits an important part of the picture.

The signs of the coefficients are as expected with the very important exception of the Vacancy Rate, V(t-lag), coefficient in the Net Absorption equation for Melbourne (Table 1). All other lags of the vacancy rate variable were considered and all had a significant negative coefficient contrary to expectation. As vacancy is largely a proxy for rent in equation A4, this reflects either a breakdown in the rent/vacancy relationship and/or a failure of rental adjustment in the marketplace to have the desired impact on the absorption of office space and/or a problem with the model specification for this location.

Fitting the author's model to the data yielded the following parameter estimates:

Table 3: Parameter estimates for Model B

Parameter	Sydney	Melbourne
Development Period, a1	4 years	4 years
Rate of Removal, a3	1.7%	1.0%
Base Absorption, a4	3.1%	3.6%
Employment related Absorption, a5	0.45	0.45
Equilibrium Construction Rate, a6	7.1%	7.1%
Development Multiplier, a7	0.48	0.70
Structural Vacancy Rate, V*	6.8%	9.7%

The values of the easily interpreted model parameters are much as expected and reasonably similar for Sydney and Melbourne. It is difficult to put meaningful t-statistics on the coefficient estimates for model B as most are estimated via non-linear equations. The main comparison of the models, however, is via their forecasts which are considered below.

The two models have been used to generate forecasts of the office markets from 1998 to 2010. Both models require estimates of employment levels over the period and the forecasts used (BIS Shrapnel) are given in Figure 4. These employment number forecasts are critical to both models and appear quite reasonable, closely following the trend of the last 25 years plus a slight bubble in employment to reflect the impact of the Olympics in Sydney.

Figures 5 to 10 give the forecasts arising from the two models. At first glance, the forecasts from the two models are somewhat disappointing lacking some of the features of the original data. On further thought, though, the results may not be too surprising. Both models are deterministic and present an expectation of the future. However, the office market - and both systems of equations - are such that shocks to the system have quite a profound impact in the short to medium term and this is missing from the "determined" outcomes. Certainly, though, the forecasts do have some expected characteristics such as the cycle of vacancy rates.

For Sydney, the forecasts from the Wheaton model A are lower for Net Absorption (Figure 5) and Net New Supply (Figure 6) but it is debatable which model better reflects the long term trend. Both models forecast vacancy rates which bottom in the Year 2000 (Figure 7), as most commentators expect, but those from the author's model (B) seem to be more consistent with the past in terms of the amplitude and period of the coming cycle.

For Melbourne, the forecasts for Net Absorption (Figure 8) are similar for the next two years but show differences from that point onward, although both remain consistently above the long term trend. For Net New Supply (Figure 9), the two models show a similar trend of increasing supply for the next 6 or so years although the author's model (B) increases more sharply and peaks some 3 years earlier. For Vacancy Rates (Figure 10), the form of the Wheaton model (A) seems preferable in amplitude and period and in its forecast of a trough in the vacancy cycle around the year 2002, but produces negative vacancy rates for a period of 4 years which is logically impossible (although it is possible to put a sensible interpretation to it) but not prevented by either of the two models in their specification or mathematical properties.

The following figures (11 and 12) of actual and (indirectly) forecast office workspace ratios reveal one area of possible improvement to the models. The figures show a steady increase in office space ratios in both Sydney and Melbourne from 1970 to 1993 with a plateauing in Sydney from 1994 to 1997 at slightly above 20 m^2 per person and a decline in Melbourne for 1994 to 1997 from 28 m^2 to 25 m^2. For Sydney (Figure 11), the Wheaton model (A) produces forecasts which continue the workspace ratio at slightly above 20 m^2 per person for 1998 to 2010 while the author's model (B) continues the long term trend to over 25 m^2 per person by 2010. For Melbourne (Figure 12), both models continue the long term trend, largely ignoring the 1994 to 1997 drop, with workspace ratios of nearly 30 m^2 per person forecast for 2010.

Most commentators would agree, that in the long term, workspace ratios will fall or, at best, remain at current levels. This factor has a substantial impact on the future absorption of office space and, consequentially, on supply and vacancy rates. To accommodate this, workspace ratios need to be incorporated into the above models but this is no easy matter as it is a direct function of Occupied Space, OS(t), and Employment, E(t), both of which are already included in the models.

