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Measuring Housing Affordability: Looking Beyond the Median

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We draw a distinction between the concepts of purchase affordability (whether a household is able to borrow enough funds to purchase a house) and repayment affordability (the burden imposed on a household of repaying the mortgage). We operationalize this distinction in the context of a new methodology for constructing affordability measures that draws on the value-at-risk concept and takes account of the whole distribution of household income and house prices rather than just the median. Empirically we find that the distinction between purchase and repayment affordability can be pronounced. In the Sydney prime mortgage market over the period 1996 to 2006, repayment affordability deteriorated very significantly while purchase affordability remained quite stable. This difference can be attributed to the loosening of credit constraints in the mortgage market which it seems has carried through primarily into higher house prices. We also consider how median house-price-to-income ratio measures of affordability can be extended to take account of the whole distribution of income and house prices. We propose a new quantile based measure which indicates that the housing affordability problem may be systematically worse than suggested by standard median measures. (JEL. C43, E25, E64, R31)

Keywords: Housing affordability; Affordability at risk; Affordable limit; Mortgage market; Price-to-income ratio

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1 Introduction

A number of OECD countries have experienced housing booms in the last decade. There is a general perception that these booms have caused a significant decline in housing affordability as well as a widening of differences in affordability across regions (see for example Demographia International 2008). The decrease in housing affordability is perceived to be causing stress in some sections of society as well as raising concerns about the sustainability of the boom. Recent events in the subprime market have added to these concerns.

Although the problem of declining affordability has been widely discussed in the media, the theoretical underpinnings of the concept of affordability have received rather less attention from academics, particularly in comparison to the related problem of constructing real estate price indexes (see for example Englund, Quigley and Redfearn 1998, Diewert 2007, and Hill and Melser 2008).

Affordability is usually defined either in terms of the ratio of income to house prices or the proportion of income to mortgage repayments or rent. One strand of the literature focuses on low income households, while the other tends to focus on the median. Most publicly available affordability indexes are of the latter type.

This article contributes to the affordability literature in three respects. First, we refine the concept of affordability by drawing a distinction between three possible interpretations. We distinguish between the concepts of purchase, repayment and income affordability. We argue that existing indexes almost always belong to the latter two categories. Second, we develop a new approach to the construction of affordability indexes that is linked to the concept of affordability at risk from the finance literature. Third, rather than focusing on either low income households or the median, our affordability indexes take account of the whole distribution of households.

We then apply our methodology to data for Sydney, Australia covering the period 1996-2006 and Houston, Texas for the period 1999-2006. Our measures of repayment and income affordability agree that housing affordability has worsened significantly

over this period in Sydney, while by contrast purchase affordability has remained fairly stable. We attribute this difference to deregulation of mortgage markets which we argue has driven a wedge between the concepts of purchase and repayment affordability. We also find that the standard measure of income affordability – the median house-price-to-income ratio – tends to significantly understate the extent of the income affordability problem. Our main findings are summarized in the conclusion.

2 Concepts of Affordability

Affordability can be thought of in at least three different ways. We draw a distinction between the concepts of *purchase affordability*, *repayment affordability* and *income affordability*. Purchase affordability considers whether a household is able to borrow enough funds to purchase a house. Repayment affordability considers the burden imposed on a household of repaying the mortgage. Income affordability simply measures the ratio of house prices to income. The former two concepts include additional parameters that describe the downpayment ratio, the per period mortgage-payment-to-income ratio, the length of the mortgage, and the mortgage interest rate. All these parameters are fixed for repayment affordability, with the exception of the mortgage interest rate. By contrast all the parameters in the purchase affordability formula adjust to changes in the mortgage market such as a loosening of credit restrictions.

The distinction between purchase and repayment affordability is best illustrated with an example. Suppose that deregulation of the mortgage market leads to an increase in the maximum available mortgage length from say 25 to 30 years. What impact does this have on affordability? Assuming for the moment that the distribution of house prices is unaffected by this change (probably an unrealistic assumption), the introduction of 30 year mortgages acts to improve purchase affordability, since now a household on any given level of income is able to raise more funds than previously and hence purchase a more expensive house. It, however, does not improve repayment affordability, since it does not make borrowing any cheaper. If instead the loosening of the borrowing

constraint feeds directly into higher house prices, then it will leave purchase affordability unchanged while worsening repayment affordability. This example illustrates how deregulation of the mortgage market can drive a wedge between the concepts of purchase and repayment affordability.

The literature on housing affordability tends to focus either on low income families or the median. Examples of the former include Hulchanski (1995), Kutty (2005) and Stone (2006). Most attempts to actually operationalize the concept of affordability – mainly by banks, real estate institutes and government agencies – focus on the median. Here we look specifically at affordability indexes for the US and Australia.

One important difference between the US and Australian markets is that fixed rate mortgages dominate in the former and variable rate mortgages in the latter. Thus, affordability measures are more reliable indicators of the long-term burden imposed on home buyers in the US than in Australia. Fixed rates, however, increase the risk faced by mortgage lending institutions.

The main providers of affordability indexes in the US are real estate institutes and government agencies. The three main indexes are produced by the National Association of Realtors (NAR), US Department of Housing and Urban Development (HUD) and the National Association of Home Builders (NAHB) (see Quigley and Raphael 2004). The NAR index measures the ratio of 25 percent of median monthly income to the monthly repayments on a fixed-rate mortgage on the median house at current interest rates. The HUD index measures the ratio of median family income to the income required to qualify for a conventional mortgage on the median valued house sold. The NAHB index measures the fraction of dwellings sold that could be purchased by the median household with 28 percent of household income.

Two of the three main indexes in Australia are produced by banks in collaboration with real estate institutes, while the third is produced by a construction consulting firm. The structures and underlying rationales of these indexes are similar to those of the US indexes. The Real Estate Institute of Australia and AMP (REIA/AMP) index measures the ratio of median household income to median loan repayments, with

the latter based on new loans in each quarter. The BIS Shrapnel index measures the ratio of mortgage repayments on a typical housing loan to average full-time male earnings. Finally, the Commonwealth Bank of Australia/Housing Industry Association (CBA/HIA) index measures the ratio of median household disposable income to the qualifying income required for a typical first home loan.

All the US and Australian indexes discussed above focus on repayment affordability. By contrast, Demographia International (2008) computes median price-to-income ratios for 227 regions in Australia, Canada, Ireland, New Zealand, the UK and US. The Demographia index therefore measures income affordability. None of these indexes measures purchase affordability. In the next section, we develop a new approach to the construction of affordability indexes that clearly demonstrates the distinction between the concepts of purchase and repayment affordability.

