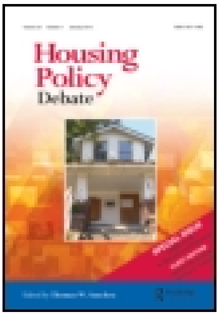

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Housing Affordability and Child Well-Being

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Housing Affordability and Child Well-Being

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We test three hypotheses about the role of housing affordability in child cognitive achievement, behavior, and health. Using longitudinal data from the Panel Study of Income Dynamics, we apply both propensity-score matching and instrumental-variable modeling as identification strategies and test the sensitivity of results to omitted variable bias. The analysis reveals an inverted-U-shaped relation between the fraction of income devoted to housing and cognitive achievement. The inflection point at approximately 30% supports the long-standing rule-of-thumb definition of affordable housing. There is no evidence of affordability effects on behavior or health.

Keywords: housing affordability; child well-being; low-income

There is general agreement that the main housing problem confronting low-income households in the United States is unaffordability. According to the 2010 American Community Survey, more than 88% of renters in the poorest income quintile spent more than 30% of their income on rent, compared with 27% or fewer renters in the middle- and upper-income quintiles.[1] The latest report of the U.S. Department of Housing and Urban Development (HUD) on affordable housing needs notes that household income must be at least 105% of the area median for a household to find housing units that are affordable, available, and physically adequate (Steffen et al., 2011).

Despite these striking statistics, and the fact that a major rationale for assisted-housing policy since the 1930s has been making housing affordable to low-income households, little research has been done on the effects of unaffordable housing on the well-being of residents. In part, this inattention may result because the policy argument for making housing affordable is essentially an income argument: Housing subsidies to make decent housing affordable are equivalent to an income supplement because the subsidies free up cash income that can be spent on other necessities (Newman, 2008). But what happens in the real world is key. Taxpayers have demonstrated their preference for providing in kind those goods that are considered "suitable necessities" (Moffitt, 2003), such as food, health care, and housing, rather than in untied cash. It is therefore important to explore the impact of increased purchasing power tied to housing, in addition to, and separately from, increases in general purchasing power. Another possible reason for the dearth of research on affordability is that, analytically, it is nearly impossible to disentangle the effects of a long-term secular decline in housing affordability from the multitude of other factors that could affect health and well-being. A third reason is the absence of data suitable to the

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task—that is, longitudinal data of sufficient duration that include a rich set of household and housing measures and that are geocoded to allow links to locational measures.

This article assesses this 80-year-old core housing-policy goal. We systematically examine the role of housing affordability from the perspective of child well-being, drawing on the distinct bodies of theory and research in the public-finance, housing, and child-development fields. Because this is among the first efforts to examine the behavioral ramifications of affordability, our analysis is, by definition, exploratory.

The next section further frames the issue and the policy questions motivating this research. This is followed by two sections that review the conceptual framework for the analysis, and the limited previous research on the topic. Next we discuss the measurement of affordability and provide an overview of the methods and data. We then present our results, followed by some concluding observations.[2]

Framing the Issue

From an economics perspective, two features of housing justify government housing policy: Housing creates externalities, and housing is a merit good. The externality argument is that the effects of a housing unit are not restricted to its occupants alone but spill over onto adjacent properties. The crux of the merit-good argument is that "good housing is good for us"—for example, physically decent housing protects its residents from injury and illness. If this makes us more productive members of society, allowing us to pursue more education and to work harder, then the neighborhood stands to benefit from healthy, productive people living near one an other. Sociologists acknowledge these "neighborhood effects" in theories on contagion effects and collective socialization (Jencks & Mayer, 1990).

The policy problem is that private housing consumers take only private benefits into account when they consume housing—not the societal benefits arising from externalities and merit goods. This results in the underconsumption of housing. Information failure also contributes to underconsumption because housing consumers lack information about the benefits of "good" housing.

A key rationale for housing policy, then, is to boost housing consumption. Because housing that is unaffordable results in consumers purchasing less of it than optimal for both the individual and society, the goal of making housing affordable fits within the rationale for housing policy. The broad policy issue is whether making housing affordable is welfare-improving—that is, does it move housing consumption closer to the socially optimal level? In this article, we attempt to gain initial insights into this general housing-policy issue by tackling the narrower question of whether housing affordability affects child well-being.

Conceptual Framework

The conventional view of how housing affordability could affect children's outcomes is by compromising the child's well-being. This would occur if high housing costs force cutbacks in basic necessities, require living in crowded or physically inadequate housing, force frequent moves, or have other deleterious effects on the child's home environment. Such outcomes are based on studies of the effects of income and poverty on child development because housing is one manifestation of a family's financial resources. This literature offers four main conceptualizations of the compromised-well-being hypothesis. The material hardship view states that income allows parents to purchase goods, services, and experiences that benefit child development (Smith, Brooks-Gunn, & Klebanov, 1997; Yeung, Linver, & Brooks-Gunn, 2002). These expenditures include child care, learning materials, enriching activities, and health and dental care. Children in low-income families are assumed to fare worse because they are less likely to benefit from these expenditures and investments by their parents. Similarly, paying for unaffordable housing may deprive families of other goods and services that are necessary for healthy child development.

A second conceptualization, the family stress model, argues that the economic hardship associated with low income or job loss is associated with parental stress and depression, which, in turn, is associated with more inconsistent and punitive parenting. The resulting lower-quality interactions between parent and child are associated with emotional and school problems for children (Conger, Patterson, & Ge, 1995; Elder, 1974; Elder & Caspi, 1988; McLoyd, Jayaratne, Ceballo, & Borquez, 1994). This model can be extended to the economic hardship posed by unaffordable housing.

A third view focuses on the importance of parental time and availability for child well-being, primarily through parental support and supervision (Chase-Lansdale et al., 2003; Morris, Huston, Duncan, Crosby, & Bos, 2001). Parents are less available to their children if household expenditures require working long hours or multiple jobs. Since housing costs constitute the largest share of a household's budget, parents who are attempting to maintain housing costs that exceed their means, typically defined as higher than 30% of income, are likely to be less available to their children, resulting in adverse effects.

A final conception focuses on the deleterious effects of residential instability on children. Residential moves disrupt children's and parents' community ties and networks, and moves to resource-poor communities reduce the quality of services available, including schools, child care, and parks and recreation. While the negative effects of moving can be mitigated by effective parental support (Masten, 2009), current evidence suggests that frequent moves are associated with negative outcomes for school functioning, educational attainment, and behavior (Astone & McLanahan, 1994; Ou & Reynolds, 2008). Poor households have higher rates of residential mobility (U.S. Bureau of the Census, 2010a), which may be linked to their choice—or need—to leave unaffordable housing.

Following the income-and-poverty literature, these four conceptualizations emphasize the hardships created by unaffordable housing, typically defined as spending an excessive share of household income on housing. But the family-stress and residential-instability hypotheses also plausibly apply when lower-income families spend too little on housing (Grigsby & Bourassa, 2004). This would occur, for example, if the only housing available at the low end of the market is physically inadequate and located in distressed neighborhoods. Instead of the traditional view that lower housing cost burdens are "better," this second hypothesis acknowledges the possible deleterious consequences of low housing-cost burdens that translate into a low-quality unit in an unsuitable neighborhood.[3] Assuming that the conventional measurement of housing affordability is the share of income devoted to housing, this amendment to the conceptualization implies an inverted-U-shaped relationship between child outcomes and affordability, with the worst outcomes at both the highest and lowest fractions of the housing-cost-burden distribution.

A less frequently acknowledged hypothesis focuses on locational features, referred to in the public-finance literature as community amenities. This model states that more expensive, less affordable housing is likely to reflect more desirable features of the "community," such as high-quality schools and low crime rates, because these features tend to be capitalized into house prices (Blomquist, Berger, & Hoehn, 1988; Fisher, Pollakowski, & Zabel, 2009; Gyourko, Kahn, & Tracy, 1999). Because these attributes are likely to be beneficial for children, less affordable, more expensive housing may yield positive outcomes for children. Households optimize over their choice set to achieve the same overall utility but with different combinations of goods and services (Zorn, 2011). Children may benefit if parents invest in resource-rich neighborhoods and communities with high-quality schools and low crime rates, or in housing that, for example, provides their children with a quiet place to read or do homework and access to safe play space. The community-amenities hypothesis, then, predicts beneficial effects on child outcomes in less affordable housing, just the opposite of the compromised-well-being hypothesis.[4]

Because of the difference in the direction of effects of affordability on child outcomes between the first two hypotheses and the third, it is impossible to predict the nature of the results. For example, housing-cost burden and locational features could cancel each other out, resulting in no association between affordability and outcomes, or the beneficial features of the location could outweigh the negative effects of housing-cost burden.

Previous Research

Although no prior research has examined the causal effects of housing affordability on child outcomes, several studies examine the related topic of the effects of housing prices on child outcomes. One cross-sectional analysis of the 1997 National Survey of America's Families (Harkness & Newman, 2005) finds that for younger children (ages 6–11), living in a metropolitan area with higher-than-average rents is associated with poorer health. For older children (12–17 years old), higher rents tend to be associated with poorer health and behavior, but these deleterious outcomes disappear in the highest-rent markets. Blau and Haurin (2013) use data from the National Longitudinal Surveys of Youth to estimate fixed-effects instrumental-variable models (see Arellano & Bond, 1991). They find "small or negligible" effects of housing prices on child and young-adult outcomes. Another longitudinal analysis examines housing affordability to shed light on whether the official poverty measure should be adjusted for geographic differences in the cost of living, and particularly the cost of housing, from the specific perspective of child outcomes (Harkness, Newman, & Holupka, 2009). Analyzing the Panel Study of Income Dynamics and its Child Development Supplements (PSID-CDS), the data set also used in the present article, Harkness et al. rely on metropolitan-area rents as their exogenous proxy to represent housing affordability, and apply a difference-in-difference estimation to address selection. The authors find that low-income children growing up in higher-rent housing markets fare no worse than those in lower-rent markets on academic achievement, behavior, and health outcomes. Several studies of food insecurity and hunger produce a mixed picture of the role of house prices. Nord (2000) finds that urban households are less food secure than comparable rural households, and attributes this finding to the lower housing costs in rural areas. Bartfeld and Dunifon (2006), using pooled data from the 1998–2001 Current Population Surveys, find that state-level median rents are a strong predictor of food insecurity. Similarly, Tapogna, Suter, Nord, and Leachman (2004) report a strong association between state median rents and hunger rates. However, an analysis by Harkness, Newman, and Tiehen (2005) fails to confirm a relationship between house prices and food insecurity. Although housing prices are correlated with housing affordability, they are not equivalent. Therefore, the results of these three studies to date pertain most directly to outcomes in higher-priced versus lower-priced markets, not affordability.

Studies of subsidized housing provide indirect evidence of the role of house prices on children's outcomes. Both Currie and Yelowitz (2000) and Newman and Harkness (2002) find beneficial effects, but because subsidized housing is a package of characteristics, with affordability only one among them, it is impossible to attribute the positive findings in these articles to affordability alone. Fertig and Reingold (2007) report no effect of public-housing residence on child health as measured by mothers' reports. But this study relies on self-reported assisted-housing receipt, whose reliability and validity are questionable (Martin & Shroder, 1996). The Welfare to Work Voucher experiment, which randomly issued vouchers to current, former, or eligible Temporary Assistance for Needy Families recipients in six locations, finds a significant reduction in homelessness but detects no effects of housing vouchers on multiple measures of child well-being (Abt Associates Inc. et al., 2006; Wood, Turnham, & Mills 2008). However, because the improvements in housing and neighborhood circumstances of voucher recipients typically occur as the result of a residential move, the authors caution that the move itself may have been disruptive to the child and that beneficial effects may take longer to emerge (Abt Associates Inc. et al., 2006).