Conclusion

The use of models to forecast future levels of supply and demand for office space is critical to the orderly planning of business districts and to the financial viability of office developments. The large costs involved in office developments and the substantial lag between the planning and commencement of construction of an office development (Supply) and its future occupancy (Demand) make for difficult, risky decisions.

The two models of the office market considered in this paper, produce some interesting results with neither model being preferable and both being worthy of further development. Areas of possible improvement include:

- the incorporation of workspace ratios directly into the models; and

- the possible use of simulation and the inclusion of stochastic elements into the models to produce a set of possible future outcomes rather than the purely deterministic ones produced in this paper. Non-predictable shocks, such as a dramatic change to economic conditions, have a profound impact on the supply and demand for office space. The models considered here are well able to reflect the consequences of these shocks on absorption, net supply and vacancy rates, etc. for office markets but currently lack suitable random impact components.

- the models specify a fixed (whole) number of periods from the commencement of planning or construction until the developed space becomes available for occupancy. This requirement could be eased with the completion of construction spread over a number of periods. However, this presents difficulties in estimating the relevant factors (average and spread of construction time) and would be simplified through the use of data on both the commencement and completion of space in each period (the currently available data comprises only completions).

It is an easy matter to vary the assumptions for future office employment from those given in this paper and to examine a variety of other possible future scenarios.

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Figure 1: Net Absorption in the Sydney and Melbourne Office Markets, 1971-1997