3 Measuring Affordability: A New Perspective

3.1 Affordable limit

A useful starting point for defining affordability is the concept of an affordable limit. The affordable limit sets the ratio of the maximum allowable loan to income. A house with price Y is deemed affordable for a household with gross income X if $Y/X \leq AL$. Otherwise the house is deemed unaffordable.[1]

We use an approximate estimate of the affordable limit in this paper. Let α denote the proportion of gross income a household can allocate to mortgage repayments. The present value of the maximum achievable mortgage repayment stream is given by $\sum_{n=1}^{N}(\alpha X)/(1+i)^n$, where i is the mortgage interest rate and N is the term of the loan.

[1]Here we will focus on gross income, although with suitable modifications we could reformulate the analysis in terms of net income. We focus on gross income because it is more easily obtainable than net income.

Following Bourassa (1996) we write the borrowing constraint as follows:

$$\sum_{n=1}^{N}\left[\frac{\alpha X}{(1+i)^n}\right] \geq Y - D, \tag{1}$$

where Y is the price of a house and D is the deposit. The borrowing constraint can be rewritten as follows:

$$\alpha X \geq (1-\beta)Y\left[\frac{i}{1-(1+i)^{-N}}\right], \tag{2}$$

where we have assumed that the minimum deposit is proportional to Y, i.e., $D = \beta Y$. Rearranging, we obtain the following affordable limit (AL):[2]

$$AL = \left(\frac{\alpha}{1-\beta}\right)\left(\frac{1-(1+i)^{-N}}{i}\right).$$

The key distinction between purchase affordability and repayment affordability is that the parameters α and N are fixed in the latter case, while in the former case they are set by market conditions and hence can vary over time. One might also allow α to vary with income. That is, higher income families may be able to devote a higher proportion of their incomes to mortgage repayments. We do not pursue this avenue here. Empirically, α does not seem to vary much with income. Using data from the consumer expenditure survey for the years 1984 to 2002, Piazzesi, Schneider and Tuzel (2007) find that in the US the lowest income quintile spends 17.8 percent of gross income on housing while the highest income quintile spends 16.9 percent.

In recent years deregulation of the mortgage market has led to falls in the level of α required by many lenders, combined with a rise in N. This has exerted downward pressure for any given house price distribution on repayment affordability but not on purchase affordability. In both cases the interest rate i is set by market conditions and hence varies over time.

[2]The affordable limit here is a decreasing function of β. This is problematic if the downpayment constraint is binding for a significant proportion of households. We avoid this problem in the empirical analysis that follows by holding β fixed at 0.2 – the minimum level to avoid private mortgage insurance.

3.2 Affordability at risk

We use the concept of Affordable Limit to construct a new measure of affordability that is related to the Value-at-Risk concept from the finance literature (see for example Manganelli and Engle 2001).

Definition Affordability at Risk (AaR)

Affordability at Risk (AaR) measures the probability that the houses available on the market at a certain time (or during a certain time period) are unaffordable for a household with a given income level.

Let $f(.)$ and $F(.)$ denote the probability density function and cumulative distribution function of house prices, respectively. The range of the house price distribution is bounded. That is, there exists $y_0 \geq 0$ and $y_1 < \infty$ such that $F(y_0) = 0$ and $F(y_1) = 1$.[3]

Let $g(.)$ and $G(.)$ denote the probability density function and cumulative distribution function of household income, respectively. The range of the income distribution is also bounded. That is, there exists $x_0 \geq 0$ and $x_1 < \infty$ such that $F(x_0) = 0$ and $F(x_1) = 1$.[4]

The AaR for a household with income x, is calculated as follows:

$$AaR(x) = \int_{x \times AL}^{y_1} f(y)dy = 1 - F(x \times AL), \tag{3}$$

For example, suppose a household has gross annual income \$50,000, and that AL = 5. The maximum price house this household can afford therefore is \$250,000. AaR(x) in this case calculates the proportion of houses on the market that have a price higher than \$250,000.

An overall measure of AaR for the whole population is obtained as follows:

$$AaR = \int_{x_0}^{x_1} AaR(x)g(x)dx. \tag{4}$$

An increase in AaR implies reduced affordability. AaR measures what proportion of the total housing stock is unaffordable on average across the whole population.

[3]For simplicity, we use continuous distributions for measurement description. We calculate empirical results on discrete distributions.

[4]We treat negative income as zero income. This treatment will not affect the AaR measure.

3.3 Affordability at risk and the housing affordability curve

We use the concept of Affordability at Risk to construct a new measure of housing affordability that is related to the Lorenz curve and Gini index.

Definition The Housing Affordability Curve (HAC) shows for the p^{th} percentile of households ranked by income, what percentage q of the total houses they can afford.

Given the income cumulative distribution function G and definition of AaR, we obtain the HAC as follows:

$$HAC(p) = 1 - AaR[G^{-1}(p)]. \tag{5}$$

The Housing Affordability Index (HAI) is derived directly from the Housing Affordability Curve (HAC).

Definition The Housing Affordability Index (HAI) is equal to twice the ratio of the area between the Housing Affordability Curve (HAC) and the 45 degree line to the area under the 45 degree line (which is 1/2).

The Gini coefficient lies between zero and 1. In contrast, the Housing Affordability Index HAI lies between -1 and 1. A negative HAI implies that a household on the qth percentile (represented as a number between zero and one) on average can purchase a proportion greater than q of the housing stock, while a positive HAI implies that a household on the qth percentile on average can purchase a proportion less than q of the housing stock. In the limiting case, an HAI equal to -1 implies that all houses are affordable for everyone, while an HAI equal to 1 implies that all houses are unaffordable. More generally, a lower HAI implies greater housing affordability in the same way that a lower value of the Gini index implies greater equality.

The Housing Affordability Index (HAI) is related to Affordability at Risk (AaR) as follows:

$$HAI = 2\int_0^1 [p - HAC(p)]dp = 1 + 2\int_{x_0}^{x_1} [AaR(x) - 1]g(x)dx = 1 + 2(AaR - 1) = 2 \times AaR - 1.$$

4 Price-to-Income Quantile Measures of Affordability

We turn our attention now to the concept of income affordability (i.e., the ratio of house prices to income). This is typically measured by comparing median income to the median house price. We show here how this approach can be extended to take account also of other quantiles, so as to generate a more robust measure of income affordability.

Let x_q and y_q denote the qth quantile (where $q \in [0,1]$) values of $G(x)$ and $F(y)$ respectively. That is

$$\int_{x_0}^{x_q} g(x)dx = \int_{y_0}^{y_q} f(y)dy = q.$$

For example, $x_{0.5}$ and $y_{0.5}$ are the median values of x and y.

Definition Affordability at quantile q (AaQ(q))

AaQ(q) is calculated as follows:

$$AaQ(q) = y_q/x_q.$$

An increase in AaQ(q) implies reduced affordability for that particular quantile.

