Using Quantitative Analytical Techniques When Researching Real Estate – Applied Example

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Introduction

The acquisition of live data through case study analysis and subsequent application of econometric modelling techniques can often prove effective in the pursuit to explain trends in real estate values, despite characteristically limited availability of data sets (observations) especially in the case of larger property developments. Both linear and non-linear (polynomial and other forms) regression analysis techniques are typically utilised for this purpose. Such regression models describe and evaluate the relationship between a dependant variable y, and other variables (independent variables $X_{1,} X_{2,} X_3 \dots \dots , X_k$).

Overview

Regression techniques can be used for example, to establish the extent of the relationship between holding costs and housing affordability (and by implication, mortgage stress), by looking at a range of explanatory variables in holding cost components (i.e. independent variables) such as interest rates, inflation, and time frames for statutory approvals and overall holding period (Garner, 2012). This is schematically represented by Figure 1.

Measuring the sensitivity of the independent variable to holding costs can achieved by measuring the slope of the equation for incrementally increasing, or decreasing values. The trend / slope of the arctangent (measured in degrees) is measured and compared against arctangents for other variables that have been increased or decreased at the exact same increments (percentages). This process is sufficient to provide indicative levels of sensitivity based on the steepness of the angle, i.e. this comparison assists in the determination of which variables holding costs are most responsive to, e.g. interest, or development time, or undeveloped land cost, etc..

A range of "what-if" scenarios for all independent variables can be used to compare the outcomes against one another in order to determine, with a degree of statistical rigour, the impact those variables have in relation to holding cost outcomes. Ultimately, it is then possible to measure their impact upon housing affordability since we can convert the holding cost outcome into a mortgage repayment equivalency expressed as a proportion of mean household income.