The literature on the effects of income on child well-being is also relevant because spending more of the household budget on housing means less discretionary income. While the economics literature finds evidence of a health gradient, that is, a positive relationship between income and children's health (Case, Lubotsky, & Paxson, 2002; Condliffe & Link, 2008; Currie & Stabile, 2003), the developmental literature finds only a weak effect, if any. This discrepancy probably arises because the developmental literature typically focuses on lower-income children, thereby attenuating the relationship between income and health. Summarizing across an extensive literature developed over more than three decades (e.g., G. Duncan, Yeung, Brooks-Gunn, & Smith, 1998; O. Duncan, Featherman, & Duncan, 1972; Gershoff, Aber, Raver, & Lennon, 2007; Hauser, 1973; Jencks et al., 1979; Yeung & Conley, 2008; Yeung et al., 2002), the effect of income is typically small, present primarily for educational achievement and cognitive outcomes but not behavior or health, larger in early than in later childhood, and stronger among low-income than among higher-income families. The mixed results and small effect sizes led Mayer (1997) to conclude that the effect of family income is mostly spurious. By contrast, a natural experiment in which Cherokee families received an average payment of $6,000 from casino profits found a 40% decline in behavioral symptoms among children moving out of poverty (Costello, Compton, Keeler, & Angold, 2003). Adding further to the confusion is that income has been found to explain only about 14% of material hardship (Mayer & Jencks, 1989). Thus, the long-standing assumption that family income is the critical element in material well-being may be incorrect. The current study considers whether housing-cost burden operates similarly to income by having differential effects on cognitive achievement, behavior, and health. It also provides insights into the effects of a housing affordability measure of material hardship on child outcomes.

Defining Affordability

The fraction of household income devoted to housing costs, or housing-cost burden, is the most widely used measure of affordability. It is relied on by financial institutions, HUD, researchers, and the media. The generally agreed-upon rule of thumb in both the public and the private sectors is that housing is affordable if the household's housing-cost burden is roughly 30% or less. HUD (2007) designates a cost burden of 30–50% as moderate and greater than 50% as severe. The housing-cost-burden measure, therefore, ranks high on policy relevance and face validity.

However, because the ultimate objective of this analysis is to estimate the causal effects of affordability, housing-cost burden is problematic because it is endogenous. Households exert at least some degree of choice over how much they spend on their housing, and it is likely that some of the factors associated with these choices could affect children's outcomes. This makes it difficult to interpret results because it is impossible to know how much of the estimated effect stems from higher housing-cost burden and how much from other factors, such as unmeasured characteristics of parents that are correlated with high or low housing-cost burdens.

As described later under Methods, we address this endogeneity problem by testing models using two different statistical approaches: propensity-score matching and an instrumental variable (IV). Propensity-score matching approximates an experiment in which household characteristics are fixed but housing affordability varies. This provides an explicit test of the compromised-well-being hypothesis resulting from both high and low housing-cost burdens. The IV approach accounts for both observed and unobserved differences by using a variable that is correlated with the causal variable, in this case housing-cost burden, but is uncorrelated with the outcomes. Variation in the instrument creates a "natural experiment" (Angrist & Pischke, 2009). Controls for locational features in both the propensity and IV models address the third hypothesis about the benefits to children of community endowments.

Research Approach

Data

This analysis relies on the PSID and its 1997 and 2002 CDS surveys. The PSID is an ongoing longitudinal survey of American households begun in 1968 by the Survey Research Center at the University of Michigan. Annual interviews were conducted until 1997 and biennially thereafter. The original 5,000 sample families have been followed over time, along with new families who split off from these families. Low-income families were originally oversampled, and despite differentially greater attrition among this subgroup, they remain overrepresented.

The CDS was designed to provide a comprehensive assessment of children and their families. All households participating in the 1997 PSID with children 12 or younger were eligible for the CDS sample. Data were collected on 3,563 children from 2,394 families, yielding a response rate of 88%. In 2002, when the CDS children were 5 to 17 years old, data were collected on 2,907 children from 2,019 families.[5] The 1997 and 2002 CDS surveys include a rich range of questions about children's physical, psychological, and emotional health, cognitive ability (e.g., tests of academic achievement), and behavior problems (Hofferth, Davis-Kean, Davis, & Finkelstein, 1997).

The PSID is the main source of demographic and socioeconomic attributes of parents and other family members. The first-wave 1997 CDS is the source of a measure of the mother's cognitive ability, while the 2002 CDS provides the child-outcome measures, as described later.[6] Data on socioeconomic attributes (e.g., family income, welfare receipt) and household composition (e.g., number of parents and siblings in the household) are averaged over the life of each child to account for possible cumulative effects over childhood (Todd & Wolpin, 2003). To avoid simultaneity bias, averages cover the period from birth to 2001, the year preceding the outcomes. School measures (described below) are missing for children in the 1997 CDS sample who had not yet reached school age. Therefore, we use 2002 school-quality measures for these youngest children. Models reestimated with 1997 school measures plus a dummy variable for missing values on these variables produce substantively similar results.

Data from multiple sources linked via geocodes provide measures of housing prices and locational features. These include metropolitan-area rent data from HUD, school-quality measures from the National Center for Educational Statistics Common Core of Data, crime data from the Uniform Crime Reports of the U.S. Department of Justice, a natural-amenities scale developed by the U.S. Department of Agriculture Economic Research Service, measures of climate and weather from the National Oceanographic and Atmospheric Administration, and measures of investments in facilities and resources (and by extension their quality) from the Census of Governments collected every 5 years.[7]

We limit the sample to children with 2002 CDS data who always lived in the same housing market (i.e., metropolitan area). This restriction is necessary in light of evidence that mismatches in labor and, by extension, housing markets bias nonexperimental studies because market characteristics are key determinants of both income and housing costs (Heckman, Ichimura, & Todd, 1997). Allowing intermetropolitan moves might result in problematic matches (e.g., children who spent their entire childhood in a moderately dense market could be matched with children who spent half of their life in a very densely populated market and the other half in a very low-density market). Beyond improving the comparability of matches on geographic measures, limiting the sample to movers within housing markets also reduces the problem of self-selection into more or less expensive and resource rich (or poor) markets.[8]

The sample is further limited to the 813 children who spent at least half of their childhood in families with incomes at or below 200% of the federal poverty line (roughly $30,000 for a family of three in 2001 and 2002; see Office of the Federal Register, 2002). Chow tests confirm that income subgroups up to 200% of poverty can be pooled, as can owners and renters.[9] We restrict our analysis of cognitive outcomes to the 688 children with complete data on cognitive measures.

Methods

As noted, although the proportion of household income spent on housing is the most widely used and understood measure of housing affordability, it is likely endogenous. Housing affordability is a function of household and family characteristics that determine how much a household is willing and able to spend, and many of these characteristics may have their own direct effects on child outcomes. A household willing to pay more to live in a better school district, for instance, probably places a higher value on educational attainment, which could have its own positive effects on child outcomes. In addition, housing affordability is also a function of how much a household has to pay in a specific housing market, and this market price is a function of neighborhood and community characteristics that may also have their own direct effects on child outcomes. The methodological challenge is to estimate the separate effect of housing affordability on child outcomes when the factors that determine how much a household is willing and able to pay, as well as the factors that influence how much a household has to pay, may have their own effects on outcomes.

We use two methods to estimate the separate effects of housing affordability. First, we develop propensity scores to match households with a similar constellation of household, family, and locational features but different housing-cost burdens. This simulates an experiment in which housing affordability is the intervention. Second, we use an IV that represents the variation in a measure of house prices across housing markets. This approach takes advantage of the relationship among locational features, housing prices, and housing affordability. If the IV is valid, housing prices should not have a statistically significant effect on child outcomes in models that include locational features, but they should have a significant effect when locational features are excluded.

The convergence of results from these two different identification strategies provides a check on the reliability of the results from each. But even if both analyses provide comparable results, there still can be concerns over omitted variables because the propensity approach controls for observed variables only and because controls for community features may be insufficient to fully purge the IV of all effects on child outcomes. Therefore, we conduct sensitivity tests that estimate whether the results would change under two different assumptions about the size of the effects of omitted variables.

Propensity-Score Matching

Propensity-score matching simulates an experiment in which household income is fixed, and we compare child well-being under different housing-affordability scenarios. Assume two scenarios where housing-cost burdens are p_0 and p_1, with $p_1 > p_0$. Propensity-score matching provides a way to analytically approximate this design. Procedurally, we begin by predicting housing cost burden (Z), the affordability measure, given individual, household, and locational characteristics (X):

$$\hat{Z} = f(X) \tag{1}$$

We then match cases based on $\hat{Z}$ (i.e., grouping the cases within strata of $\hat{Z}$), checking the quality of matches on each individual, household, and locational characteristic used in matching to make sure the Xs balance within each stratum. In a third step, we use ordinary least squares (OLS) to estimate child outcomes (Y) as a function of stratum dummies, housing affordability, and individual, household, and locational characteristics:

$$Y = f(\text{stratum dummies}, Z, X) \tag{2}$$

Typically, propensity-score matching is used with a dichotomous treatment condition (Z), in which cases are divided into "treatment" or "control." But propensity scores can also be used with continuous treatment measures, as in the present case, where we measure housing affordability using housing-cost burden.[10] Various matching methods can be used in propensity analysis. Some, such as 1:1 and k:1 matching, require dropping cases without appropriate matches. Imai and van Dyk (2004), however, recommend subclassification when propensity scores are used with nondichotomous/continuous treatment conditions. Subclassification creates groups based on similar propensity scores and has the advantage of using all cases in the analysis (Stuart, 2010).[11]

The first-stage propensity model includes a broad range of variables that may reasonably be associated with treatment assignment, in this case housing-cost burden, because excluding a potentially important confounding variable can introduce bias (Stuart, 2010). Concerns about the exclusion of unobservables in propensity methods is somewhat abated by the recent statistical literature demonstrating that the inclusion of an extensive set of covariates in the propensity model produces results similar to those of experimental designs (Cook, Shadish, & Wong, 2008; Cook, Steiner, & Pohl, 2009; Steiner, Cook, & Shadish, 2011; Stuart, 2010). Therefore, we include a broad array of controls in the first-stage propensity model. Beyond demographics and other background measures, we include measures of parenting, self-esteem, efficacy, and depression, along with multiple locational measures, as shown in Table A1.

The second-stage outcome model examines the relationship between housing-cost burden and child outcomes. The outcome model includes both propensity-stratum indicators (dummy variables) and additional covariates. The outcome model is therefore doubly robust because a reliable estimate will be produced as long as either the propensity or outcome regression model is correct (Kang & Schafer, 2007).[12]

The propensity-score approach assumes that unmeasured characteristics (U) that predict Y are independent of housing-cost burden (Z) after controlling for individual, household, and locational characteristics (X):

$$U \perp Z|X \tag{3}$$

IV Approach

We use a measure of metropolitan-area housing prices, HUD's "fair market rents" (FMRs), as the IV for housing-cost burden. Our intuition behind this IV is that housing prices are correlated with housing-cost burdens but should not be correlated with child outcomes once we remove the relationship between housing prices and locational features. That is, what affects child outcomes is what is capitalized into housing prices, not housing prices per se. Thus, although higher housing prices are likely to be associated with better-performing schools via such pathways as higher property taxes, once we purge the price measure of these locational attributes via controls in the second-stage outcome models, we eliminate this endogeneity. Additionally, excluding intermetro movers removes selection based on locational attributes. Evidence that this IV meets the exclusion rule is that the housing-price measure has no effect on child outcomes, never achieving statistical significance at even the 10% level when models include locational features (results available upon request).