The median price-to-income ratio AaQ(0.5) is used by Demographia (2008) to measure housing affordability. As far as we know, AaQ(0.5) is the only income affordability measure that has been used empirically.

Focusing on a single quantile, however, will not always generate results that are representative of the whole population. For example, suppose the function y_q/x_q has a single turning point at $q = 0.5$, as depicted in Figure 1. The turning point here is a minimum. It can be seen that AaQ(0.5) in this case provides a biased estimate of affordability in the sense that it underestimates the ratio y_q/x_q for all values of q except $q = 0.5$.

Insert Figure 1 Here

For this reason, we advocate averaging the ratio y_q/x_q across all values of q. This ensures that the resulting index is representative of the whole distribution of quantile ratios.

Definition Average Quantile Affordability (AQA)

Average Quantile Affordability (AQA) is defined as follows:

$$AQA = \int_0^1 \frac{y_q}{x_q} dq.$$

It can be seen that $AaQ(0.5) = AQA$ when y_q/x_q is a linear function of q. Otherwise, in general these two quantile based affordability measures will tend to give different answers. In practice, the measurement of income becomes problematic for the highest and lowest quantiles. For this reason it may be preferable to restrict the quantile range over which AQA is calculated to say $q \in [0.1, 0.9]$.

One important difference between income measures of affordability and AaR based measures is that the former do not react explicitly to changes in the mortgage interest rate while the latter do. That is, income affordability is a different concept again from either purchase affordability or repayment affordability.

5 Affordability Indexes for Sydney and Houston

5.1 The data sets

Our income data for Sydney were obtained from the Australian Bureau of Statistics (ABS) Census for the years 1996, 2001 and 2006. The incomes for non-Census years are imputed. The data on house prices in Sydney for the years 1996-2006 were obtained from Australian Property Monitors (APM). We trim the top and bottom 0.5 percent of the house price distribution because of the greater prevalence of data entry errors there. This leaves us with an average of 72,817 house sales each year.

To calculate Affordability at Risk (AaR) it is first necessary to compute i, α, β and N. Here we focus on the prime mortgage market. Chomsisengphet and Pennington-

Cross (2006) show that, at least in the US, the mortgage interest rate premium in the subprime market is about 2 percentage points.

Data on i for Australia are obtained from the Reserve Bank of Australia (RBA) F05 Indicator Lending Rates Table. Given that the majority of mortgages in Australia are variable rate, the standard variable housing loan rate is used.[5]

Data on the proportion of income spent on mortgage repayments for new loans in the prime mortgage market (i.e., α) in Sydney are provided by the reciprocal of the REIA/AMP index multiplied by ten. This index is considered by REIA/AMP as an affordability index in its own right. Here, however, we use it as an input in the construction of our index. The REIA/AMP index started at a value of 0.324 in March 1996, and then fell to 0.267 in March 1998 before rising to 0.372 in December 2006. When computing purchase affordability we allow α to vary over time. For repayment affordability we hold it fixed.

Households purchasing houses with a downpayment ratio (β) less than 0.2 are required in Australia to pay Lenders Mortgage Insurance (LMI) (see Liu and Skully 2005). In the event of default on the loan, LMI protects the lender not the borrower. Hence although lower downpayment ratios are certainly possible, purchasers incur extra transaction costs in the process. We will assume therefore that β equals the minimum level that does not incur LMI (i.e., $\beta = 0.2$).

There is evidence that the average loan length has increased in recent years. According to Bourassa (1996), $N = 20$ in 1989/1990 in Australia. By 2004, according to the OECD (2004), typical mortgage loan terms in Australia had risen to $N = 25$. Brischetto and Rosewall (2007) document a further rise in N to 30 in recent years. When computing purchase affordability for Sydney we will assume that N rises at a constant rate from 20 in 1990 to 30 in 2006. It follows that the differences between purchase and repayment affordability in the results for Sydney are driven by changes in

[5]A recent report by Brischetto and Rosewall (2007) indicates that the average new borrower is paying 60 basis points below the standard variable indicator rate due to high competition between mortgage providers.

α and N between 1996 and 2006, holding β fixed. In both cases i varies over time. None of these parameters are required to calculate Average Quantile Affordability (AQA).

For comparison, we compute Affordability at Risk (AaR) and Average Quantile Affordability (AQA) for Houston, Texas. Our data set for Houston consists of house price sales and gross household income data over the period 1999-2006. Our housing data set was obtained from the Real Estate Center at Texas A & M University and the income data from the American Community Survey (ACS).

Mortgage interest rates are provided by HSH Associates' National Mortgage Statistics. Estimates of realized α for Houston can be obtained from ≪www.housingtracker.net/affordability/≫ Between 1999 and 2006 it fluctuated between 12 and 16 percent. The much lower level of α observed in Houston as compared with Sydney can be attributed to the fact that housing is more affordable in Houston (see Demographia International 2008). Since households in Houston in the prime mortgage market do not seem to be borrowing to the affordable limit, there is no reason to expect that α and N have risen over this period. For this reason, we do not distinguish here between purchase and repayment affordability. We set α at 0.27 – the value used by McCarthy and Peach (2004) for the US.

Again we assume that the down-payment ratio (β) is 0.2. This is because, like in Australia, loans with a value of β below 0.2 incur private mortgage insurance (PMI) (see Federal Reserve Bank of San Francisco 2008). Following McCarthy and Peach (2004) we assume loans are for 30 years (i.e., $N = 30$). Therefore, for Houston, the interest rate i is the only parameter allowed to vary over time.

5.2 Results for Sydney

The Affordable Limit for Sydney each year from 1996 to 2006 and for Houston from 1999 to 2006 are shown in Table 1. The Affordable Limit for Sydney rises continuously from 1996 to 2004 before falling back slightly in 2005 and 2006. Similarly, for Houston it rises continuously from 1999 to 2005, before falling back in 2006. It should be noted that an increase in the Affordable Limit does not necessarily translate to an improvement in

affordability, since a loosening of credit constraints may also impact on the house price distribution.

Insert Table 1 Here

The Affordability at Risk (AaR) results for Sydney and Houston are shown in Table 2. We calculate AaR from 1996 to 2006 for Sydney under three different scenarios. First, we allow the Affordable Limit parameters to vary from year to year. Second, we fix the Affordable Limit parameters at their 1996 levels. Third, we fix the Affordable Limit parameters at their 2006 levels. The second and third sets of results are analogous to Laspeyres and Paasche indexes. From the results below we see the difference between purchase affordability and repayment affordability. When we allow parameters to change from year to year (purchase affordability – denoted by AaR_{PA}), it can be seen that affordability is at its lowest level in Sydney in 2002 and in Houston in 2000. When we fix the parameters (repayment affordability), affordability is at its lowest level in Sydney in 2004 for both the Laspeyres and Paasche type indexes, denoted by AaR_{RA96} and AaR_{RA06} respectively.