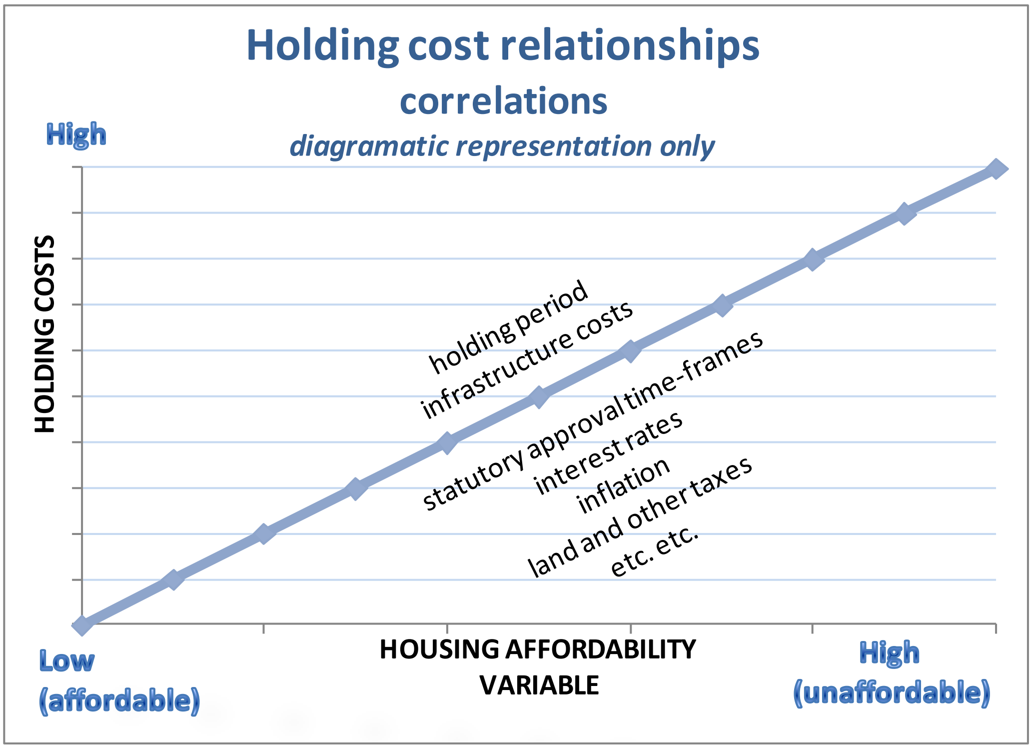

Figure 1 Holding cost relationships and possible correlations

Trend Line Fitting

Regression Form – Overview

In the process of the aforementioned measuring and comparing outcomes, the econometric modelling first appears in the establishment of a "best fit" linear trend line that expresses the equation relating to the dependant variable y (in this case, mortgage repayment equivalent as a result of holding costs, expressed as a % of mean household income) and the independent variable x being the relevant factor impacting holding cost (e.g. interest rate, development time, number of lots in the subdivision, undeveloped land cost, developments costs, etc). Since the independent variable x's are all equally incremented (increased or decreased) when conducting the "what-if" scenarios, it is then possible to measure the angle (arctangent or inverse tangent) of the best fitting linear regression equation for that variable, [in concert with the Equation 1 Linear (two variable regression) form]. Thus, sensitivity can be determined, i.e. the greater (more steeper) the angle, the higher the degree of sensitivity is the independent variable x.

Case studies (Field Research) detail

The utilisation of case study data enables inter-alia validation of theoretical modelling. In this instance, we are analysing four case study projects ranging in size from 17 to 142 allotments, with their scope ranging from AUD$1.3m to AUD$23.4m, with the cost of greenfield site (undeveloped land) acquisition ranging from $0.1m to $7.2m. Average gross realisations (i.e. the final sale prices for the allotments) range from $86,621 to $521,303 per allotment. Development timeframes range from 28 months to 52 months.

Variability in the case studies can be appreciated with reference to Table 1, where the extent of the variability between case studies is explored with reference to the SD Standard Deviation σ, VAR Variance σ^2, and Population Mean μ for all major cost components. The confidence interval $\hat{p}$ (for the population mean) with a confidence level alpha α of 0.05 is completed for each of the major cost components and relative percentage proportions of (1) Acquisition (land) cost, (2) Levies, charges, DA, consultants; (3) Development Costs (building and construction); (4) Developers Margin; (5) Selling Costs; and (6) Holding Costs. Since the population size N is only 4 (i.e., four case studies), financially "significant" differences may not be statistically significant, but confidence intervals nevertheless do highlight the significant variability between the case studies, and provide a comparison between the extent of the variables with respect of each individual cost component. For example, the confidence interval $\hat{p}$ for selling costs @ 0.97% and standard deviation σ of 0.98% is at the extreme low end of variability, compared to development costs (building and construction) which, at a confidence interval $\hat{p}$ of 47.06% and standard deviation σ of 11.06%, are at the extreme high end of variability.

Table 1 - Case Study population statistics: variations in cost components as a percentage of gross realisation

Percentage of Gross Realisation						
Case Study Population Statistics	**SD Standard Deviation σ**	**VAR Variance σ^2**	**Population Mean μ**	**Confidence interval $\hat{p}$ (population mean)**	**Confidence (min)**	**Confidence (max)**
Gross Realisation	**190,690**	**4.E+10**	**$254,573**	**$249,477**	**$5,096**	**$504,051**
Acquisition (land)	9.43%	0.89%	**17.86%**	17.51%	0.36%	35.37%
Levies, charges, DA, consultants	4.78%	0.23%	**7.34%**	7.19%	0.15%	14.53%
Development Costs (building and construction)	11.06%	1.22%	**47.06%**	46.12%	0.94%	93.18%
Developers Margin	7.32%	0.54%	**20.56%**	20.15%	0.41%	40.70%
Selling Costs	0.98%	0.01%	**0.99%**	0.97%	0.02%	1.96%
Holding Costs	3.41%	0.12%	**6.08%**	5.96%	0.12%	12.04%
Confidence level alpha α =				0.05		
Population size N =				4		

Verification of the theoretical modelling

In authenticating the theoretical model, best fit trend equations – linear or non-linear - can be established for each case study based on the dependant variable y (once again, measured by the mortgage repayment equivalent as derived from the quantum of holding costs, expressed as a % of mean household income,) and the independent variable x, this time being the length of development period. Thus we can establish a *"Holding Cost - Housing Affordability Trend Line"* based on actual results for each specific (i.e. case study) property development. A significant point here is that the *"Holding Cost - Housing Affordability Trend Line"* has the ability to determine the impact of shortened or lengthened time frames on housing affordability – whatever their cause.

To explain further, the "Holding Cost – Housing Affordability Trend Lines" plot the equation depicting the length of development period against the cost of mortgage payment equivalent due to holding costs as a percentage of mean household income. These trend lines therefore establish the impact of holding costs over time against housing affordability, both for the theoretical model and actual cases. This provides an indication of the theoretical impact for either shortened or lengthened time-frames, as well as the "actual" result.