HUD sets the FMR annually for every housing market in the country and uses this measure to determine eligibility of rental housing units for the Housing Choice Voucher rental-assistance program. "The FMR for an area is the amount that would be needed to pay the gross rent (shelter rent plus utilities) of privately-owned, decent, and safe rental housing of a modest (non-luxury) nature with suitable amenities" Office of the Federal Register, 2011). It is generally set at the 40th percentile of the rent distribution for standard-quality units occupied by recent movers. Strengths of the FMR for this study are that it is adjusted annually for every housing market, it is strongly grounded in actual policy, and it is available from 1986, when the oldest children in the PSID-CDS analysis sample used in this study were born. This provides a consistent time series of house-price measures over the life of each child.

The standard IV model assumes a linear specification in the second stage (Terza, Bradford, & Dismuke, 2007). However, our conceptualization of worse child outcomes at both low and high housing-cost burdens requires a nonlinear specification, and a likelihood ratio test (presented later) supports this curvilinear form. Therefore, we use the two-stage residual inclusion (2SRI) method (Terza, Basu, & Rathouz, 2008; J. Terza, personal communication, March 6, 2012).[13] The first stage estimates a nonlinear regression model:

$$X_{\mathrm{p}} = \exp^{(W,B)} \tag{4}$$

where X_{p} is the predicted causal factor (here, housing-cost burden), W is the instrument, and B is a set of additional covariates. We compute the residual by subtracting the predicted causal score, X_p from the observed causal score, X_u:

$$X_{resid} = X_u - X_p \quad (5)$$

The second stage includes this residual term in an OLS model of each outcome:

$$Y_i = X + X^2 + X^3 + B + X_{resid} \quad (6)$$

where Y_i is the outcome; X, X^2, and X^3 are linear, quadratic, and cubic expressions of the causal factor, respectively; B is a vector of additional covariates; and X_{resid} is the residual from the first-stage model.

Sensitivity Testing

There is no way to guarantee in any observational study that unobserved factors are not causing the observed relationships. However, following a procedure recommended by VanderWeele and Arah (2011), we test how different assumptions about the strength of the relationship between an unknown covariate, $U*$, to both housing cost burden (Z) and child outcomes (Y), affects the observed relationship between Z and Y. Results that are sustained under reasonable assumptions about the effect of omitted variables provide further confidence in the estimates.

Measures

Dependent Variables

Table 1 provides a brief description of each outcome measure. The PSID-CDS measures children's cognitive development using scores on tests in the battery of the well-established Woodcock–Johnson (W–J) Revised Tests of Achievement: letter word, passage comprehension, and applied problems (Woodcock & Johnson, 1990). We combine the first two W–J tests, which pertain to reading comprehension and verbal ability and are highly correlated ($r = .73$), into a broad reading measure. The third W–J test measures math ability. Behavior is assessed using the Behavior Problems Index (BPI), an abbreviated version of the Child Behavior Check List (Peterson & Zill, 1986). The BPI includes questions such as how often the child is disobedient or has trouble getting along with other children.[14] The child's health is measured using a 5-point ordinal scale, ranging from 1 = poor to 5 = excellent, and is based on a question asked of the primary caregiver, typically the mother.[15,16] All children in the 2002 PSID-CDS have BPI assessments and health ratings. Although missing data on the cognitive scores range between about 5% and 15%, there are few statistically significant differences between those with full data compared with those missing cognitive data.[17]

Independent Variables

The key covariate and policy variable of interest is housing-cost burden. Housing costs are the sum of (1) mortgage principal, mortgage interest, property taxes, and homeowners insurance (for owners); (2) rent (for renters); and (3) out-of-pocket utility costs (electricity, fuel, water, and sewer).[18] Housing-cost burden is the ratio of housing costs to total household income.

Demographic characteristics include child's age, sex, race and ethnicity, number of siblings, and mother's age. Socioeconomic background attributes include mother's

Table 1. Description of child outcomes.

Variable	Sample *N* (% of total)	Scoring range	Description[a]
W–J broad reading (age 6+)	693 (100%)	1–200 (avg. = 100.1)	Combination of W–J letter-word (57-item test measuring child's reading skills) and W–J reading passage (43-item test measuring language comprehension and vocabulary) comprehension. Both tests are normed,[b] standardized average (100). Higher score indicates better reading skills. Broad reading score is computed by averaging the two tests.
W–J math: Applied problems (age 5+)[c]	692 (99%)	1–200 (avg. = 98.6)	60-item test measuring child's skill analyzing and solving practical math problems. Normed,[b] standardized average (100). Higher score indicates better math skills.
Behavior Problems Index	813 (100%)	30–90 (avg. = 45)	Average of 30 items asked of primary caregiver about child's behavior in past 3 months. Higher score indicates more behavioral problems.
Health status	813 (100%)	1–5	Primary caregiver's assessment of child's general health; 5-point range from 1 = excellent to 5 = poor.

Note. W–J = Woodcock–Johnson Revised Tests of Achievement. Sample limited to families with incomes ≤ 200% of poverty for 50% or more of child's life.
[a]Descriptions summarized from "CDS II Measurement Domains by Data Collection Module" (last updated September 28, 2004), developed by the Institute for Social Research, University of Michigan (2004). Retrieved from http://psidonline.isr.umich.edu/CDS/questionnaires/cdsiimeas.pdf
[b]Normed score is based on a child's test score (number of correct items) compared with a normative table of scores based on the child's age to determine the percentile the child falls into, which is the score for that child on that test.
[c]Sample for cognitive outcomes (W–J tests) restricted to children with W–J broad reading scores.

education, family income, welfare receipt, and family structure. Based on past research, we also control for whether the child was breastfed as an infant, mother's cognitive ability, whether the child had a consistent caregiver during childhood, and residential mobility.[19] All monetary values are adjusted to constant 2002 dollars.

We address the community-amenities hypothesis with direct measures of locational features for different levels of geography, from the school the child attended to the metropolitan area in which the child resides. The quality of the child's school is captured with two measures: the fraction of students in the school receiving subsidized lunch,[20] and the number of full-time teachers. The latter pertains to school size, whose relationship to achievement is the subject of considerable debate (e.g., Borland, Howsen, & Trawick, 2005; Leithwood & Jantzi, 2009; Levine, 2010; Weiss, Carolan, & Baker-Smith, 2010). School measures apply to the individual schools that PSID children attended. Although these measures are available for children in public schools only, more than 95% of children in the study sample attended public schools. Neighborhood measures include the census-tract poverty rate and the respondent's self-reported assessments of the neighborhood's quality and safety. Metropolitan-area measures include violent (Part I) crimes per 100,000 population,[21] natural amenities,[22] library expenditures per capita and park expenditures per capita (to measure community investment), housing vacancy rate, and population density.

We also include an index of housing prices, measured by HUD's FMRs, as a covariate in the propensity models and as the instrument in the IV models.[23] All locational features appear in the first-stage propensity-score model because it is advisable to include a broad range of measures, as noted earlier. To avoid multicollinearity, all other models include a representative subset of these characteristics.[24]

Results

Sample Characteristics[25]

The PSID-CDS analysis sample of households with incomes at or below 200% of poverty and with at least one child age 5–17 in 2002 is distributed across 86 metropolitan areas and 58 nonmetropolitan areas. The sample is concentrated primarily in large metro areas of 1 million or more.

Table 2 provides a wide range of descriptive statistics on the analysis sample. In all cases, differences between these values and those for a cross-section of children in the same age range in the 2002 CDS are statistically significant ($p \leq .001$). Children in the analysis sample rate lower on all four outcomes, consistent with their lower income. Their W–J broad reading score is 5 points lower than that of the cross-section sample and 6 points lower on the W–J applied problems test. The mean BPI value for analysis-sample children is nearly 20% of a standard deviation higher than in the cross-section, and the health rating, typically provided by the mother, is about three-tenths of a point lower, which is roughly 30% of a standard deviation.

It may be surprising to see that despite being a low-income sample, average housing-cost burdens across childhood are only 31% of income, roughly the rule-of-thumb definition of housing affordability. Families accomplish this by living in housing units that rent, on average, for $450, roughly $200 less than the FMR in their respective housing markets. Thus, their rents fall considerably below the 40th percentile, which HUD considers the threshold for achieving decent and safe housing conditions. They also live in lower-priced "neighborhoods," as reflected by the median tract rent of $433.[26] Consistent with these lower-than-FMR actual housing costs is that, over childhood, nearly half of the children never experienced severe (51% or greater) housing-cost burdens. But about 17% experienced severe burdens for half of their childhoods or longer, and the remaining roughly 34% experienced severe burdens at some point.

The fact that, on average, analysis-sample families pay $200 less than the FMR and almost half never experience severe housing-cost burdens raises an intriguing possibility. Perhaps some of these families are particularly resourceful and maximize the potential benefits to their children from high-priced housing markets while maintaining affordable housing costs by finding the least expensive units in expensive housing markets. We examined this possibility by looking at children living in the most expensive housing markets (top two FMR quintiles) but whose housing costs were low (bottom two quintiles). This analysis indicates that about 10% of families meet these criteria, living in a well-below-market-rate housing unit in an expensive housing market. But without controls for housing quality (which do not exist in the PSID), it is impossible to say whether they found a true "bargain" in the sense of a dwelling in sound shape in a decent neighborhood. Preliminary analysis suggests that these families generally fit a profile of being more capable. For example, compared with other households, mothers have more education and higher cognitive and self-efficacy scores, and families have higher incomes, fewer children, lower rates of welfare receipt, and fewer residential moves.

Table 2. Univariate statistics of the Child Development Supplements to the Panel Study of Income Dynamics.

	Mean (standard deviation)
Child outcomes	
W–J broad reading score	100.14 (16.84)
W–J applied problems test	98.56 (15.43)
Behavior Problems Index	45.02 (10.19)
Health status	4.16 (0.86)
Housing affordability	
Average housing-cost burden (HCB)	31.2 (19.7)
Average monthly housing cost	\$450 (\$267)
Average fair market rent	\$660 (\$165)
Median tract rent	\$433 (\$159)
% years HCB > 30%	32.5 (29.5)
% years HCB > 40%	22.0 (25.9)
% years HCB > 50%	16.5 (21.6)
Background	
Child female	49.5 (50)
Age of child, 2002	10.0 (3.64)
Age of mother, 2002	35.85 (7.59)
Breastfed as infant	42.0 (49.4)
Mother's education < high school	30.0 (45.8)
Mother's education = high school	42.3 (49.4)
Mother's education = some college	19.4 (39.6)
Mother's education = college grad	5.5 (22.9)
Mother's cognitive test score	28.75 (4.85)
Average family income	\$23,881 (\$11,628)
% years in two-parent family	46.9 (40.8)
Never in two-parent family	28 (45.0)
% years on welfare	48.7 (36.5)
Always on welfare	17 (37.5)
Number of siblings in household	1.76 (1.17)
Number of years with move	2.25 (2.10)
Primary caregiver consistent	93 (25.8)
% White	36.2 (48.1)
% Black	41.9 (49.4)
% Hispanic	17.6 (38.1)
% other	4.4 (20.4)
% years in owned home	34.3 (37.9)
% always own	16.0 (36.3)
% always rent	41.0 (49.3)
Home Observation Measurement of the Environment cognitive subscale	8.67 (2.21)
Parental warmth	4.46 (0.61)
Parental activities	2.23 (0.64)
Rosenberg self-esteem scale	3.36 (0.37)
Pearlin self-efficacy scale	3.09 (0.42)
Kessler depression scale	0.75 (0.48)
Community and metropolitan characteristics	
Number of full-time equivalent teachers	43.63 (28.60)
% receiving free/reduced-price lunch	51.92 (22.16)
Average persons per room	0.91 (0.41)
Neighborhood poverty	22.63 (12.96)
Neighborhood quality	3.28 (0.98)
Neighborhood danger	2.06 (0.69)

(*Continued*)

Table 2 – *continued*

	Mean (standard deviation)
Crimes per 100,000 population	3,393.2 (1,356.0)
Natural-amenities scale	0.96 (3.28)
Library expenditures per capita	$25.85 ($15.05)
Park expenditures per capita	$83.79 ($54.46)
% metropolitan vacant housing units	9.0 (4.9)
Metro population per square mile	1,950 (5,698)
Northeast	2.0 (14.3)
Mid-Atlantic	11.0 (31.0)
East North Central	19.0 (39.1)
West North Central	7.0 (25.4)
Mountain	8.0 (27.1)
Pacific	14.0 (34.2)
West South Central	12.0 (32.8)
East South Central	10.0 (30.0)
South Atlantic	18.0 (38.1)

Note:
1. Sample limited to families with incomes $\leq$ 200 percent of poverty for 50 percent or more of child's life.
2. Weighted estimates. Unweighted $N = 813$.
3. Child outcomes measured in 2002, time-varying measures averaged from child's birth to 2001.
4. Monetary values expressed in 2002 constant dollars.
5. Table includes all variables used in creating propensity strata; some of these variables are not discussed in text.