It is noticeable in Table 2 that purchase affordability remains fairly stable for Sydney from 1996 to 2006 while both measures of repayment affordability deteriorate very significantly. This suggests that the loosening of credit restrictions in the mortgage market has been a major cause of the rise in house prices over this period. That is, a significant proportion of house purchasers seem to have responded to a loosening of credit restrictions by bidding up house prices (this is consistent with the findings of Vigdor 2006). As a result, purchase affordability is not affected much by a loosening of credit restrictions, while repayment affordability is adversely affected. By comparison, purchase affordability in Houston worsened slightly between 1999 and 2006.[6]

Insert Table 2 Here

Changes over time in the affordability of housing for given levels of real income can be observed by graphing the AaR curve for different years denominated in the dollars of one particular year. For example, using the purchase affordability concept, in

[6]We refer to purchase rather than repayment affordability for Houston.

Figure 2 it can be seen that in Sydney in 1996 a household with gross income of $90,000 in 2006 dollars could afford more than 60 percent of houses (i.e., AaR(90,000) < 0.4). By 2001, this percentage had fallen to about 50 percent, since when it has remained reasonably stable. A similar pattern is observed at other income levels. The fact that overall purchase affordability (AaR) in Table 2 actually improved slightly from 1996 to 2001 for Sydney implies that average real incomes must have risen enough over this period to compensate for this decline in purchasing affordability at any given level of real income. A similar pattern is observed in Figure 3 for Houston. For any given level of real income, purchase affordability worsened between 2000 and 2006. The concurrent increase in real incomes over this same period was enough to offset this decline. Overall purchase affordability was virtually the same in 2006 as in 2000.

Insert Figure 2 Here

Insert Figure 3 Here

We plot the Housing Affordability Curve (HAC) for Sydney in 1996, 2001 and 2006 using the purchase affordability concept in Figure 4, and for Houston in 2000 and 2006 in Figure 5. A striking difference between Figures 4 and 5 is that the HAC lies below the 45 degree line for Sydney and above it for Houston. This finding is reflected in the HAI_{PA} results in Table 2. The Housing Affordability Indexes for Sydney are positive, while the corresponding indexes for Houston are negative. This implies that on average, a household on the pth income percentile in Houston can afford to buy a proportion greater than p of the houses on the market while in Sydney a household on the pth percentile can afford to buy a proportion less than p. This difference can be explained by the very high levels of immigration in Sydney [see Robertson (2006)], tough zoning restrictions [see Glaeser and Gyourko (2003)] and the geographical constraints provided by the ocean on one side and the blue mountains on the other. These factors help explain why Sydney was ranked as the seventh most unaffordable market (after five markets in California and Honolulu) in the third annual Demographia International Housing Affordability Survey published in 2007, while by contrast Houston was tied in 122nd place.

Insert Figure 4 Here

Insert Figure 5 Here

We calculate AQA by averaging y_q/x_q over percentiles in the range [0.1 0.9]. The AQA and AaQ(0.5) results for Sydney and Houston are shown in Table 3. A striking feature of Table 3 is the fact that AQA is consistently higher than AaQ(0.5) for both cities, suggesting that the median ratio systematically underestimates the extent of the housing affordability problem.

Insert Table 3 Here

We plot AaQ for each decile for Sydney in 1996, 2001 and 2006 in Figure 6 and for Houston in 2000 and 2006 in Figure 7. Two important findings are revealed in Figures 6 and 7. First, the AaR decile curve for both Sydney and Houston shifts upwards over time. This implies that income affordabilty has deteriorated for all deciles over this period. Second, the price-to-income ratio is far higher for lower income deciles than it is for the median. It follows that the median price-to-income ratio is not representative of all quantiles. This explains why when the price-to-income ratio is averaged across quantiles, as our AQA measure does, we end up with a price-to-income ratio that is systematically higher than the median ratio.

Insert Figure 6 Here

Insert Figure 7 Here

6 Conclusion

In this article we have drawn a distinction between the concepts of purchase and repayment affordability. Purchase affordability considers whether a household is able to borrow enough funds to purchase a house. Repayment affordability considers the burden imposed on a household of repaying the mortgage. We have shown that empirically these two affordability measures diverged very significantly for Sydney over the period 1996 to 2006. This divergence can be attributed to changes in the mortgage market over this period, with the relaxation of credit constraints feeding through into higher house

prices. We also have emphasized the importance of looking at the whole distribution of household income and house prices and not just at medians. In particular, we find that the median price-to-income ratio seems to systematically understate the average of price-to-income quantile ratios, and hence may be a misleading measure of income affordability for the overall population.

References

Bourassa S. C. (1996), "Measuring the Affordability of Homeownership," *Urban Studies* 33(10), 1867-1877.

Brischetto A. and T. Rosewall (2007), "Loan Approvals, Repayments and Housing Credit Growth," *Reserve Bank Bulletin*, July, 1-7.

Chomsisengphet S. and A. Pennington-Cross (2006), "The Evolution of the Subprime Mortgage Market," Federal Reserve Bank of St. Louis *Review* 88(1), 31-56.

Demographia International (2008), 4th Annual Demographia International Housing Affordability Survey, downloadable at ≪http://www.demographia.com/dhi-ix2005q3.pdf≫.

Diewert W. E. (2007), "The Paris OECD-IMF Workshop on Real Estate Price Indexes: Conclusions and Future Directions," Discussion Paper 07-01, School of Economics, University of British Columbia, Vancouver, Canada.

Ellis L. (2006), "Housing and Housing Finance: The View from Australia and Beyond," Research Discussion Paper 2006-12, Reserve Bank of Australia.

Englund, P., J. M. Quigley and C. L. Redfearn (1998), "Improved Price Indexes for Real Estate: Measuring the Course of Swedish Housing Prices," *Journal of Urban Economics* 44, 171-196.

Federal Reserve Bank of San Francisco (2008), *Private Mortgage Insurance*, downloadable at ≪http://www.frbsf.org/publications/consumer/privatemortgage.pdf≫.

Glaeser E. and J. Gyourko (2003), "The Impact of Zoning on Housing Affordability," Federal Reserve Bank of New York *Economic Policy Review* 9(2), 21-39.

Hill, R. J. and D. Melser (2008), "Hedonic Imputation and the Price Index Problem: An Application to Housing," *Economic Inquiry*, forthcoming.

Hulchanski J. D. (1995), "The Concept of Housing Affordability: Six Contemporary Uses of the Housing Expenditure-to-Income Ratio," *Housing Studies* 10(4), 471-491.

Kutty N. K. (2005), "A New Measure of Housing Affordability: Estimates and Analytical Results," *Housing Policy Debate* 16(1), 113-142.