However, since the relationship is not always straight line, it may be necessary to choose an alternative functional form of the two variable linear regression model shown at Equation 1 which assumes that, with α being the constant, the dependant variable y is a linear function of an independent variable x under the general formula (Pindyck & Rubinfeld, 1987, p. 47; Studenmund, 2010, p. 15 and others):

Equation 1 Linear (two variable regression) form

$y = \beta_0 + \beta_1 X + \epsilon_i$ OR alternatively $y = \alpha + \beta X_i + \epsilon_i$

If a linear regression model is found not to be appropriate because the regression function is curvilinear (nonlinear), the employment of a second degree polynomial regression function may be indicated. The decision to transform into another form such as binomial or multinomial probit or logit models is based upon the interpretation of an incorrect functional form. Where applicable, this is obviated by the observation of poor fit, difficulty in interpretation, and / or having established the possibility of biased estimates. The validity of nonlinear modelling is becoming increasingly recognised as a way of testing co-integration relations extending to investment and other contexts (Barnett et al., 2000, p. 26), for both macro and microeconomic variables such as examined here. In keeping with established model selection process principles (e.g. Studenmund, 2010, p. 221), the choice of a non-linear function will be on the basis of a selection that best matches the underlying theory of the equation, even though in the majority of cases the linear form may prove adequate. It is recognised that an incorrect functional form may well provide a reasonable fit (established by say the regression coefficient R^2 alone); however selection is optimally based on the model exhibiting logically non-linearity characteristics, even though the exact form of the nonlinearity may not be readily apparent. As stated by Studenmund (2010, p. 229), *"a choice between the non linear forms cannot be made on the basis of economic theory"*. Pindyck & Rubinfeld (1987, pp. 108-109) suggest that choosing regression parameters is equivalent to finding the best parabola which fits the point on a two dimensional graph of y and X. The resultant quadratic form is therefore useful for testing nonlinearities. These alternate forms considered (tested for goodness of fit) could include:

Equation 2 Polynomial form

$$y = \beta_0 + \beta_1 X_{1i} + \beta_2 (X_{1i})^2 + \beta_3 X_{2i} + \varepsilon_i$$

Equation 3 Exponential form

$$y = \exp[(\beta_1 + \beta_2 X_2 + \beta_3 X_3)]\varepsilon$$

Equation 4 Logarithmic (semilog) form

$$y = \beta_0 + \beta_1 In X_{1i} + B_2 X_{2i} + \epsilon_i$$

Where y = the dependant variable (i.e. Holding Costs)

X's = independent or explanatory variables (e.g. in this case, interest rates, inflation, and time frames for statutory approvals and overall holding period(s), etc).

ε = stochastic error term

β_1 = constant or intercept of the equation (denoted β_0 in the single equation model)

i = ith observation

In = natural log

Testing under the multiple linear form, where appropriate, is conducted under the formula at Equation 5:

Equation 5 Multiple linear regression analysis form

$$y = \beta_1 + \beta_2 X_{2i} + \beta_3 X_{3i} \ldots\ldots\ldots\ldots\ldots + \beta_k X_{ki} + \varepsilon_i$$

All usual assumptions which make up the *classical multiple regression model* should be adopted, i.e. (Brooks & Tsolacos, 2010, p. 86; Pindyck & Rubinfeld, 1987, p. 76; Studenmund, 2010, p. 94 and others):

- X's are non-stochastic, with no exact linear relationship existing between two or more of the independent variables (i.e. no perfect multicollinearity)
- Error term has 0 expected value (mean) and constant variance for all observations (i.e. no heteroskedasticity)
- Errors corresponding to different variations X are uncorrelated
- Error variable is normally distributed

It is pointed out that the usefulness of testing under the multiple linear form is limited. For example, multicollinearity issues when using multiple regression models (i.e. problems between some variables where there is already a clear existing relationship - one obvious example in this instance might be inflation rate, and interest rate, but such problems are largely dependent upon the particular time period selected)[1].

There may also be limitations due to sample size, i.e. as a general rule it is accepted that as the number of observations increase, the reliability of the obtained correlations also increases; on the other hand, if the sample size is sufficiently large virtually any null hypothesis can be rejected – often found to be a problem in finance[2]. However, even though sample size is problematic in this example (the case studies relate to large residential developments where there are typically very limited transactions occurring), the regression analysis conducted nevertheless informs by: (1) determining indicative sensitivity (slope of the regression trend) of the base case scenario independent variables, which is also confirmed and tested by the case study data; and (2) developing a table of cross sectional bivariates to assist in interpretation of the Holding Cost – Housing Affordability trend lines.