Although the 31% average housing-cost burden that children experience over their childhood years is very similar to the 29% cross-sectional estimate for 2001, this similarity belies fluctuations in income and housing costs over time. Further analysis demonstrates that in any one year, income and housing cost could have been more than 50% higher or lower than their respective averages over childhood ($23,881 for income, $450 for housing cost). However, 29% of children never experience such a dramatic change in income, and an additional 15% experience a change of this magnitude only once during childhood. For housing cost, 43% of children never experience a change of 50% or more, and 17% experience it only once. Thus, the small disparity between the cross-sectional and time-series estimates of housing affordability probably arises because the average child in this sample experienced relatively small income and housing-cost variations over childhood.

On average, children are 10 years of age, with an even gender split. Mothers are about 36 years old; nearly 70% have at least a high school degree, but only about 6% are college graduates. The cognitive scores of mothers in this sample are nearly one-third lower than those for the full 2002 sample.

Consistent with a threshold income of 200% of poverty, this is a disadvantaged sample. As already noted, the average income is less than $24,000, more than 60% of the sample is minority, and children spent nearly half of their childhood on welfare and less than half of their lives in a two-parent family. They also experienced considerable residential instability, averaging more than two moves over childhood. However, most (93%) have had stable caregiving, defined as the same primary caregiver over time.

The average FMR, the measure of house prices, is $660, only $25 less (14% of a standard deviation) than for the 2002 cross-section. Among locational features, the largest difference between children in this sample and the 2002 CDS is in neighborhood poverty. On average, analysis-sample children live in tracts with roughly 23% of households below poverty, which is nearly three-fourths of a standard deviation higher than for the full sample. Another sizable difference is the fraction of children in the sample child's school who receive subsidized lunch. The 44% average among analysis-sample children is more than half a standard deviation higher than for the full sample. Parents' ratings of neighborhood quality and danger are also distinct between the analysis sample and the full sample (nearly half of a standard deviation for each measure). Differences for other locational measures are much smaller, in the range of 15% of a standard deviation or less, although the direction of the difference consistently shows analysis-sample children to be worse off.

Multivariate Models

Tables A1 and A3 provide the results of the first-stage propensity and IV models, respectively. Unfortunately, there is no direct test of the strength of an IV in nonlinear equations. The Stock–Yogo test of IV strength, a variation on the *F*-test, assumes that both stages of the IV model are linear (Murray, 2006; Terza et al., 2007, 2008). Because our IV model and the 2SRI estimation method that we implement are nonlinear, the Stock–Yogo test is inappropriate.[27] Unfortunately, similar constructs for nonlinear models and estimators do not currently exist (J. Terza, personal communication, February 19, 2013). Suggestive evidence of the IV's strength is reassuring, however. The FMR IV is statistically significant ($p \leq .001$) in the first-stage model and is also a significant predictor of child outcomes in models that exclude locational covariates. However, once these locational covariates are included, thereby purging the price variable of its endogeneity, its effect disappears and the FMR measure does not even approach statistical significance at conventional levels.

The theoretical framework hypothesizes a nonlinear relationship between housing-cost burden and child outcomes, with worse outcomes occurring at both low and high housing-cost burdens.[28] These hypotheses are consistent with two functional forms: quadratic, which specifies a U- or inverted-U-shaped distribution, and cubic, which also conforms to an inverted-U-shaped distribution but with a flattening of the tails of the distribution.

We therefore assess the conceptual framework by testing three specifications of the relationship between housing-cost burden and child outcomes: linear, quadratic, and cubed. Because the linear model is nested within the quadratic, and the quadratic within the cubic, we can use a likelihood ratio test to estimate the relative improvement in explanatory power from adding each of the nonlinear terms, thereby determining the best-fitting functional form (Kleinbaum, Kupper, Muller, & Nizam, 1998; Singer & Willett, 2003).

Table 3 demonstrates that nonlinear specifications of cognitive outcome models fit best for both the propensity (top panel) and IV (bottom panel) approaches. The table provides linear, quadratic, and cubic log-likelihood values for the four outcomes, and *p*-values for comparisons between the linear and quadratic and between the quadratic and cubic models.[29] For both the propensity and IV models, the quadratic specification is the best fit for W–J broad reading, and the quadratic-plus-cubic specification is the best fit for W–J applied problems. None of the nonlinear specifications fit either the behavior or health outcome models better than the linear model, however.

Table 4 indicates that housing affordability, measured by the family's housing-cost burden, has a statistically significant effect on child cognitive achievement but not on behavior or health, consistent with the literature on the role of income and poverty in child well-being (e.g., G. Duncan et al., 1998; Yeung et al., 2002). The table lists the estimated coefficients (and *p*-values) of the propensity models (top panel) and IV models (bottom panel) on housing-cost burden for each outcome (full regression results are shown in Tables A2 and A4). We also include Wald-test results to assess the statistical significance

Table 3. Goodness-of-fit tests.

	W–J broad reading	W–J applied problems	BPI	Health status
A. Propensity-score model				
Log likelihood				
Linear HCB	−2,756.9998	−2,717.1482	−2,942.0493	−948.0285
Quadratic HCB	−2,753.7218	−2,714.6523	−2,942.0452	−948.0147
Cubic HCB	−2,753.5145	−2,710.7396	−2,942.0362	−946.5299
p*-value of log likelihood test*				
Quadratic to linear	.010	.010	.928	.868
Cubic to quadratic	.520	.005	.893	.085
Best-fitting model	Quadratic	Cubic	Linear	Linear
B. Instrumental-variable model				
Log likelihood				
Linear HCB	−2,787.3051	−2,740.3319	−2,959.8964	−974.4063
Quadratic HCB	−2,782.3727	−2,735.6372	−2,959.8886	−974.3130
Cubic HCB	−2,782.3567	−2,729.4856	−2,959.8620	−973.1142
p*-value of log likelihood test*				
Quadratic to linear	.002	.003	.901	.666
Cubic to quadratic	.858	< .001	.818	.121
Best-fitting model	Quadratic	Cubic	Linear	Linear

Note. BPI = Behavior Problems Index; HCB = housing-cost burden; W–J = Woodcock–Johnson Revised Test of Achievement. Sample limited to families with incomes ≤ 200% of poverty for 50% or more of child's life. Unweighted N = 688 for W–J tests, 805 for BPI and health. Weighted regression. P-value of the likelihood ratio test statistic. The test statistic is defined as 2[(log likelihood of model 2) – (log likelihood of model 1)].

of the full set of housing-cost-burden variables.[30] Housing-cost burden has a statistically significant effect on the two cognitive-achievement measures in both the propensity and IV models. By contrast, neither behavior nor health is predicted by housing affordability in either set of models.

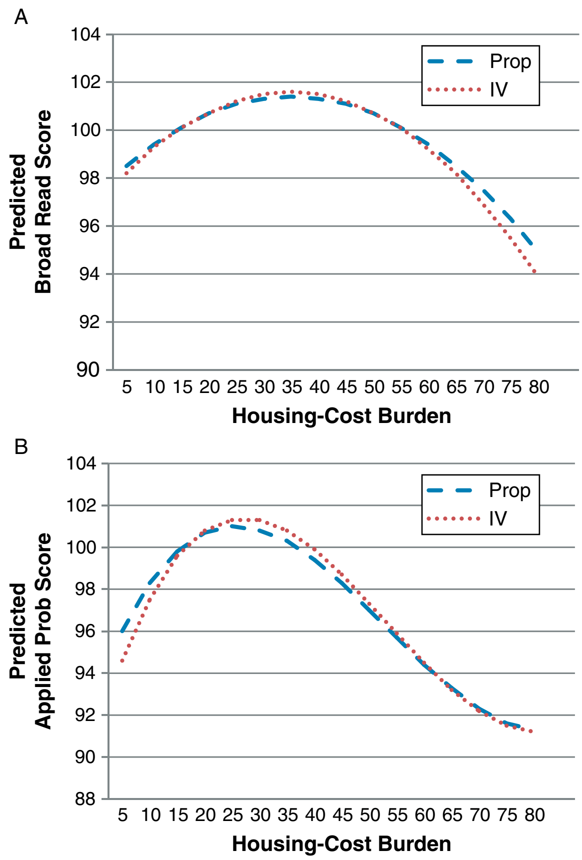
To assess whether poor cognitive achievement is associated with the highest housing-cost burdens, as posited by the first hypothesis, or with the lowest cost burdens, consistent with the second hypothesis, Figure 1 plots the predicted outcomes of the two cognitive

Table 4. Regression results: housing affordability.

	W–J broad reading	W–J applied problems	BPI	Health status
A. Propensity-score model				
HCB	.223* (.105)	.711* (.278)	−.037 (.033)	−.004 (.003)
HCB^2	−3.189*** (1.223)	−18.256* (7.167)		
HCB^3		.114* (.049)		
Wald test	3.62 (.027)	3.31 (.037)	1.32 (.250)	2.12 (.146)
B. Instrumental-variable model				
HCB	.264 (.214)	.886** (.334)	−.073 (.100)	−.004 (.010)
HCB^2	−3.783** (1.257)	−21.909** (6.920)		
HCB^3		.136** (.048)		
Wald test	5.17 (.006)	5.01 (.007)	.52 (.469)	.14 (.710)

Note. BPI = Behavior Problems Index. HCB = housing-cost burden. W–J = Woodcock–Johnson Revised Test of Achievement. Sample limited to families with incomes ≤ 200% of poverty for 50% or more of child's life. Regression coefficients, robust standard errors in parentheses. Unweighted N = 688 for W–J tests, 805 for BPI and health. Weighted regression. $HCB^2 = (HCB \times HCB)/1{,}000$; $HCB^3 = (HCB \times HCB \times HCB)/1{,}000$. Wald test of likelihood that $HCB = HCB^2 = HCB^3 = 0$ (when HCB^2 or HCB^3 in model). F-test value, p value in parentheses. *≤ .05; **≤ .01; ***≤ .001.