Liu B. and M. T. Skully (2005), "The Determinants of Mortgage Yield Spread Differentials: Securitization," *Journal of Multinational Financial Management* 15(4-5), 314-333.

Manganelli S. and R. F. Engle (2001), "Value at Risk Models in Finance," Working Paper 75, European Central Bank, Frankfurt.

McCarthy J. and R. W. Peach (2004), "Are Home Prices the Next 'Bubble'?" Federal Reserve Bank of New York *Economic Policy Review*, Dec., 1-17.

OECD (2004), "Housing Markets, Wealth and the Business Cycle," *OECD Economic Outlook* 75, Chapter 4, 127-147. OECD Publications: Paris, France.

Piazzesi M., M. Schneider and S. Tuzel (2007), "Housing, Consumption and Asset Pricing," *Journal of Financial Economics* 83, 531-569.

Quigley J. M. and S. Raphael (2004), "Is Housing Unaffordable? Why Isn't It More Affordable," *Journal of Economic Perspectives* 18(1), 191-214.

Robertson R. (2006), *Thinking About the Big Drop in Australian Housing Affordability*, Discussion Draft, Macquarie Research Strategy, Macquarie Bank.

Stone M. (2006), "What is Housing Affordability? The Case for the Residual Income Approach," *Housing Policy Debate* 17(1), 151-184.

Vigdor J. L. (2006), "Liquidity Constraints and Housing Prices: Theory and Evidence from the VA Mortgage Program," *Journal of Public Economics* 90, 1579-1600.

Table 1: Affordable Limit

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Sydney: AL	3.60	4.02	4.17	4.46	4.20	4.53	4.83	5.30	5.77	5.53	5.38
Houston: AL	–	–	–	3.94	3.74	4.17	4.39	4.73	4.77	4.84	4.49

Table 2: Affordability at Risk and Housing Affordability Indexes

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Sydney											
AaR_{PA}	0.62	0.58	0.61	0.61	0.64	0.61	0.63	0.62	0.61	0.60	0.59
AaR_{RA96}	0.62	0.62	0.67	0.69	0.70	0.70	0.74	0.76	0.78	0.76	0.74
AaR_{RA06}	0.47	0.47	0.52	0.55	0.56	0.55	0.59	0.62	0.64	0.62	0.59
HAI_{PA}	0.24	0.16	0.23	0.22	0.29	0.22	0.26	0.24	0.22	0.20	0.18
HAI_{RA96}	0.24	0.24	0.33	0.37	0.39	0.40	0.48	0.52	0.55	0.52	0.49
HAI_{RA06}	-0.07	-0.05	0.05	0.09	0.11	0.09	0.18	0.24	0.29	0.23	0.18
Houston											
AaR_{PA}	–	–	–	0.37	0.42	0.37	0.40	0.39	0.38	0.40	0.42
HAI_{PA}	–	–	–	-0.25	-0.16	-0.25	-0.21	-0.22	-0.24	-0.19	-0.17

Note: AaR=Affordability at Risk, HAI=Housing Affordability Index, PA=purchase affordability, RAt=repayment affordability with the parameters of period t.

Table 3: Average Quantile Affordability (AQA) and Median Price-to-Income Ratios

	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006
Sydney											
AQA	5.11	5.12	5.69	6.20	6.61	6.17	7.01	7.69	7.40	7.13	6.97
AaQ(0.5)	4.65	4.58	5.64	5.87	5.89	5.55	6.10	6.47	6.73	6.45	6.18
Houston											
AQA	–	–	–	2.88	3.09	3.09	3.46	3.70	3.61	3.90	3.78
AaQ(0.5)	–	–	–	2.54	2.89	2.81	3.12	3.36	3.23	3.47	3.37

Figure 1: Example where Median Affordability AaQ(0.5) is Misleading

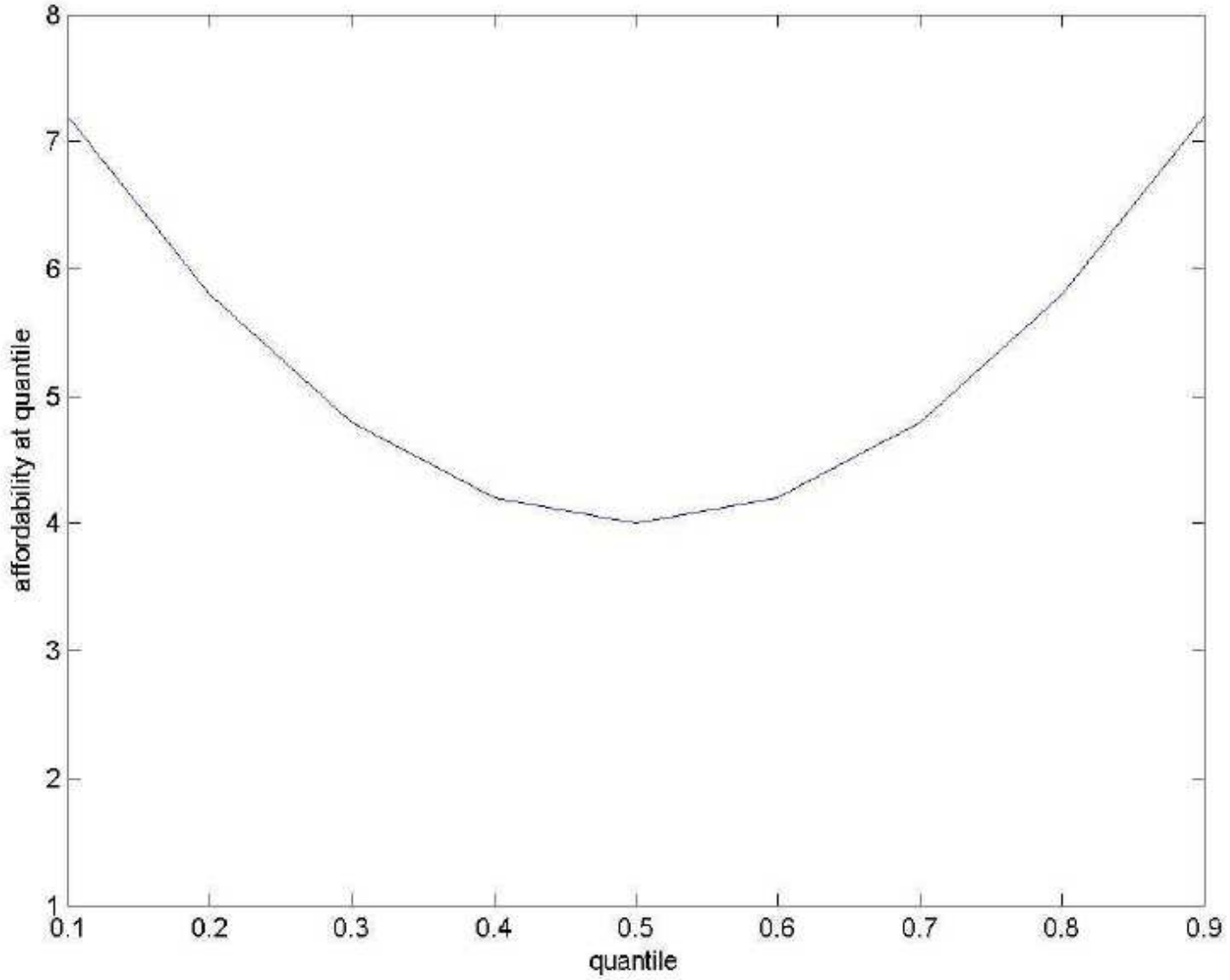

Figure 2: Affordability at Risk (Sydney)