This leads to consideration of the institutional context, and the inability often experienced by researchers concerning non-disclosure of transactional details (a point not lost on AHURI researchers recently)[3], and limited market evidence. Notwithstanding the foregoing, in this instance, it is more important to ensure a focus on the *quality* of responses,

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[1] This is overcome by using certain methods such as transforming the highly correlated variable into a ratio and using that as the X; ignoring it (if the model is otherwise adequate in terms of each coefficient being of a plausible magnitude); collation of additional data and / or changing the time period where possible; or even eliminating one of the collinear variables if deemed necessary.

[2] In real estate where, as in this case, sample sizes are often very small, a 5 per cent significance level is widely used (Brooks & Tsolacos, 2010, pp. 62-63). Other " rules of thumb" indicate that the sample size should be not less than 10 times the number of variables (Comrey & Lee, 1992), or utilising at least 30 observations to estimate even the simplest models, and at least 100 is desirable (Brooks & Tsolacos, 2010, p. 66). Traditionally, statisticians prefer larger sample sizes of $n \geq 200$ (Comrey & Lee, 1992, p. 200 - sample sizes of 200 rates as "fair", and 300+ rates as "good"), i.e. the more complex models rely heavily on available information and therefore require larger quantities of data. It is recognised that sampling error is minimised by increasing the size of the sample since small samples are more likely to be inherently unrepresentative. Other problems with obtaining a small sample size relate to the nature of real estate data, in particular the infrequency of transactions, and evidence of yields, rents (if applicable) and prices.

[3] It was recorded by researchers that their overall analysis of planning costs was limited by a lack of financial data provided by the sample of case study developers. In itself, this inability or unwillingness to provide specific cost data on planning related expenses supports claims that this information is difficult to ascertain with certainty (Gurran et al., 2009, p. 13). This prevented scrutiny of, inter alia, holding costs, and other key variables.

rather than relying upon response numbers. In this regard, the most important criteria in relation to sampling is to obtain a survey from participants in a highly specific target property development market.

Use of a cross sectional model

Development of a cross sectional regression model, of the kind used to explain yield differences between global real estate markets (Hollies, 2007) may appropriate to assist interpretation. Output consists of a series of bivariate regressions estimated to assess the explanatory ability of determinate variables on the dependant variable. For instance, in this example a model can be developed along the lines generically expressed at Table 2.

Table 2 Concept of the cross sectional regression table

Dependant variable		Constant		X Multiplier	Independent variable X			Correlation coefficient
Y	=	9.999	+	99.999	interest rate	R^2	=	9.99
Y	=	9.999	+	99.999	Inflation	R^2	=	9.99
Y	=	9.999	+	99.999	statutory approval time period	R^2	=	9.99
Y	=	9.999	+	99.999	holding period	R^2	=	9.99
Y	=	9.999	+	99.999	mortgage rates	R^2	=	9.99
Y	=	9.999	+	99.999	... etc. etc	R^2	=	9.99

A summary of data modelling for each of nine independent variables, along with their best fit regression equations (i.e. impact on holding costs) is shown at Figure 2. The housing affordability curves provide a comparative overview of all variables (Figure 4).

The table of bivariate regressions enables the sensitivity of the independent variables to be demonstrated both statistically, and visually, as per Appendix 1: Linear Trend line Analysis - Sensitivity of Factors Impacting Holding Costs and Subsequent Effect on Housing Affordability. The output of that analysis is summarised at Table 3; it contains critical results from which we can derive our conclusions. For example, this analysis shows that interest rates and development timeframes are critical to the holding cost equation. Whilst this result broadly confirms the general thrust of the literature on the topic, it also highlights that the extent of these impacts may not have been hitherto fully appreciated.

It should be noted that although some of the variables have limited or no impact on holding costs (as measured by the sensitivity assessment), that does not mean they have a correspondingly limited impact on housing affordability. This is important in the context of housing affordability, since a factor could have a limited or even no impact on holding costs, yet have a significant impact on housing affordability because it affects gross realisation prices. A good example of this is the developer's margin: it has no impact on holding costs at all, yet could be significant for end-users. In this regard, comparisons can be made between Figure 2 and Figure 3 for different variables.