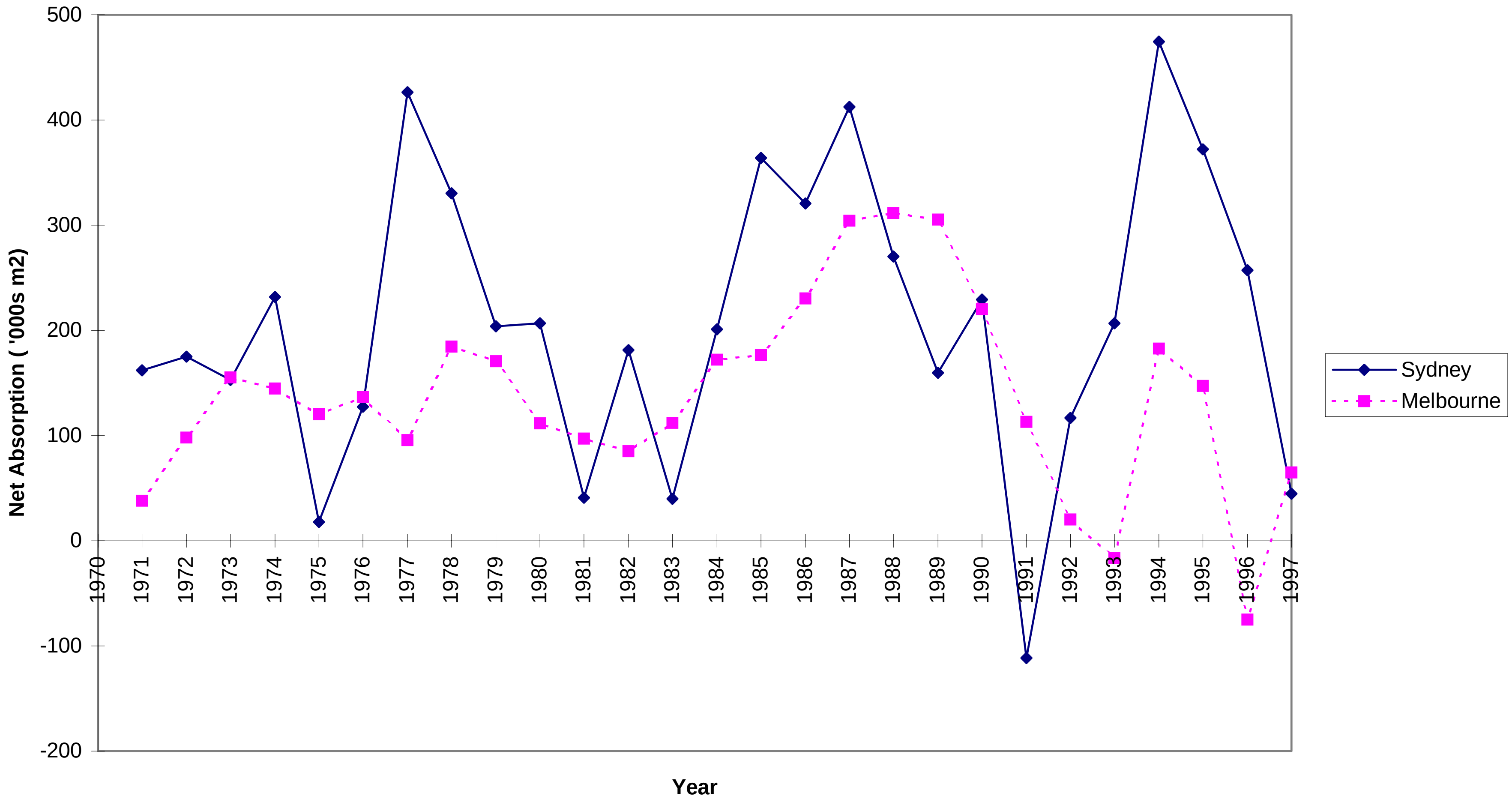

Figure 2: Net new Supply in the Sydney and Melbourne Office Markets, 1971-1997

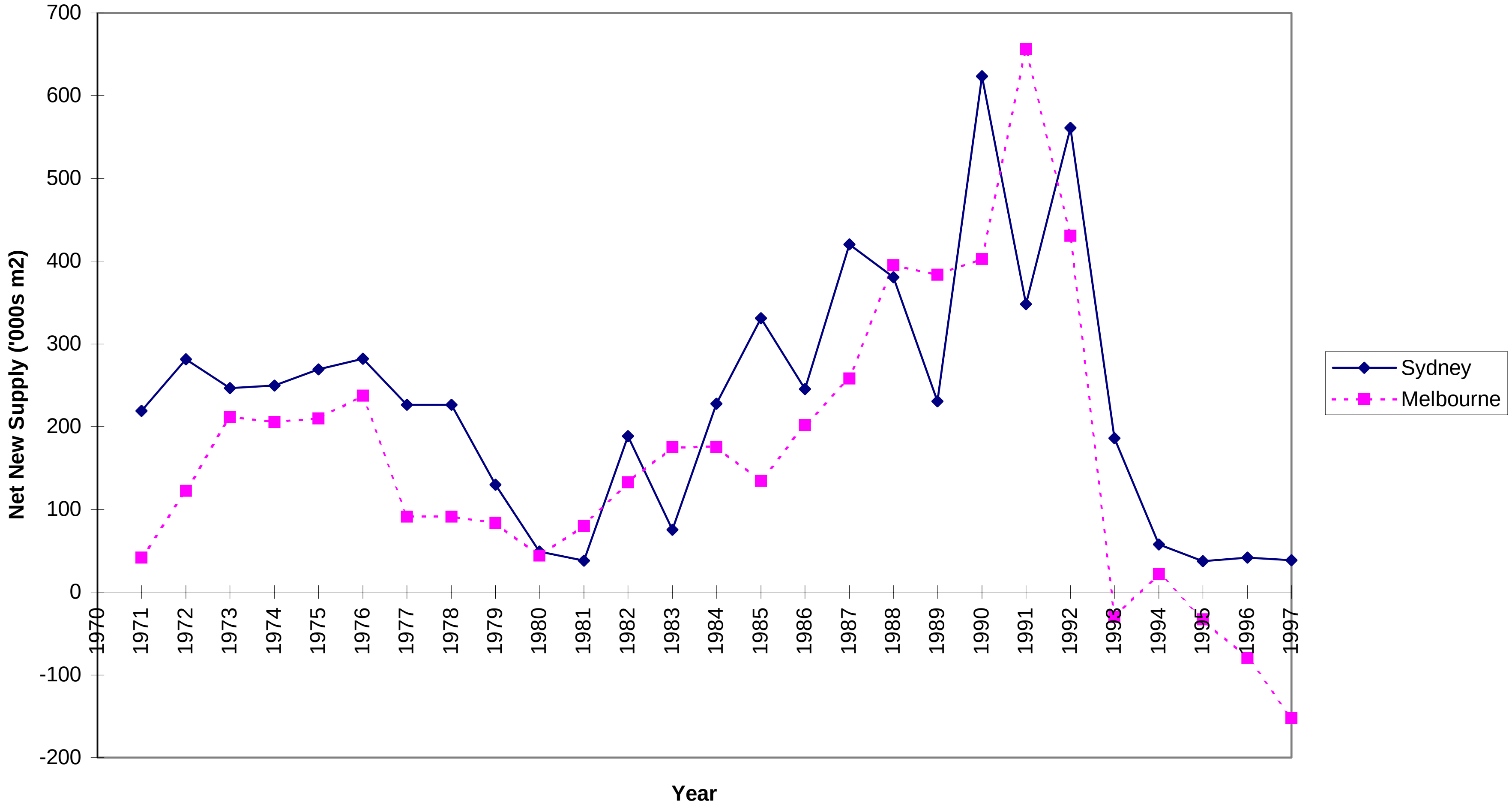

Figure 3: Vacancy Rates in the Sydney and Melbourne Office Markets, 1970-1997

Figure 4: Workforce Numbers in the Sydney and Melbourne Metropolitan Office Markets, 1971-1997 and Forecasts 1998 to 2010