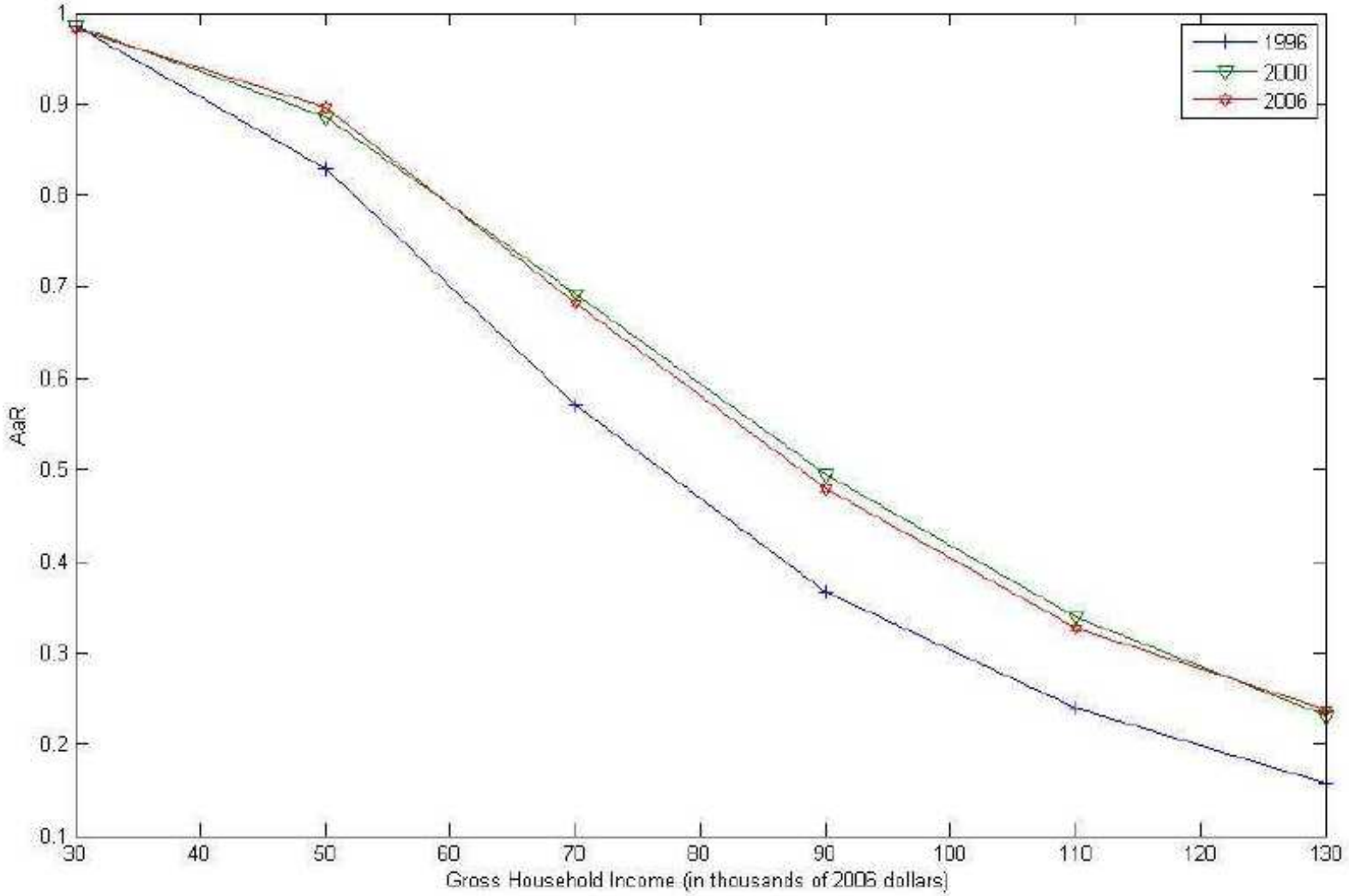

Figure 3: Affordability at Risk (Houston)