Table 3 Sensitivity of factors impacting holding costs, and subsequent effect on housing affordability

Sensitivity Assessment	Angle	Variable
Very Extreme	>10 °	Interest / Inflation rate Change
Extreme	7-10 °	Mean equivalised household income Development time from acquisition
Significant	4-7 °	Undeveloped Land Cost Number of Lots in subdivision
Moderate	1-4 °	Development Costs, including major civil works, building and construction - per lot
Minor	up to 1 °	Rates, infrastructure charges, DA, consultants, etc - % land acquisition costs per lot p.a. Acquisition costs (% of undeveloped land cost)
Nil	zero °	Developers Margin

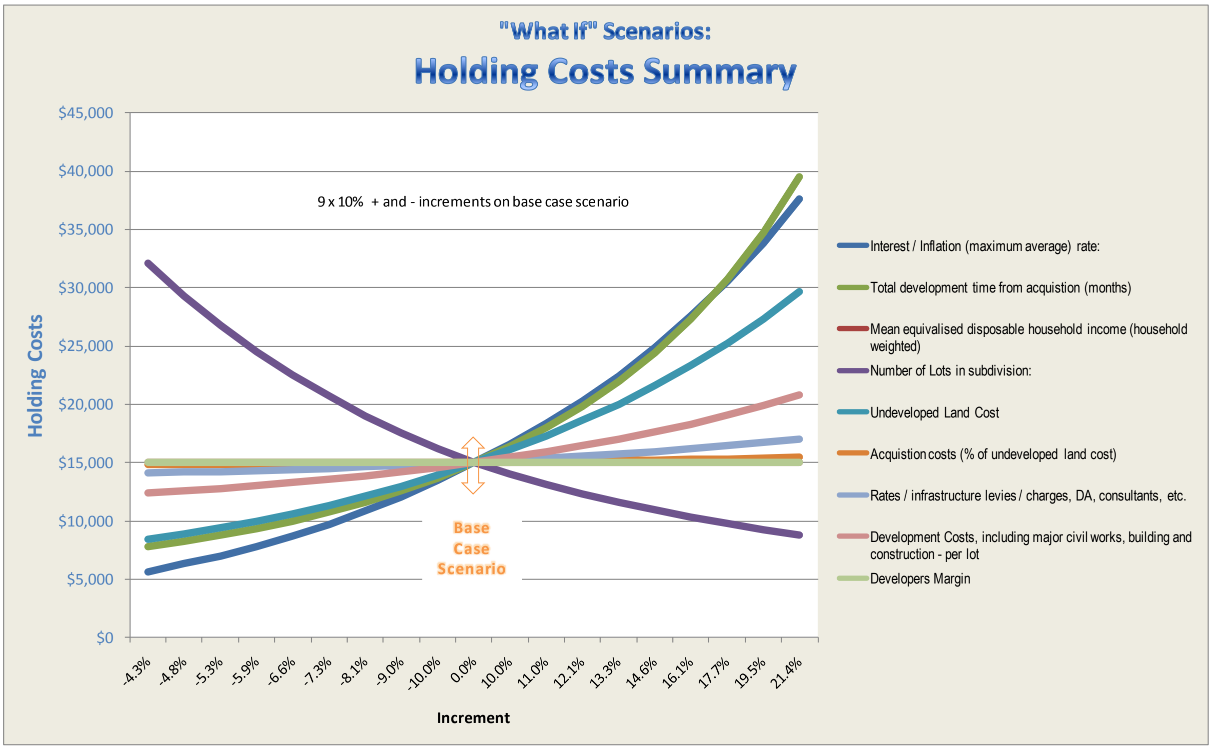

Figure 2 "What-If" Scenarios: Holding Costs summary of all independent variables

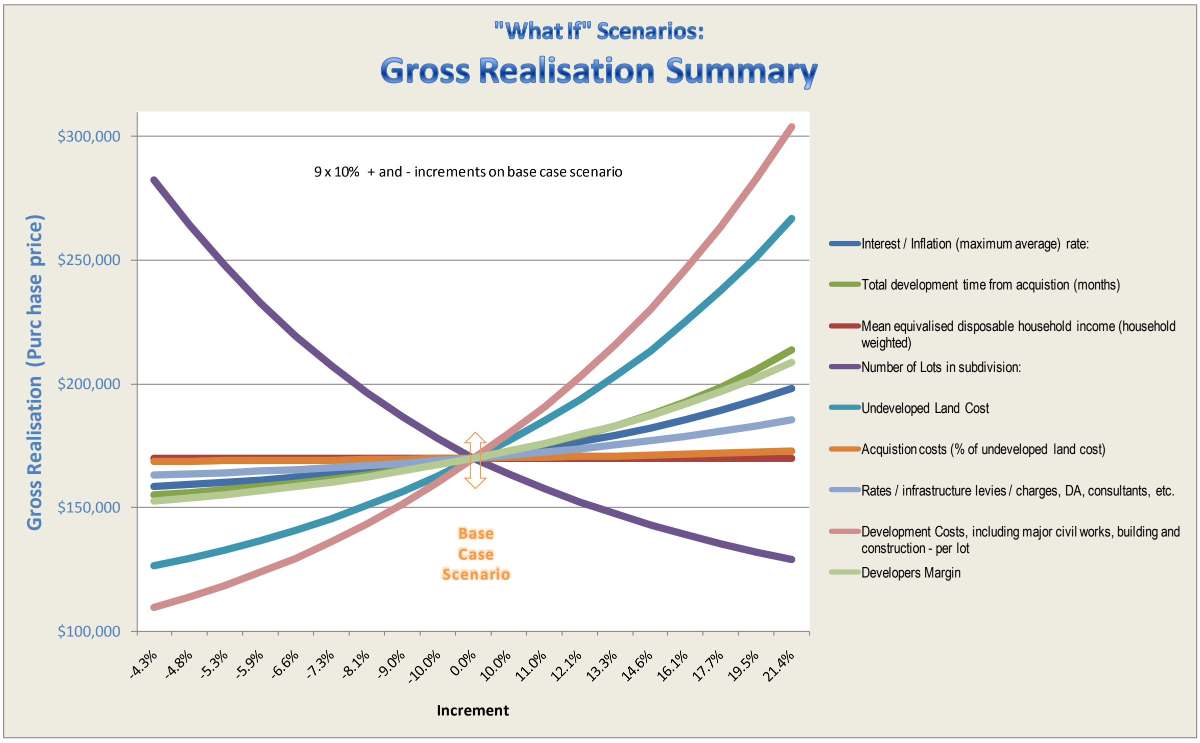

Figure 3 "What-If" Scenarios: Gross Realisation summary of all independent variables

Holding cost – housing affordability trend lines

The final part of the econometric modelling in this example establishes "best fit" trend equations – linear or non-linear - for each of the case studies, based on the dependant variable y (once again, measured by the mortgage repayment equivalent as derived from the quantum of holding costs, expressed as a % of mean household income,) and the independent variable x, being the length of development period.

First, we establish the *"Holding Cost - Housing Affordability Trend Line"* (which is shown at Figure 4). This is achieved by inputting the actual results for each specific property development project (along with a base case scenario) into a Holding Cost model. The baseline data inputs, and the primary outputs of the model is shown at Appendix 2: Case Study Comparisons against the Base case Scenario (summary data).

It is then possible to run the best fit linear or non-linear trend analysis on the *"Holding Cost - Housing Affordability Trend Lines"*, which in this case results in polynomial regression equations which are summarised at Table 4. Here, polynomial regression equations are used to solve for the housing affordability variable y.