Figure 1. Predicted standardized effects, cognitive achievement tests (Woodcock–Johnson Revised Test of Achievement). A: Broad reading. B: Applied problems.



Note: IV, instrumental-variable model; Prop, propensity-score model.
1. Sample limited to families with incomes $\leq$ 200 percent of poverty for 50 percent or more of child' life.
2. Unweighted $N = 688$ for W-J tests. Weighted regressions.

tests (W–J broad reading and W–J applied problems) across the affordability distribution for those models where housing-cost burden is statistically significant. Two features of these graphs are particularly noteworthy. First, the general pattern in both graphs is an inverted U, denoting better cognitive performance in the middle of the distribution and worse performance at both high and low levels of housing-cost burden. In addition, the inflection point occurs at a housing-cost burden in the general range of 30%, the long-standing rule-of-thumb definition of affordable housing.[31]

Although the traditional approach to characterizing the size of effects is to follow Cohen's (1988) general guidelines, Hill, Bloom, Black, and Lipsey (2007) argue persuasively for using empirical benchmarks that are relevant to the particular topic being analyzed. Therefore, our frame of reference for judging the size of housing affordability effects consists of the two strongest predictors of cognitive outcomes in this analysis: mother's cognitive score and whether the child was breastfed as an infant. For example, in both the propensity and IV models, a one-standard-deviation change in mother's cognitive

Table 5. Change in effect sizes for strongest predictors and housing-cost burden: Cognitive achievement.

		W–J broad reading	W–J applied problems
A. Strongest predictors, propensity-score model			
Mother's cognitive	Beta	0.245	0.215
	Test score points	4.126	3.317
Breastfed as infant	Beta	0.192	0.195
	Test score points	3.233	3.009
Change in HCB			
10% to 30%	Beta	0.113	0.167
	Test score points	1.912	2.581
60% to 30%	Beta	0.114	0.415
	Test score points	1.914	6.407
B. Strongest predictors, instrumental-variable model			
Mother's cognitive	Beta	0.210	0.183
	Test score points	3.536	2.824
Breastfed as infant	Beta	0.202	0.203
	Test score points	3.402	3.132
Change in HCB			
10% to 30%	Beta	0.134	0.243
	Test score points	2.250	3.744
60% to 30%	Beta	0.137	0.442
	Test score points	2.300	6.817

Note. HCB, housing-cost burden; W–J, Woodcock–Johnson Revised Test of Achievement. Sample limited to families with incomes $\leq$ 200% of poverty for 50% or more of child's life. Unweighted $N = 688$ for W–J tests, 806 for BPI and health. Weighted regression. For change in HCB, beta = change in outcome predicted by change in HCB divided by standard deviation of outcome.

score produces a 3–4-point change in the child's W–J broad reading score and a 3-point change in the W–J applied problems score.

Table 5 shows, for both the propensity (top panel) and IV (bottom panel) models, the standardized betas and changes in test scores for these two strong predictors and for housing-cost burden. We compare the effects of moving from a housing-cost burden of 60%, corresponding to the 90th percentile of the distribution, to the 30% standard, which falls at about the middle of the distribution, and from a housing-cost burden of 10%, roughly the 10th percentile of the distribution, to the 30% standard. Moving from a high housing-cost burden of 60% to the rule-of-thumb level of 30% increases test scores by 1.9 points for W–J broad reading in the propensity model and by 2.3 points in the IV model. These effects are roughly one-half to two-thirds as large as the improvements associated with mother's cognitive score or whether the child was breastfed. The effects on W–J applied problems are larger, at 6.4 points (propensity) and 6.8 points (IV). The effects are more modest from increasing the housing-cost burden from 10% to 30%. The W–J broad reading score increases by 1.9 points (propensity) or 2.3 points (IV), again about one-half to two-thirds as strong as the effects of the two strongest predictors. The effects on W–J applied problems—2.6 points (propensity) and 3.7 points (IV)—are nearly as large, or larger than, the effects of the strongest predictors.

Sensitivity Tests

The comparability of results across the propensity-matching and IV approaches is reassuring. To stress-test estimates even further, we conduct an additional analysis of the propensity-matching results because this method addresses only differences in observed characteristics between households with high and low housing-cost burdens, leaving the possibility that unobserved differences could still bias the results (Altonji, Elder, & Taber, 2005; Shadish, Clark, & Steiner, 2008; Stuart, 2010). This supplementary analysis tests the sensitivity of the propensity model results to different assumptions about the size of the bias, following the approach developed by VanderWeele and Arah (2011). It uses observed relationships to draw logical inferences about values for two parameters: the relationship between the unmeasured factor $U*$ and outcomes, Y; and the relationship between $U*$ and housing-cost burden, Z. A reasonable assumption is that omitted variables have the median effect on child outcomes and housing-cost burden, based on observed relationships. Thus, we apply the median effect of covariates on the outcome (beta = 0.1; median test score increments of 1.6–1.9) and the median correlation of covariates to housing-cost burden (0.15). The most conservative test of the estimated effect of $U*$ on Y assumes that the unmeasured factor has an effect on child outcomes as large as the strongest predictor, mother's cognitive test score (beta = 0.24; 4.1 score points), and that the correlation between $U*$ and Z (housing-cost burden) is equivalent to the largest correlation in this analysis: between the percentage of the child's life spent in a two-person family and housing-cost burden ($r = .32$).

Table 6 summarizes the results.[32] Looking first at the effect of moving from the less affordable 60% housing-cost burden to a more affordable 30%, the main propensity regressions (see Table 5) show increases in both the W–J broad reading score (1.9 points) and the W–J applied problem score (6.4 points). The reasonable bias adjustment retains all results. The conservative bias adjustment retains an effect on W–J applied problems that is still more than two-thirds as large as the effect of mother's cognitive score (2.1 score points versus 3.3 score points, respectively), but the effect on W–J broad reading disappears. Turning next to the effect of moving from a very low housing-cost burden of 10% to the "standard" burden of 30%, the main propensity regressions indicate increases in both the W–J broad reading score (1.9 points) and the W–J applied problems score (2.6 points). Here, again, the reasonable bias adjustment has little effect on results of moving

Table 6. Sensitivity tests of omitted variable bias on effect sizes for propensity model results.

		W–J broad reading	W–J applied problems
Change from 10% to 30% HCB		0.113	0.167
Conservative adjustment	Beta	0.029	0.059
	Test score points	0.49	0.91
Moderate adjustment	Beta	0.079	0.099
	Test score points	1.33	1.52
Change from 60% to 30% HCB		0.114	0.415
Conservative adjustment	Beta	0.028	0.136
	Test score points	0.47	2.10
Moderate adjustment	Beta	0.075	0.161
	Test score points	1.27	2.48

Note. HCB, housing-cost burden; W–J, Woodcock–Johnson Revised Test of Achievement. Sample limited to families with incomes ≤ 200% of poverty for 50% or more of child's life. Unweighted $N = 688$. Weighted estimates. Conservative adjustment based on largest observed relationship between measured covariates and outcome (mother's cognitive, beta = 0.24) and largest observed correlation between measured covariates and HCB (percentage years in two-parent family, $r = .322$). Moderate adjustment based on median observed relationship between measured covariates and outcome (beta = 0.1) and median observed correlation between measured covariates and HCB ($r = .15$).

from a 10% to a 30% housing-cost burden. Under the conservative bias adjustment, the effect on W–J broad reading essentially disappears, while the effect on W–J applied problems drops by more than two-thirds from the main regression result (0.9 score points). Using bias adjustments midway between the conservative and reasonable values yields results that are 55–60% as large as those reported in Table 5 for both W–J broad reading and W–J applied problems, and for both from moving from unaffordable to affordable (60% to 30% housing-cost burden) and from low cost burden to affordable (10% to 30% housing-cost burden). Overall, the sensitivity tests bolster the propensity model results and lend further support to the consistent relationship between housing affordability and children's cognitive achievement demonstrated by both the propensity and IV models.

Discussion

This study focuses on households with children and with incomes at or below 200% of poverty who did not move between metropolitan areas over the period of this analysis. We test three distinct views about how housing affordability could affect a lower-income child's well-being. The first view represents the conventional wisdom. It posits that healthy child development is jeopardized when families devote too large a share of their low incomes to housing costs. The second view predicts deleterious outcomes from the opposite housing-affordability condition: devoting too small a share of a family's low income to housing. The third hypothesis states that because less affordable housing is likely to be located in more expensive areas, it may be beneficial to children because desirable features of these communities, such as higher-quality schools and low crime rates, are capitalized into house prices.

We find substantial support for the first two hypotheses. Consistent with the results of an extensive literature on the effects of family income on child development among lower-income households, housing affordability affects children's cognitive achievement but not their behavior or health (e.g., G. Duncan et al., 1998; Yeung et al., 2002). This consistency may occur because housing affordability is one manifestation of a family's financial resources and material hardship. The disparate results for cognitive achievement versus behavior has been interpreted as the ability of higher-income families to invest resources in their children's development, while behavior problems are more closely linked to family events and family process (G. Duncan et al., 1998; Yeung et al., 2002).

Among those paying a very large share of their income for housing, simple correlations offer some support for the family-stress interpretation of how housing affordability conveys its effects to children's cognitive achievement. Mothers in families living in unaffordable housing rank significantly higher on the Kessler Depression Scale than do their counterparts in more affordable circumstances. For those paying too small a share of income for housing, however, the explanation may lie in housing and neighborhood characteristics such as living in physically inadequate housing or in distressed neighborhoods. In the current analysis samples, reports of neighborhood quality are significantly lower in families with very low housing-cost burdens compared with other families, and they live in areas with lower community investment and that ranked lower on the amenities scale than the average sample family. Recent work by Emrath and Taylor (2012) finds that the very large majority of households living in physically inadequate dwelling units and dwellings in deteriorated neighborhoods pay less than 30% of their income for rent. Other research reports that the physical environment of the child's home has a strong mediating effect on cognitive ability (Yeung et al., 2002). This intriguing circumstantial evidence at both ends of the affordability distribution suggests possible mechanisms through which housing affordability may affect cognitive achievement. In future work, we plan to examine these mediating pathways systematically using unique data to be collected as part of the MacArthur Research Network on Housing and Families with Children.

We find no support for the third hypothesis, concerning the role of locational characteristics. The addition of locational controls to the outcome models does not appreciably change the size or significance of effects of affordability on any of the four child outcomes. However, this probably occurs because very few families live in what could be considered "high-priced housing" (e.g., only 4% had monthly housing costs of $1,000 or more in 2002). Although higher the housing-cost burdens are correlated with significantly higher house prices and desirable locational features, we cannot take this story much further. Therefore, this analysis simply does not provide a fair test of the community-amenities hypothesis.

From a housing-policy perspective, several findings are particularly noteworthy. First, finding that the inflection point is at approximately 30% validates the long-standing 30% housing-cost-burden rule of thumb relied upon by both the public and the private sectors to define affordable housing, because the inflection point of children's cognitive achievement approximates this level. However, although cognitive achievement is worse when the housing-cost burden exceeds HUD's 51% threshold definition of a severe burden compared with 30%, this effect is roughly half that at a housing-cost burden of 60%.[33] Thus, at least from the perspective of children's cognitive achievement, the most deleterious consequences are not observed until the housing-cost burden reaches about 60%. More than 40% of the sample children experienced a housing-cost burden of 60% or more during their childhood, although, fortunately, only 10% were in this status for half or more of childhood.