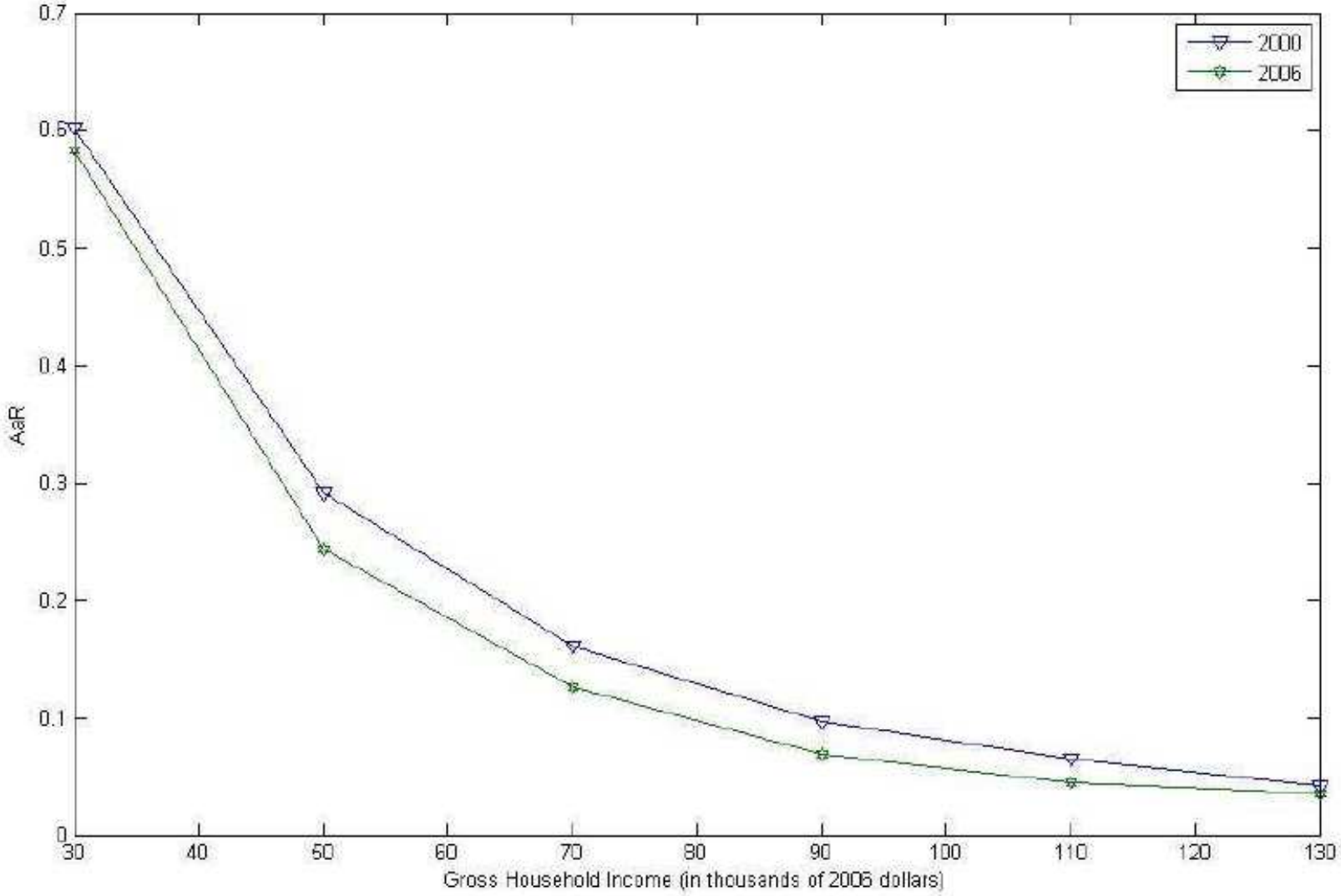

Figure 4: Housing Affordability Curve (Sydney)

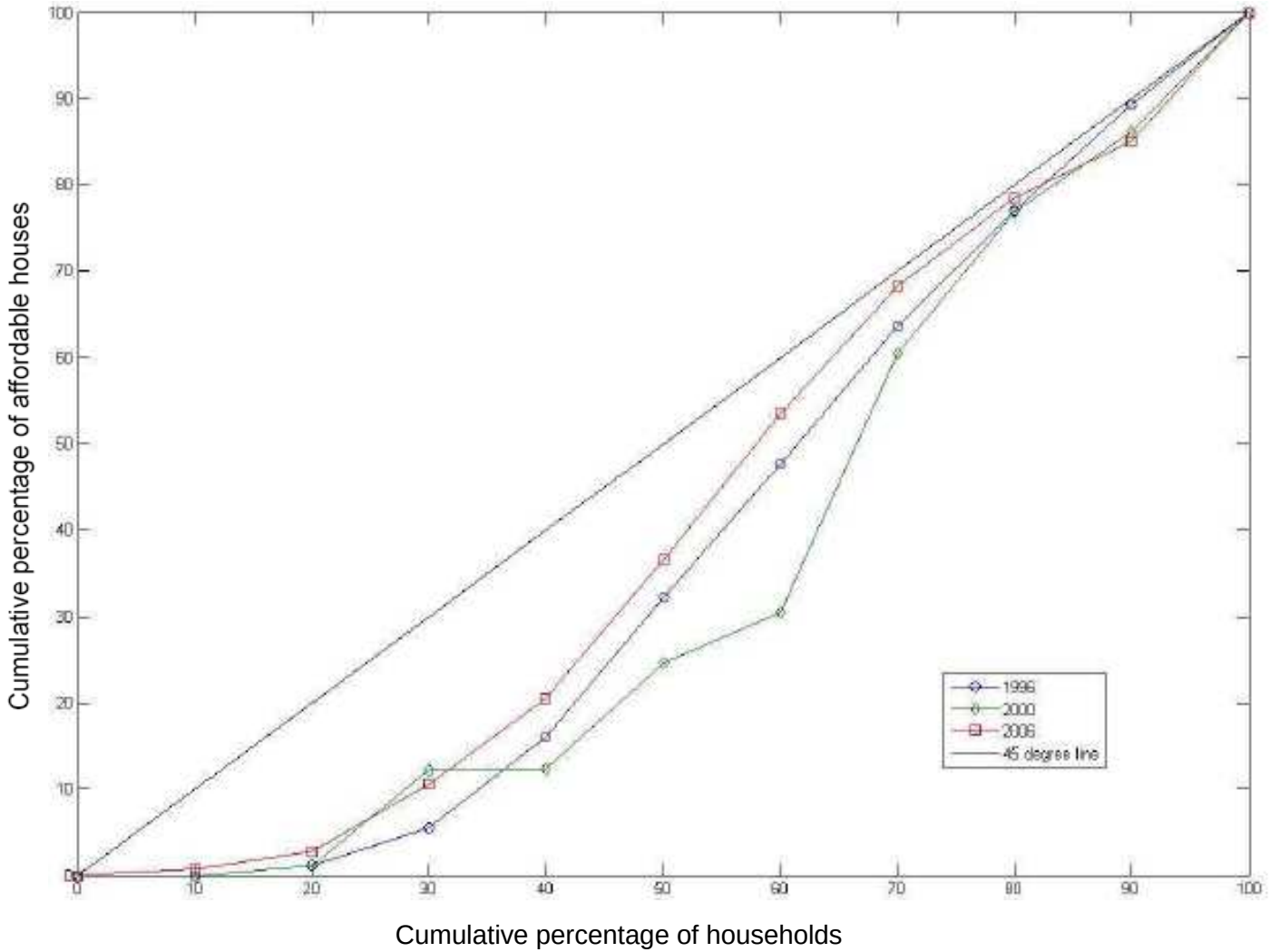

Figure 5: Housing Affordability Curve (Houston)