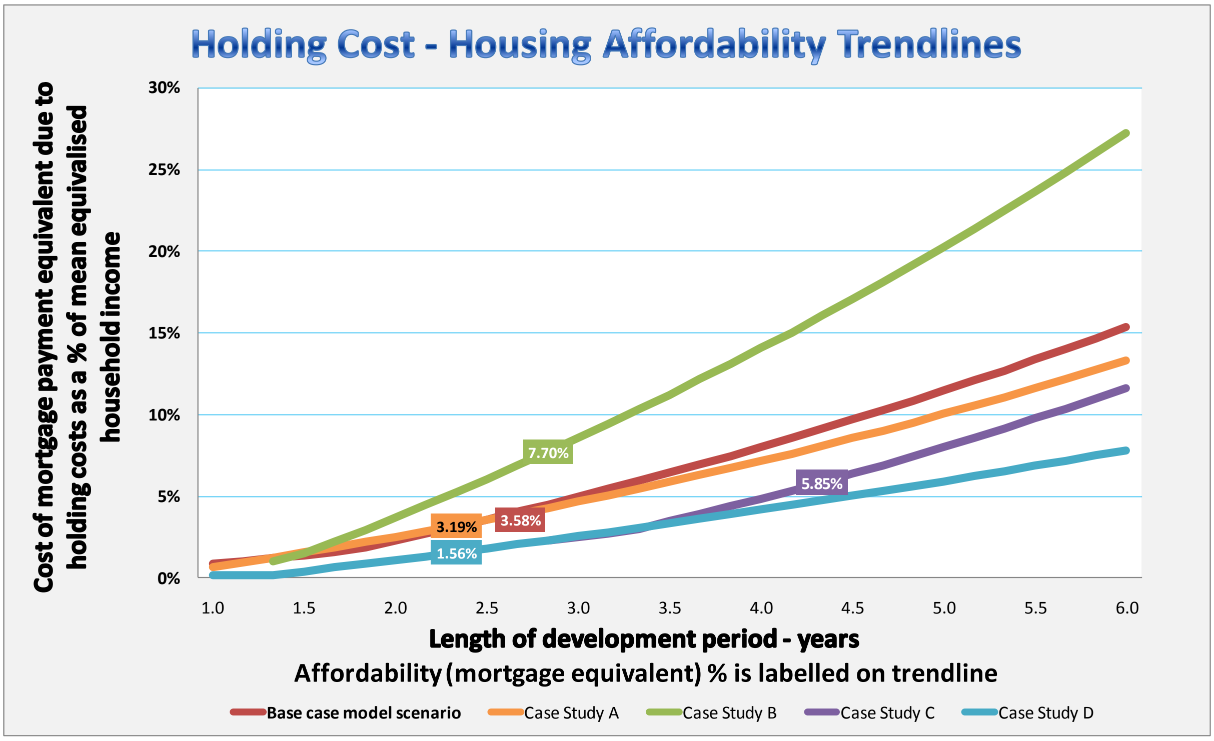

Figure 4 Holding Cost – Housing Affordability Trend Lines

Table 4 Polynomial trend line equations summary for case studies and the Holding Cost Economic Model base case scenario

Base case Scenario - Case Study Comparisons	Base case model scenario	Case Study A	Case Study B	Case Study C	Case Study D
Detail	**Per Lot**	**Per Lot**	**Per Lot**	**Per Lot**	**Per Lot**
Holding Costs	$15,039	$14,072	$32,941	$21,423	$5,006
Gross realisation (total price of allotment)	$170,000	$331,349	$521,303	$177,798	$85,621
Detail	Gross	Gross	Gross	Gross	Gross
Number of Lots in subdivision:	200	83	17	142	20
Project Commencement	Dec-10	Aug-06	Jun-06	Feb-04	Dec-03
Project Completion (final settlement)	Dec-13	Jun-09	Jul-09	Dec-08	Apr-06
Total Project time - acquisition to final settlement (years)	3.0	2.8	3.1	4.8	2.3
Development time from acquisition (months)	30.00	28.00	34.00	52.00	28.00
Development time from acquisition (years)	2.50	2.33	2.83	4.33	2.33
Mean equivalised household income utilised - per annum *	$51,656	$47,320	$50,936	$42,120	$35,620
Cost of mortgage repayment equivalent due to holding costs as a % of mean household income	3.58%	3.19%	7.70%	5.85%	1.56%
Polynomial (curvilinear) trendline equation	$y = 7E\text{-}05x^2 + 0.0027x + 0.0027$	$y = 5E\text{-}05x^2 + 0.0026x + 0.0044$	$y = 1E\text{-}04x^2 + 0.0061x - 0.0102$	$y = 9E\text{-}05x^2 + 0.0012x - 0.0064$	$y = 2E\text{-}05x^2 + 0.0019x - 0.0029$
R^2 (Correlation coefficient) of the polynomial equation	0.9993	1.0000	1.0000	0.9994	0.9995
** Mean equivalised household income utilised is calculated as at date of first settlement*					
Holding Costs	$3,007,720	$1,168,000	$560,000	$3,042,000	$100,122
Gross realisation (total price of allotment)	**$33,999,962**	**$27,501,945**	**$8,862,145**	**$25,247,313**	**$1,712,420**
Detail	**% of Gross Realisation**	**% of Gross Realisation**	**% of Gross Realisation**	**% of Gross Realisation**	**% of Gross Realisation**
Holding Costs	8.85%	4.25%	6.32%	12.05%	5.85%

Appendix 1 - Linear Trend line Analysis: Sensitivity of Factors Impacting Holding Costs and Subsequent Effect on Housing Affordability