Third, the markedly poorer cognitive performance of children in families with extremely low housing-cost burdens undercuts the implicit housing-policy assumption that lower housing-cost burdens are "better." Finding that the average poor family actually spends about $200 less per month on housing than the 40th-percentile rent designated by HUD as the rent that achieves adequate housing raises the optimistic prospect that at least some of these families are particularly resourceful and live in the least expensive units in high-priced areas. But only about 10% of the lower-income families in this analysis appear to fit this resourcefulness profile, and this group does not overlap substantially with families having very low housing-cost burdens of 10% or less. Very-low-housing-cost-burden families have a mixed socioeconomic profile. On the one hand, their incomes are 40% higher than the average, and throughout the observation period, they were more likely to own a home and to be two-parent families and less likely to receive welfare or make residential moves. On the other hand, they tend to live in small metropolitan and nonmetropolitan areas with lower-than-average house prices, community investment, and amenities. They also rated their neighborhood quality lower than did the average household. A more likely scenario than finding a bargain, solid-quality unit in a good neighborhood, then, is living in a low-quality housing unit and neighborhood—as suggested by Grigsby and Bourassa (2004) and Emrath and Taylor (2012)—with spillover effects on children's cognitive achievement. On a positive note, only about 10% of lower-income children spend more than half of their childhood years in these very-low-housing-expenditure situations, and even a modestly higher housing-cost burden of 15–20% reduces the negative effect on cognitive achievement substantially.

Another explanation for the negative effects of extremely low cost burdens may have to do with how parents in highly affordable units spend their relatively greater disposable incomes. In principle, affordable housing enables parents to spend more on their children, both for necessities, such as medical care, and for enrichment, including books, computers, and educational trips. Recent research finds that lower-income parents in affordable housing actually spend more on child enrichment (Newman, & Holupka, 2014).

From a broader policy perspective, this analysis demonstrates that although housing affordability and income have similar effects on children's cognitive achievement, housing affordability is not simply a proxy for income. As already noted, it is plausible that very low housing-cost burdens result in poorer cognitive performance because children in these families are living in inadequate housing and neighborhood environments. Perhaps even more strikingly, there is a roughly monotonic relationship between income and housing-cost burden, with incomes decreasing as cost burden increases. If higher disposable income were the main source of the cost-burden effect, the relation between housing-cost burden and child outcomes should display a linear, negative slope, not the curvilinear relationship we find in this analysis.

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Notes

1. Authors' calculations based on the 2010 American Community Survey's 1 - year sample (U.S. Bureau of the Census, 2012).
2. The main analysis results are provided in tables. All other analyses and results discussed are documented in a technical appendix available from the authors.
3. This hypothesis addresses a major criticism of the housing-cost-burden measure, namely, that it does not account for differences in housing quality (Belsky, Goodman, & Drew, 2005; Bogdon & Can, 1997; Goodman, 2001; Hulchanski, 1995).
4. This hypothesis may also be extended to the social environment associated with more-affordable versus less-affordable locations. In this case, a mechanism such as collective socialization or contagion (e.g., Jencks & Mayer, 1990) would result in beneficial effects for poor children. Although this hypothesis has never been tested, qualitative research on children living in poor, inner-city neighborhoods compared with more affluent, suburban neighborhoods suggests that children benefit more from the institutional resources available in the suburban settings than from social interaction with more affluent neighbors (Keels, 2008).
5. This represents 84% of families interviewed in 1997 and 74% of families eligible for the 1997 wave.
6. Children were ages 0–12 in the 1997 CDS and 5–17 in the 2002 CDS. Thus, the period of observation for the oldest child in this analysis is 1986–2001, with outcomes measured in 2002.
7. Data are interpolated linearly between decennial years, and state estimates are used as proxies for nonmetropolitan areas.
8. Only a minority of households migrate from one housing market to another. In 2010, for example, roughly 20% of the population made intermetropolitan moves in the prior year (U.S. Bureau of the Census, 2010b). Excluding intermetro movers results in the loss of only 26% of cases. Intermetro movers have higher incomes, more education, and lower average housing-cost burdens than do nonmovers and intrametro movers, supporting concerns about self-selection effects that could bias results if these cases were included in the analysis.
9. Chow test results are available in a technical appendix available from the authors. Because the PSID-CDS is nationally representative, some fraction of the children in this sample lived in assisted housing. We examined whether relationships differed when the assisted housing

subgroup was excluded using a special version of the PSID in which PSID addresses between 1968 and 1995 have been matched to assisted-housing addresses (see Newman & Schnare, 1997, for a description of the PSID-Assisted Housing Database). The fraction of cases with at least 1 year of assisted-housing receipt is 11.4%. Results do not differ substantively when we exclude these cases.

10. Raudenbush, Jean, and Art (2011), for example, compute propensity scores on a measure of school mobility that, while bounded, is essentially continuous.
11. The number of propensity strata required to obtain balance (i.e., absence of a statistically significant relationship between each covariate and housing-cost burden controlling for propensity stratum) is determined in an iterative process, varying the number of strata until the best balance is obtained on all covariates. The cognitive-outcomes sample required 19 strata to obtain balance on all covariates, and the behavior and health sample required 15 strata.
12. We thank one of the reviewers for highlighting this double robustness.
13. While some argue that linearity restrictions are not necessarily a major concern with IV models (e.g., Angrist & Pischke, 2009), others, such as Leamer (1983), come to the opposite conclusion. Recent work by Mogstad and Wiswall (2010) and Løken, Mogstad, and Wiswall (2012), for instance, demonstrates that IV and fixed-effect models are sensitive to functional form assumptions. It is also possible to estimate nonlinear IV models such as ours using extensions of the standard two-stage predictor substitution (2SPS) method because the model is linear in the parameters, although this would require finding additional instruments for the power terms. However, Terza et al. (2008) find that the 2SRI method is consistently superior to the 2SPS in estimating nonlinear IV models, and this is therefore the approach we have chosen.
14. The BPI is skewed because most children have few, if any, problems. However, logging the BPI has no effect on results. For ease of interpretation, we present the OLS estimates of the untransformed BPI.
15. Models estimated using an ordered logit instead of OLS produced similar results (see technical appendix available from authors). We present OLS estimates for ease of interpretation.
16. Roughly 96% of caregivers rated the child's health as "excellent," "very good," or "good." Therefore, reverse causality (poor health affecting family income and housing cost) is unlikely.
17. Missing data arises for various reasons such as the age thresholds for cognitive questions (6 or older for W–J broad reading) and limitations on distances that PSID-CDS interviewers were authorized to travel to interview respondents (Hofferth et al., 1997).
18. We imputed utility costs for renters in years in which none or only a subset of utility costs were collected by the PSID. Respondents are asked how much rent *they pay* per month, not the monthly rent of the unit. This should avoid confusion for those receiving housing assistance where part of the monthly rent is covered by a government subsidy. (There are no instances of families that were "no cash renters" across childhood in this sample. Any year with zero rent is averaged into the rent calculation across childhood years; see technical appendix available from authors for details.) We also include the category "other lodging expenses," a miscellany of expenses (e.g., special security fees in condos and co-ops) that are relatively rare and nominal.
19. Previous research indicates that breastfeeding has positive effects on child development (Kramer, 2005; Lawrence, 2005; Perez-Escamilla, 2005; Woodward & Liberty, 2005). In the PSID-CDS, mother's cognitive ability is based on a passage comprehension test of the W–J Achievement Test–Revised during the 1997 CDS interview.
20. Children eligible for subsidized lunches score between 0.69 and 0.76 standard deviations below ineligible children on a commonly used standardized achievement test (the National Assessment of Educational Progress; Pallas, 2010).
21. Part I crimes included are murder, rape, robbery, assault, burglary, larceny, and motor vehicle theft (arson is excluded because it is not reported uniformly). Crime data cover the 1985–2002 period and are matched to the child's housing market.
22. The six items in this scale are average January temperature, average days of sun in January, winter/summer low temperature gap, average July humidity, topographic variation, and water area in county (McGranahan, 1999).
23. There are few missing data on the independent variables with the exception of a few locational features. We assign the mean when less than 1% of cases are missing. If these measures indicate a difference between Whites and Blacks, we assign the mean for each race instead of the full sample mean. If missing data exceed 1% of cases, we use regression model–based imputation.

24. The propensity-score first-stage model also includes measures of the census geographic division and crowding in the home (persons per room).
25. This description pertains to the full analysis sample of 813 children.
26. About 35% of poor children live in the central cities or counties of their metro areas, which tend to have lower rents than do the rest of their metro areas that include more expensive, suburban jurisdictions.
27. There is no obvious connection between the Stock–Yogo test results for the linear case (test statistics, corresponding asymptotics, and tables of critical values) and the nonlinear contexts for which 2SRI is appropriate (J. Terza, personal communication, February 19, 2013).
28. The community-amenities hypothesis predicts better outcomes in higher-priced markets, and higher housing prices are correlated with higher housing-cost burdens. However, it is unclear how controls for locational features will affect the shape of the relationship between housing-cost burden and child outcomes. We therefore focus on the housing-cost-burden hypotheses, controlling for locational features.
29. Although we tested all combinations of these three specifications, we display only the two that reveal the most distinct patterns. Assuming linear = a, quadratic = b, and cubic = c, if b is superior to a, and c is superior to b, then because a is nested in b, c must also be superior to a. Further, if b is not superior to a, but c is superior to b, then c must also be superior to a.
30. It is inappropriate to look at the individual effects of polynomial variables. For linear models, the *p*-values from the Wald test are identical to the regression results. For quadratic models, the Wald test shows the likelihood that both the linear and quadratic terms are zero. For the cubic model, the Wald test shows the likelihood that the linear, quadratic, and cubic terms are zero.
31. The inflection point in the propensity and IV models is 35% in both cases for W–J broad reading, and 26% and 27%, respectively, for W–J applied problems. The range of scores for W–J broad reading is approximately 50% larger than the range for the W–J applied problems (36–185 versus 43–150, respectively), and the distribution for broad reading is more skewed (skewness value of 0.81 versus 0.03, respectively). The more skewed distribution for broad reading may be pulling the inflection point upward compared with the more normal distribution for applied problems.
32. Table 5 provides the results for housing-cost burden. Results for the mother's cognitive score appear in Table 4.
33. At 51%, there is a decrement of about 1 test score point for the W–J broad reading test and 4 points for W–J applied problems test.

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Appendix

Table A1. Propensity regression results.