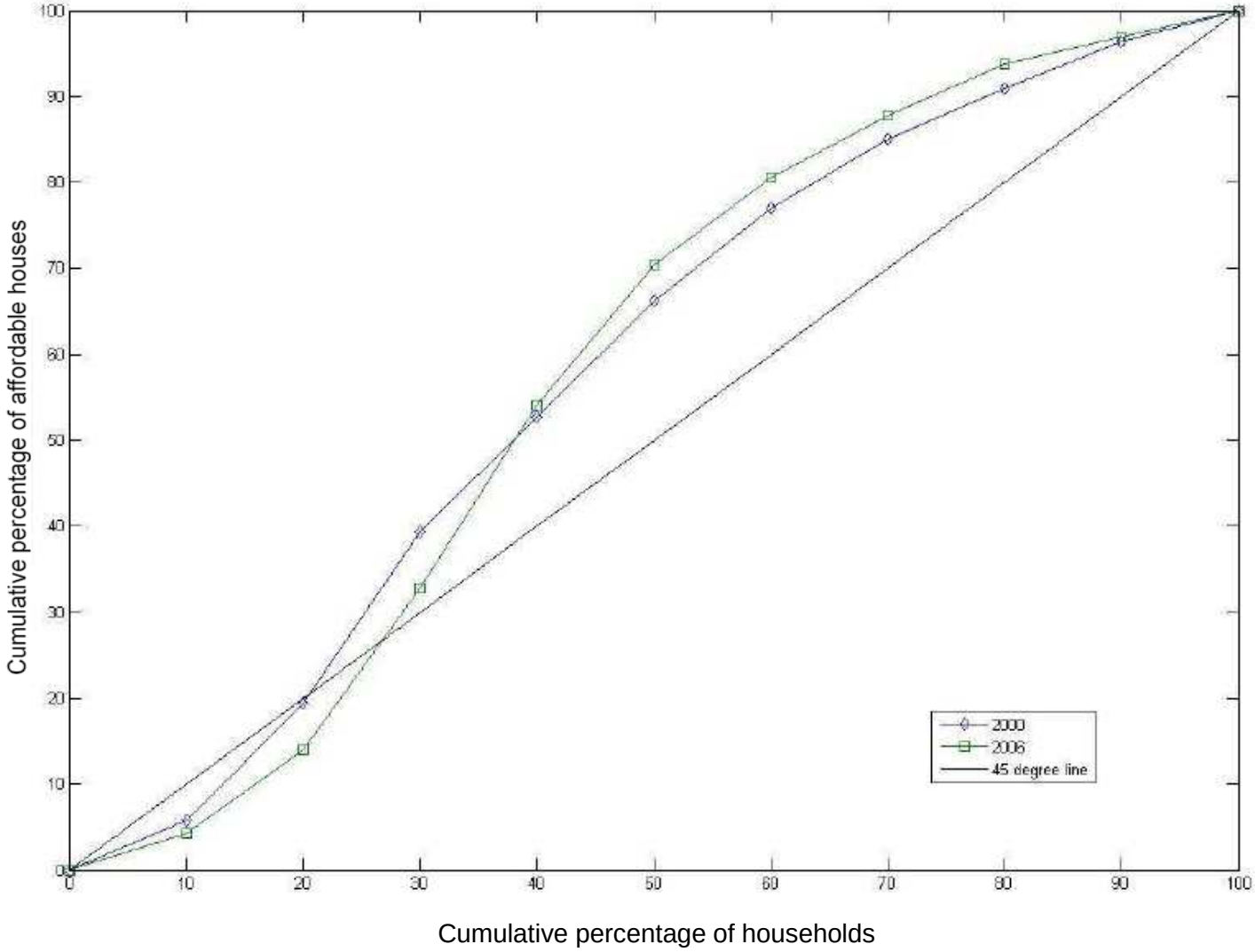

Figure 6: Affordability at Quantile q (Sydney)

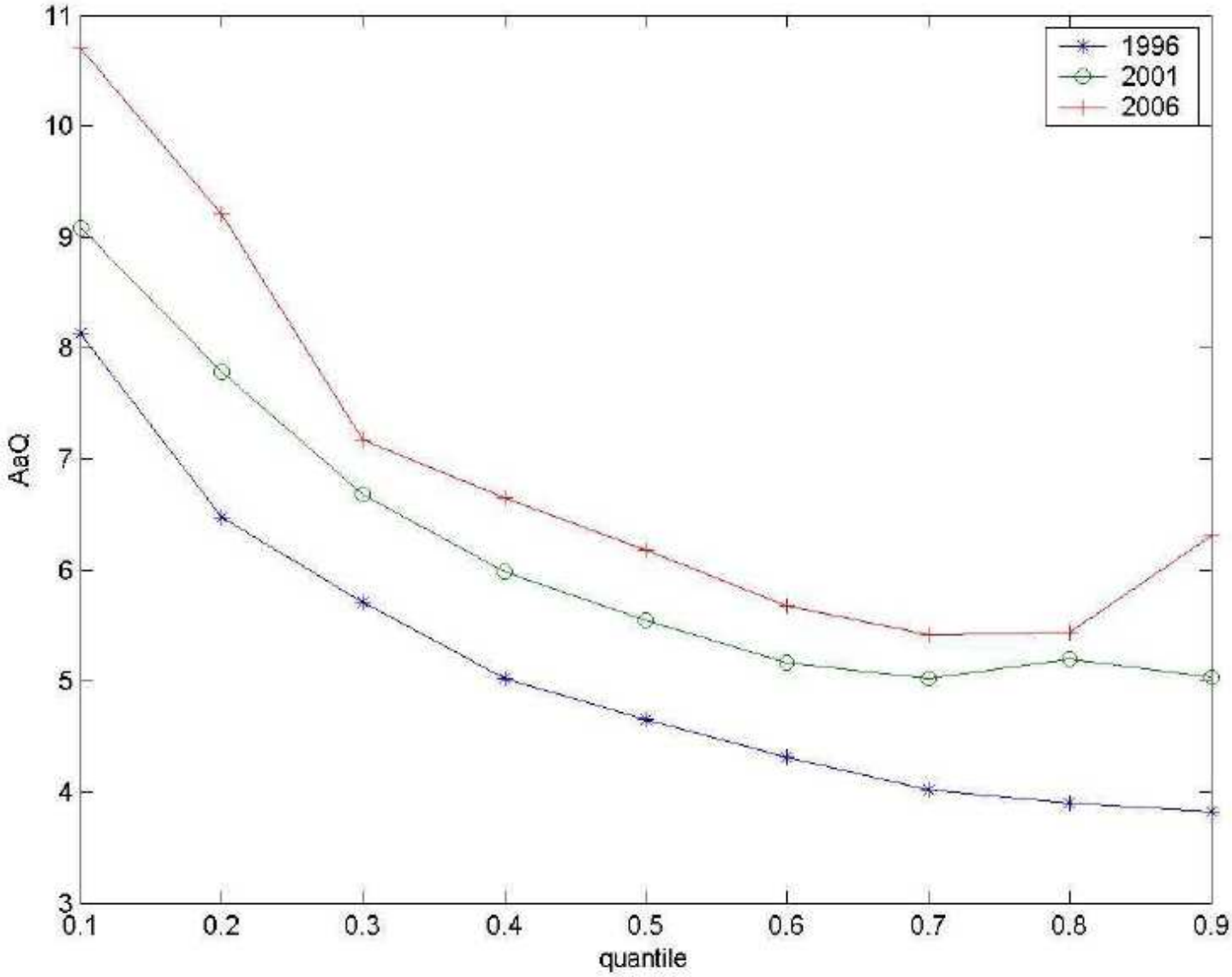

Figure 7: Affordability at Quantile q (Houston)