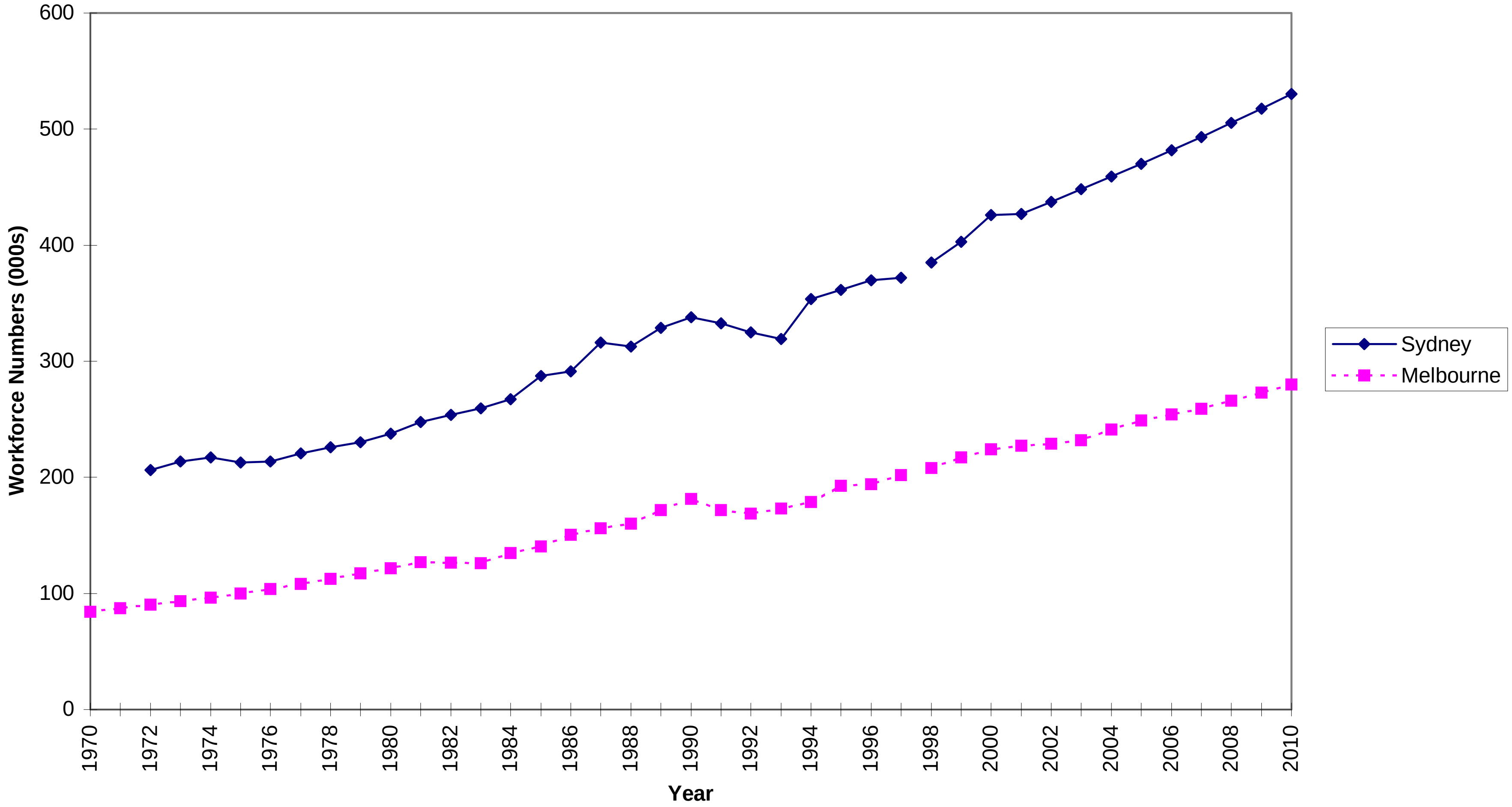

Figure 5: Net Absorption in the Sydney Metropolitan Office Market, 1971-1997 and Forecasts 1998-2010

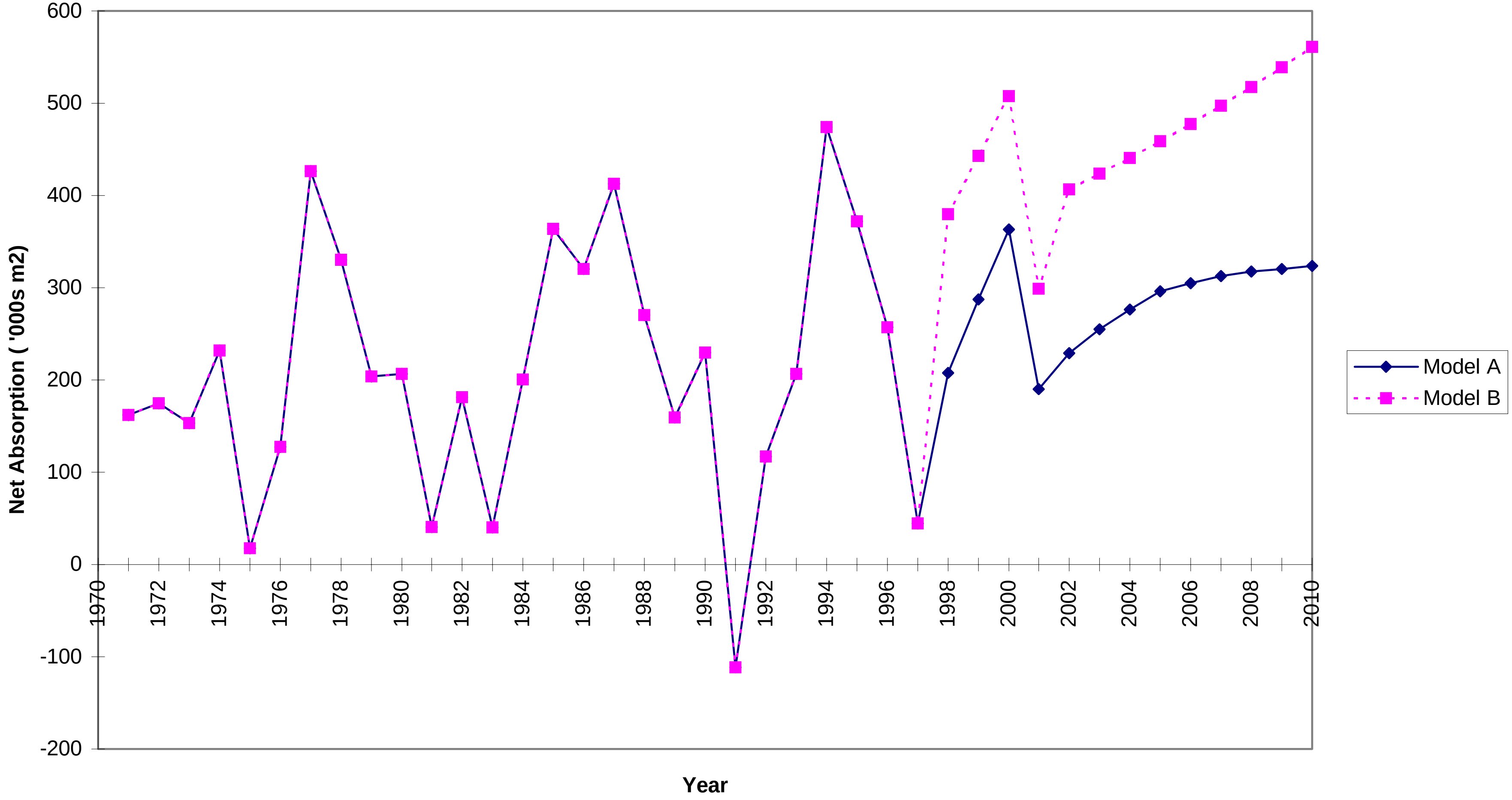

Figure 6: Net New Supply in the Sydney Office Market, 1971-1997 and Forecasts 1998-2010