	Housing-cost burden: Cognitive sample	Housing-cost burden: Total sample
Fair market rent	1.3799 (0.9008) [0.1260]	1.9515^{+} (1.1717) [0.0962]
Child female	−1.1028 (1.3218) [0.4044]	−2.2558^{+}(1.3463) [0.0942]
Age of child, 2002	−0.2552 (0.2805) [0.3633]	−0.0776 (0.2524) [0.7587]
Age of mother, 2002	−0.2574* (0.1073) [0.0167]	−0.2101* (0.1034) [0.0424]
Breastfed as infant	−1.3785 (1.5715) [0.3807]	−1.6432 (1.6326) [0.3145]
Mother's education < high school	3.3012^{+} (1.9479) [0.0906]	2.4218 (2.0027) [0.2270]
Mother's education = some college	1.1414 (1.7879) [0.5235]	0.9334 (1.8226) [0.6087]
Mother's education = college graduate	4.2369 (3.2350) [0.1908]	4.3707 (3.3766) [0.1959]
Mother's cognitive test score	−0.3476* (0.1685) [0.0395]	−0.4301** (0.1608) [0.0076]
% years in two-parent family	−5.9762* (2.4735) [0.0160]	−4.2771^{+} (2.5010) [0.0877]
Never in two-parent family	5.8779* (2.3832) [0.0139]	5.6465* (2.3125) [0.0148]
% years on welfare	9.9820*** (2.8374) [0.0005]	7.9912** (2.8260) [0.0048]
Always on welfare	1.1387 (2.7489) [0.6788]	2.1407 (2.6859) [0.4257]
Number of siblings in the household	0.4138 (0.6639) [0.5333]	0.7610 (0.6819) [0.2648]
Number of years with move	1.6940*** (0.3684) [0.0000]	1.8723*** (0.3549) [0.0000]
Primary caregiver consistent	3.7256* (1.8035) [0.0393]	4.9011* (1.9216) [0.0110]
Black	1.4571 (2.5960) [0.5748]	1.9799 (2.4073) [0.4111]
Hispanic	8.3883** (3.1721) [0.0084]	10.7646** (3.6292) [0.0031]
Other race/ethnicity	13.3323** (4.7687) [0.0053]	13.9737** (5.0305) [0.0056]
Parental warmth	−2.3349 (1.4956) [0.1190]	−0.2370 (1.5687) [0.8799]
Parenting	1.8134 (1.3059) [0.1654]	1.1083 (1.5275) [0.4683]
Self-esteem	0.4550 (1.9439) [0.8150]	1.4819 (2.0834) [0.4771]
Self-efficacy	0.8244 (2.0144) [0.6825]	−1.0394 (2.1257) [0.6250]
Kessler depression	−1.1960 (1.6255) [0.4621]	−0.4597 (1.6711) [0.7833]
Home Observation Measurement of the Environment cognitive score	−0.1042 (0.3575) [0.7707]	0.1398 (0.3879) [0.7186]

(*Continued*)

Table A1 – *continued*

	Housing-cost burden: Cognitive sample	Housing-cost burden: Total sample
Census division New England	19.2177^{+}(11.6556) [0.0997]	−0.0252 (7.8453) [0.9974]
Census division Mid-Atlantic	9.4942** (3.1703) [0.0029]	9.5136** (3.1863) [0.0029]
Census division East North Central	6.4605* (2.8580) [0.0241]	6.8145** (2.5190) [0.0070]
Census division West North Central	4.1550 (2.8069) [0.1393]	2.5061 (2.7389) [0.3605]
Census division Mountain	0.9932 (3.7283) [0.7900]	3.6202 (4.0006) [0.3658]
Census division Pacific	0.4858 (4.1554) [0.9070]	3.3973 (3.9853) [0.3942]
Census division West South Central	4.2910^{+} (2.4453) [0.0798]	6.7592** (2.3982) [0.0050]
Census division East South Central	6.4224* (2.5797) [0.0130]	6.7430** (2.5446) [0.0082]
Persons per room	−2.8989 (2.0565) [0.1591]	−2.0262 (2.1119) [0.3377]
Neighborhood poverty	−0.0654 (0.0861) [0.4481]	−0.0756 (0.0834) [0.3648]
Neighborhood quality	−1.6808* (0.8450) [0.0471]	−2.1527** (0.7942) [0.0069]
Neighborhood danger	−2.1621^{+} (1.2209) [0.0770]	−2.9126* (1.2487) [0.0199]
Number of full-time equivalent teachers	−0.0320 (0.0230) [0.1642]	−0.0300 (0.0279) [0.2815]
% free/reduced-price lunch	−0.1394** (0.0442) [0.0017]	−0.1176** (0.0422) [0.0055]
Crimes per 100,000 population	0.0002 (0.0006) [0.7874]	−0.0005 (0.0006) [0.4525]
Natural-amenities scale	1.7521** (0.5827) [0.0027]	1.3725* (0.6078) [0.0242]
Library expenditures per capita	0.0266 (0.0488) [0.5860]	0.1092 (0.0758) [0.1501]
Park expenditures per capita	0.0180 (0.0176) [0.3060]	0.0051 (0.0223) [0.8188]
% metro vacant housing units	−68.3093*** (18.4607) [0.0002]	−55.9096** (18.3530) [0.0024]
Metro population density	0.0001 (0.0002) [0.5954]	−0.0000 (0.0002) [0.9935]
Constant	53.8552*** (14.2045) [0.0002]	40.9855** (14.0560) [0.0037]
N	688	806
R^2	0.5373	0.4990

Notes:
*≤.05; **≤.01; ***≤.001.
1. Sample limited to families with incomes ≤200 percent of poverty for 50 percent or more of child's life.
2. Weighted estimates.
3. Time-varying measures averaged from child's birth to 2001.
4. Fair Market Rent (FMR) expressed in 2002 constant dollars (in $100s).
5. Table includes all variables used in creating propensity strata; some of these variables are not discussed in text.
6. Table shows regression coefficient, standard error in parentheses, and *p*-value in brackets.

Table A2. Propensity regression outcome results.

	WJ broad reading	WJ applied problems	Behavior Problems Index	Health status
Housing-cost burden (HCB)	0.2232*	0.7110*	−0.0374	−0.0039
	(0.1046)	(0.2782)	(0.0325)	(0.0026)
	[0.0332]	[0.0108]	[0.2501]	[0.1463]
HCB^2	−3.1886**	−18.2560*		
	(1.2231)	(7.1669)		
	[0.0093]	[0.0111]		
HCB^3		0.1140*		
		(0.0493)		
		[0.0212]		
Predicted HCB	0.3207	0.1961	−0.3323	−0.0339
	(0.4384)	(0.4838)	(0.2662)	(0.0257)
	[0.4647]	[0.6854]	[0.2124]	[0.1871]
Propensity stratum 2	−3.6660	−5.2080	5.0547^{+}	0.0350
	(4.6239)	(4.6792)	(2.6802)	(0.2682)
	[0.4282]	[0.2661]	[0.0597]	[0.8962]
Propensity stratum 3	−2.9637	−1.5875	3.5793	0.1405
	(5.6950)	(6.7457)	(2.9693)	(0.3138)
	[0.6030]	[0.8140]	[0.2284]	[0.6546]
Propensity stratum 4	−3.8434	−3.6295	6.6312^{+}	0.4586
	(6.1619)	(7.1349)	(3.9598)	(0.3734)
	[0.5330]	[0.6111]	[0.0944]	[0.2198]
Propensity stratum 5	−8.9064	−2.0149	4.6028	0.4843
	(7.5985)	(8.3567)	(4.2009)	(0.4162)
	[0.2416]	[0.8095]	[0.2736]	[0.2449]
Propensity stratum 6	−12.1185	−7.1677	11.9067*	0.0764
	(8.4353)	(9.3572)	(5.0531)	(0.4736)
	[0.1513]	[0.4440]	[0.0187]	[0.8718]
Propensity stratum 7	−17.0499^{+}	−11.2133	7.1559	0.4099
	(8.9001)	(10.1236)	(5.1614)	(0.5563)
	[0.0558]	[0.2684]	[0.1660]	[0.4615]
Propensity stratum 8	−8.9639	−5.7796	9.0451	0.6907
	(10.0293)	(11.4413)	(5.7748)	(0.5638)
	[0.3718]	[0.6136]	[0.1177]	[0.2209]
Propensity stratum 9	−10.9393	−3.0568	10.8225^{+}	0.4687
	(10.6443)	(12.1690)	(6.3418)	(0.6539)
	[0.3045]	[0.8017]	[0.0883]	[0.4737]
Propensity stratum 10	−6.8691	−1.5297	13.6144*	0.5765
	(11.3472)	(12.6776)	(6.7358)	(0.6743)
	[0.5452]	[0.9040]	[0.0436]	[0.3928]
Propensity stratum 11	−12.2645	−6.6304	9.1862	1.1147
	(11.8938)	(13.6513)	(7.5219)	(0.7313)
	[0.3028]	[0.6273]	[0.2224]	[0.1279]
Propensity stratum 12	−10.9114	−5.7188	13.0212	1.0553
	(13.3728)	(14.4252)	(8.0344)	(0.7833)
	[0.4148]	[0.6919]	[0.1055]	[0.1783]
Propensity stratum 13	−9.5149	−5.6878	13.2972	0.9596
	(13.6784)	(15.2034)	(8.5839)	(0.8599)
	[0.4869]	[0.7084]	[0.1218]	[0.2648]
Propensity stratum 14	−10.0356	−5.7574	11.8933	1.2482
	(16.7564)	(16.2083)	(9.7119)	(0.9539)
	[0.5494]	[0.7225]	[0.2211]	[0.1911]
Propensity stratum 15	−23.8384	−15.6756	19.3290	0.9777
	(16.2292)	(17.6579)	(12.2122)	(1.2302)
	[0.1424]	[0.3750]	[0.1139]	[0.4270]

(*Continued*)

Table A2 – *continued*

	WJ broad reading	WJ applied problems	Behavior Problems Index	Health status
Propensity stratum 16	−20.4261	−10.6410		
	(16.9143)	(18.4248)		
	[0.2276]	[0.5638]		
Propensity stratum 17	−27.5163	−15.8641		
	(17.6084)	(19.3659)		
	[0.1186]	[0.4130]		
Propensity stratum 18	−25.4413	−14.9989		
	(21.1096)	(25.2191)		
	[0.2286]	[0.5522]		
Propensity stratum 19	−26.7548	−14.9564		
	(23.3671)	(25.7554)		
	[0.2526]	[0.5616]		
Fair market rent	1.3299^{+}	0.9107	0.2838	0.0731^{+}
	(0.8045)	(0.8638)	(0.6147)	(0.0436)
	[0.0988]	[0.2921]	[0.6445]	[0.0940]
Child female	1.4308	0.1786	−1.2200	−0.0592
	(1.3627)	(1.3751)	(1.0051)	(0.0902)
	[0.2941]	[0.8967]	[0.2252]	[0.5118]
Age of child, 2002	−0.9229**	−0.5581^{+}	0.0728	−0.0270^{+}
	(0.2838)	(0.2936)	(0.1785)	(0.0160)
	[0.0012]	[0.0578]	[0.6835]	[0.0924]
Age of mother, 2002	−0.0161	−0.0688	0.0101	−0.0012
	(0.1237)	(0.1775)	(0.0774)	(0.0074)
	[0.8964]	[0.6982]	[0.8960]	[0.8712]
Breastfed as infant	6.5515**	6.0558***	0.0245	0.0816
	(2.1621)	(1.8252)	(1.1458)	(0.0867)
	[0.0025]	[0.0010]	[0.9830]	[0.3471]
Mother's education < high school	2.9432^{+}	−2.5737	1.1238	−0.1794^{+}
	(1.6613)	(1.7629)	(1.2114)	(0.1038)
	[0.0769]	[0.1448]	[0.3538]	[0.0842]
Mother's education = some college	4.5716*	3.0055	0.6166	−0.1565
	(2.1363)	(1.9858)	(1.2250)	(0.1021)
	[0.0327]	[0.1307]	[0.6149]	[0.1258]
Mother's education = college graduate	4.8778	2.9722	−2.1196	0.1258
	(3.5064)	(3.2038)	(1.9558)	(0.1691)
	[0.1647]	[0.3539]	[0.2788]	[0.4570]
Mother's cognitive test score	0.8379***	0.6697***	−0.0370	0.0234*
	(0.1766)	(0.1463)	(0.1100)	(0.0105)
	[0.0000]	[0.0000]	[0.7364]	[0.0256]
% years in two-parent family	−0.5250	−0.5707	−0.4766	−0.1138
	(3.3015)	(3.2165)	(1.9137)	(0.1543)
	[0.8737]	[0.8592]	[0.8034]	[0.4610]
Never in two-parent family	2.4648	2.1243	0.2093	−0.0591
	(3.0860)	(2.7127)	(2.0504)	(0.1415)
	[0.4248]	[0.4339]	[0.9187]	[0.6762]
% years on welfare	0.0773	0.9091	7.5410***	0.0476
	(2.9961)	(3.4076)	(1.9331)	(0.1665)
	[0.9794]	[0.7897]	[0.0001]	[0.7751]
Always on welfare	1.5010	1.3050	−1.6484	−0.1156
	(2.4326)	(2.6157)	(1.8787)	(0.1626)
	[0.5374]	[0.6180]	[0.3805]	[0.4773]