Sensitivity*	Very Extreme >10 deg	Extreme 7-10 deg		Significant 4-7 deg		Moderate 1-4 deg	Minor up to 1 deg		Nil zero deg
"What If" Scenario:	Interest / Inflation rate Change	Mean equivalised household income	Development time from acquisition	Undeveloped Land Cost	Number of Lots in subdivision	Development Costs- per lot	Rates, infrastructure charges, DA, consultants, etc -	Acquisition costs (% of undeveloped land cost)	Developers Margin
Regression Formula #	y=0.0078x - 0.00241	y= 0.0041x +0.0833	y = 0038x - 0.0046	y = 0.0027x + 0.012	y = 0.0029x + 0.699	y = 0.0011x + 0.0264	y = 0.0004x + 0.0326	y = 8E-05x + 0.0351	y = 3E-18x + 0.0358
R2 #	0.8452	0.9336	0.9002	0.9554	0.9336	0.9554	0.9554	0.9564	0.00E+00
Regression Formula (forced intercept@ zero)	y = 0.0059x	n/a	y = 0.0042x	y = 0.0036x	n/a	y = 0.0031x	y = 0.0029x	y = 0.0028x	y = 0.0028x
R2 (forced intercept zero)	0.7826	n/a	0.8904	0.813	n/a	3.496	-54.4	-1444	3.00E+14
x Coefficient (forced)]	0.0059	0.0041	0.0042	0.0036	0.0029	0.0031	0.0029	0.0028	0.0028
Arctangent, in degrees (forced)	0.34	0.23	0.24	0.21	0.17	0.18	0.17	0.16	0.16
Width	4.33	2.33	2.14	1.69	1.55	0.38	0.27	0.07	0.00
Height	14.05	15.85	15.75	15.90	15.84	15.91	15.91	15.89	16.76
Tangent of the linear trend	0.31	0.15	0.14	0.11	0.10	0.02	0.02	0.00	0.00
Angle[4]	17.13	-8.36	7.74	6.07	-5.59	1.37	0.97	0.25	0.00

Linear Trend Analysis - conducted on cost of mortgage repayment as a result of holding costs as a % of equivalised disposable household income
* Sensitivity - based on angle of variable (arctangent [inverse tangent], in degrees) achieved in + - 10% incremental shifts
# Unforced intercept

[4] Angle: Arctangent (inverse tangent), in degrees - unforced

Appendix 2: Case Study Comparisons against the Base case Scenario (summary data)

Base case Scenario - Case Study Comparisons: Summary Data	**Base case model scenario**	**Case Study A**	**Case Study B**	**Case Study C**	**Case Study D**
Detail	**Per Lot**	**Per Lot**	**Per Lot**	**Per Lot**	**Per Lot**
Acquisition cost (undeveloped land)	$38,663	$49,771	$107,941	$50,627	$5,225
Rates, infrastructure levies / charges, DA, consultants, special council charges & land tax	$7,733	$26,687	$34,529	$23,585	$1,400
Development Costs, including major civil works, building and construction	$75,000	$167,048	$227,824	$68,887	$55,000
Developers Margin	$27,287	$72,122	$112,906	$11,516	$16,658
Selling Costs	$6,279	$1,649	$5,161	$1,760	$2,332
Holding Costs	$15,039	$14,072	$32,941	$21,423	$5,006
Gross realisation (total price of allotment)	**$170,000**	**$331,349**	**$521,303**	**$177,798**	**$85,621**
Number of Lots in subdivision:	**200**	**83**	**17**	**142**	**20**
Project Commencement	Dec-10	Aug-06	Jun-06	Feb-04	Dec-03
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Mean equivalised household income utilised - per annum *	$51,656	$47,320	$50,936	$42,120	$35,620
Cost of mortgage repayment equivalent due to holding costs as a % of mean household income	3.58%	3.19%	7.70%	5.85%	1.56%
Polynomial (curvilinear) trend line equation	y = 7E-05x2 + 0.0027x + 0.0027	y = 5E-05x2 + 0.0026x + 0.0044	y = 1E-04x2 + 0.0061x - 0.0102	y = 9E-05x2 + 0.0012x - 0.0064	y = 2E-05x2 + 0.0019x - 0.0029
R^2 (Correlation coefficient) of the polynomial equation	0.9993	1.0000	1.0000	0.9994	0.9995
** Mean equivalised household income utilised is calculated as at date of first settlement*					

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