Figure 7: Vacancy Rates in the Sydney Office Market, 1970-1997 and Forecasts 1998-2010

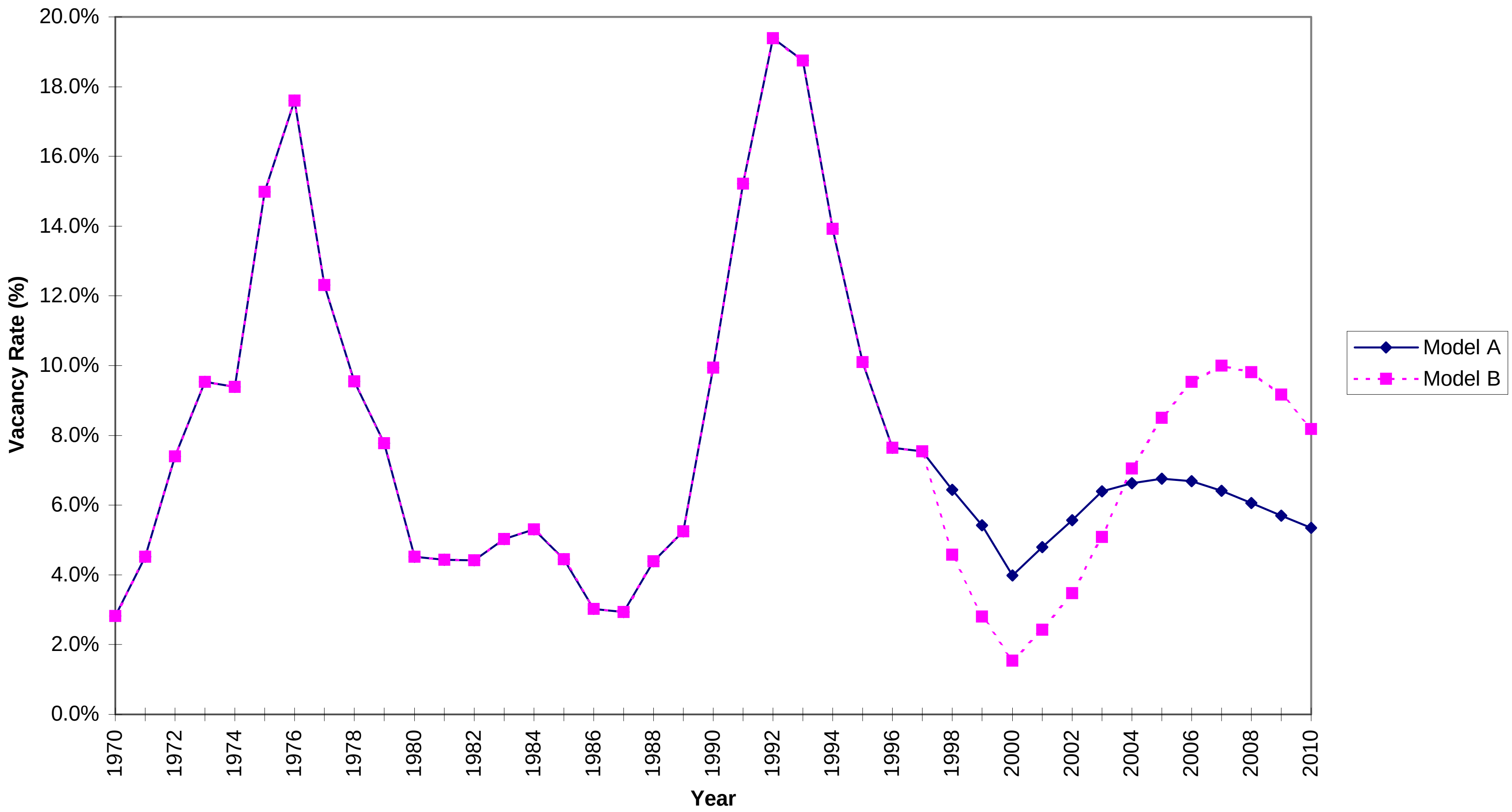

Figure 8: Net Absorption in the Melbourne Metropolitan Office Market, 1971-1997 and Forecasts 1998-2010

Figure 9: Net new Supply in the Melbourne Office Market, 1971-1997 and Forecasts 1998-2010

Figure 10: Vacancy Rates in the Melbourne Office Market, 1970-1997 and Forecasts 1998-2010

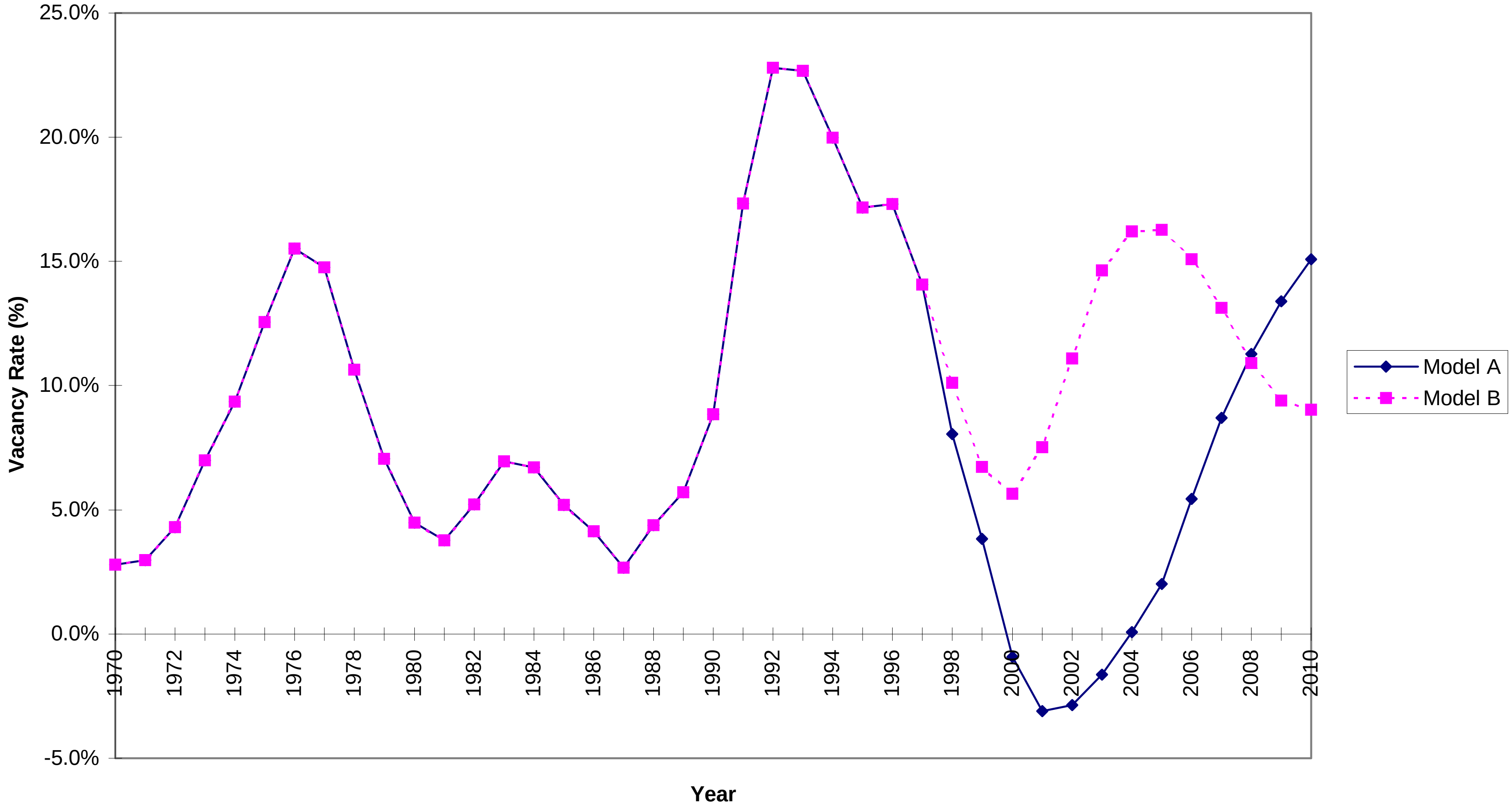

Figure 11: Workspace Ratios in the Sydney Metropolitan Office Market, 1971-1997 and Forecasts 1998 to 2010

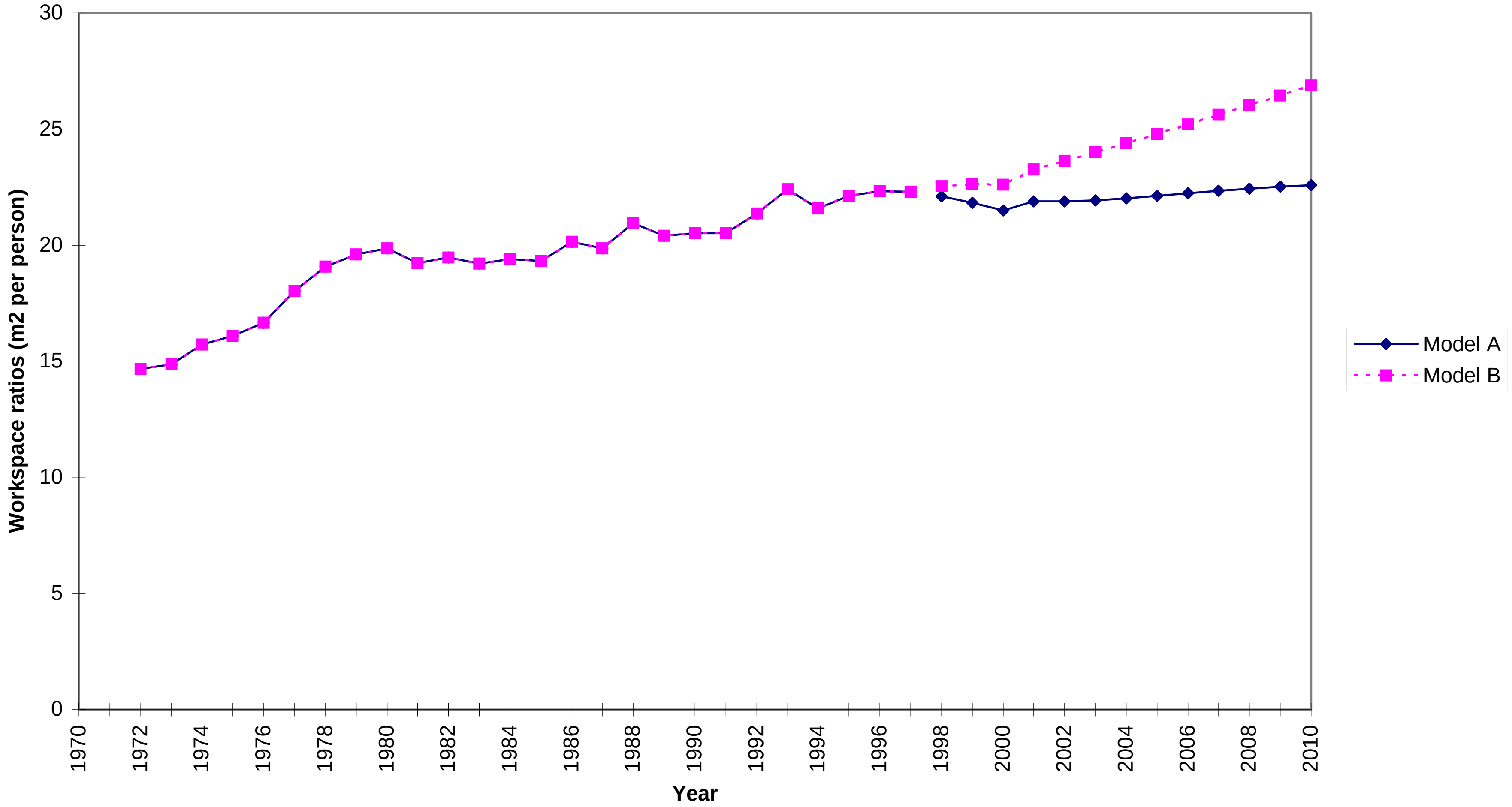

Figure 12: Workspace Ratios in the Melbourne Metropolitan Office Market, 1971-1997 and Forecasts 1998 to 2010