(*Continued*)

Table A2 – *continued*

	WJ broad reading	WJ applied problems	Behavior Problems Index	Health status
Number of siblings in the household	−1.9735**	−0.6780	−0.8049+	0.0208
	(0.7535)	(0.6493)	(0.4129)	(0.0359)
	[0.0090]	[0.2968]	[0.0516]	[0.5614]
Number of years with move	−0.5692	0.6389	0.1822	0.0131
	(0.6493)	(0.5596)	(0.3984)	(0.0323)
	[0.3810]	[0.2540]	[0.6475]	[0.6847]
Primary caregiver consistent	3.2302	1.7875	−5.2141*	0.0329
	(3.0510)	(3.5774)	(2.4145)	(0.2039)
	[0.2901]	[0.6175]	[0.0311]	[0.8720]
Black	−0.9231	−3.9341+	−3.1934*	0.0450
	(2.4239)	(2.3090)	(1.4889)	(0.1129)
	[0.7035]	[0.0889]	[0.0323]	[0.6900]
Hispanic	−3.0545	−2.5812	−0.8772	−0.0345
	(3.3170)	(3.1905)	(2.0991)	(0.1828)
	[0.3575]	[0.4188]	[0.6762]	[0.8503]
Other race/ethnicity	8.9726	−4.9371	1.2908	0.2866
	(5.4744)	(5.2811)	(3.2363)	(0.2346)
	[0.1017]	[0.3502]	[0.6901]	[0.2222]
Neighborhood quality	−0.4327	1.5245	−1.5582*	0.0504
	(1.1687)	(0.9683)	(0.7160)	(0.0592)
	[0.7113]	[0.1159]	[0.0298]	[0.3947]
Neighborhood danger	−1.5125	−1.8113	0.0838	−0.0548
	(1.2681)	(1.3682)	(1.2046)	(0.0961)
	[0.2334]	[0.1860]	[0.9445]	[0.5687]
Number of full-time equivalent teachers	−0.0339	−0.0072	−0.0331+	0.0008
	(0.0288)	(0.0227)	(0.0180)	(0.0019)
	[0.2402]	[0.7503]	[0.0653]	[0.6830]
Crimes per 100,000 population	0.0002	0.0005	0.0005	0.0000
	(0.0008)	(0.0006)	(0.0004)	(0.0000)
	[0.8384]	[0.3390]	[0.2589]	[0.4041]
Natural-amenities scale	0.2736	−0.2213	−0.0888	0.0023
	(0.3526)	(0.3276)	(0.2043)	(0.0189)
	[0.4382]	[0.4996]	[0.6641]	[0.9045]
% metro vacant housing units	−23.6559	−2.5245	−17.3263	−1.2639
	(20.5923)	(26.1322)	(10.9472)	(1.0306)
	[0.2511]	[0.9231]	[0.1139]	[0.2204]
Constant	81.6806***	71.8438***	55.7551***	3.9093***
	(12.2710)	(12.0072)	(8.6515)	(0.7351)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]
N	686	685	806	806
R^2	0.3695	0.3228	0.1621	0.1753

Notes:
*≤.05; **≤.01; ***≤.001.
1. Sample limited to families with incomes ≤200 percent of poverty for 50 percent or more of child's life.
2. Weighted estimates.
3. Time-varying measures averaged from child's birth to 2001.
4. Table includes all variables used in creating propensity strata; some of these variables are not discussed in text.
5. Table shows regression coefficient, standard error in parentheses, and *p*-value in brackets.
6. Predicted HCB = predicted housing-cost burden based on propensity model (see Table A1).
7. Propensity Stratum = categories based on predicted HCB.

Table A3. Instrumental-variable first-stage regression results.

	Housing-cost burden: Cognitive sample	Housing-cost burden: Total sample
Child female	−0.0754 (0.0529) [0.1541]	−0.0924^{+} (0.0487) [0.0584]
Age of child, 2002	−0.0056 (0.0097) [0.5678]	−0.0109 (0.0088) [0.2167]
Age of mother, 2002	−0.007 (0.0044) [0.1144]	−0.0048 (0.0042) [0.2526]
Breastfed as infant	0.0009 (0.0582) [0.9873]	−0.0098 (0.0581) [0.8667]
Mother's education < high school	0.0794 (0.0588) [0.1773]	0.0285 (0.0588) [0.6273]
Mother's education = some college	0.0258 (0.0697) [0.7113]	−0.0289 (0.0720) [0.6880]
Mother's education = college graduate	0.2219^{+} (0.1224) [0.0704]	0.1461 (0.1252) [0.2437]
Mother's cognitive test score	−0.0052 (0.0060) [0.3903]	−0.0103^{+} (0.0057) [0.0703]
% years in two-parent family	−0.3411*** (0.0974) [0.0005]	−0.2318* (0.1000) [0.0207]
Never in two-parent family	0.0882 (0.0802) [0.2717]	0.0557 (0.0778) [0.4743]
% years on welfare	0.3912*** (0.1034) [0.0002]	0.3528*** (0.1057) [0.0009]
Always on welfare	−0.0096 (0.0837) [0.9089]	0.0016 (0.0858) [0.9849]
Number of siblings in the household	−0.0185 (0.0238) [0.4369]	−0.007 (0.0232) [0.7637]
Number of years with move	0.0656*** (0.0118) [0.0000]	0.0694*** (0.0111) [0.0000]
Primary caregiver consistent	0.2614*** (0.0686) [0.0002]	0.2577*** (0.0754) [0.0007]
Black	−0.0801 (0.0715) [0.2632]	−0.0396 (0.0713) [0.5792]
Hispanic	0.2125** (0.0788) [0.0072]	0.2897** (0.0914) [0.0016]
Other race/ethnicity	0.3754** (0.1218) [0.0021]	0.3477** (0.1064) [0.0011]
Neighborhood quality	−0.0767* (0.0315) [0.0151]	−0.1066*** (0.0290) [0.0003]
Neighborhood danger	−0.0934* (0.0394) [0.0180]	−0.1200** (0.0395) [0.0025]
Number of full-time equivalent teachers	−0.0012 (0.0008) [0.1574]	−0.0007 (0.0008) [0.4019]
Crimes per 100,000 population	0 (0.0000) [0.5093]	−0.0000^{+} (0.0000) [0.0895]
Natural-amenities scale	0.0107 (0.0101) [0.2898]	0.0095 (0.0116) [0.4100]
% metro vacant housing units	−2.2929*** (0.5726) [0.0001]	−1.7614** (0.5903) [0.0029]
Fair market rent	0.1023*** (0.0203) [0.0000]	0.1035*** (0.0253) [0.0000]
Constant	3.4874*** (0.3823) [0.0000]	3.7289*** (0.3629) [0.0000]
N	688	806
R^2	0.8618	0.8511

Notes:
*≤.05; **≤.01; ***≤.001.
1. Sample limited to families with incomes ≤200 percent of poverty for 50 percent or more of child's life.
2. Weighted estimates.
3. Time-varying measures averaged from child's birth to 2001.
4. Table shows regression coefficient, standard error in parentheses, and *p*-value in brackets.

Table A4. Instrumental-value regression outcome results.

	W–J broad reading	W–J applied problems	Behavior Problems Index	Health status
Hou sing-cost burden (HCB)	0.2638	0.8865**	−0.0715	−0.0036
	(0.2139)	(0.3336)	(0.0991)	(0.0099)
	[0.2178]	[0.0081]	[0.4704]	[0.7185]
HCB^2	−3.7831**	−21.9090**		
	(1.2568)	(6.9196)		
	[0.0027]	[0.0016]		
HCB^3		0.1362**		
		(0.0482)		
		[0.0048]		
Residual HCB	0.0028	−0.0182	0.0277	−0.0000
	(0.1615)	(0.1660)	(0.1060)	(0.0103)
	[0.9860]	[0.9125]	[0.7937]	[0.9963]
Child female	1.3784	0.4129	−1.2530	−0.0544
	(1.5493)	(1.4570)	(1.0896)	(0.0960)
	[0.3740]	[0.7770]	[0.2505]	[0.5708]
Age of child, 2002	−1.0886***	−0.6677*	0.0186	−0.0263
	(0.2707)	(0.2954)	(0.1840)	(0.0169)
	[0.0001]	[0.0241]	[0.9193]	[0.1195]
Age of mother, 2002	0.0052	−0.0553	0.0183	−0.0036
	(0.1255)	(0.1662)	(0.0768)	(0.0081)
	[0.9669]	[0.7394]	[0.8116]	[0.6584]
Breastfed as infant	6.9170**	6.3268***	−0.1841	0.1196
	(2.2837)	(1.8845)	(1.1278)	(0.0906)
	[0.0026]	[0.0008]	[0.8704]	[0.1873]
Mother’s education < high school	1.4547	−3.2981$^+$	1.0478	−0.1832$^+$
	(1.8219)	(1.8342)	(1.2140)	(0.1083)
	[0.4249]	[0.0726]	[0.3883]	[0.0911]
Mother’s education = some college	5.2406*	3.4117$^+$	0.4776	−0.1194
	(2.2483)	(2.0474)	(1.2628)	(0.1007)
	[0.0201]	[0.0961]	[0.7054]	[0.2361]
Mother’s education = college graduate	4.2508	2.8212	−1.5510	0.1662
	(3.4754)	(3.2270)	(1.9669)	(0.1603)
	[0.2217]	[0.3823]	[0.4306]	[0.2999]
Mother’s cognitive test score	0.7201***	0.5705***	−0.0544	0.0292**
	(0.1769)	(0.1481)	(0.1048)	(0.0106)
	[0.0001]	[0.0001]	[0.6042]	[0.0059]
% years in two-parent family	−0.5829	−0.4316	−1.6363	−0.0328
	(3.9257)	(3.6188)	(1.8821)	(0.1552)
	[0.8820]	[0.9051]	[0.3849]	[0.8328]
Never in two-parent family	0.6498	1.4557	−0.1351	−0.0985
	(2.9751)	(2.5928)	(1.9082)	(0.1401)
	[0.8272]	[0.5747]	[0.9436]	[0.4820]
% years on welfare	−0.9310	0.2157	8.0408***	0.0153
	(3.6907)	(3.7584)	(2.1604)	(0.1766)
	[0.8009]	[0.9542]	[0.0002]	[0.9308]
Always on welfare	0.3387	0.1874	−1.4889	−0.2256
	(2.6751)	(2.7143)	(1.8967)	(0.1681)
	[0.8993]	[0.9450]	[0.4327]	[0.1800]

(*Continued*)

Table A4 – *continued*

	W–J broad reading	W–J applied problems	Behavior Problems Index	Health status
Number of siblings in the household	−1.7957*	−0.5734	−0.8151+	0.0066
	(0.7819)	(0.6684)	(0.4361)	(0.0377)
	[0.0220]	[0.3913]	[0.0620]	[0.8620]
Number of years with move	−1.1251+	0.2957	0.2772	−0.0007
	(0.6435)	(0.4935)	(0.3882)	(0.0321)
	[0.0809]	[0.5493]	[0.4753]	[0.9835]
Primary caregiver consistent	2.3725	1.4534	−4.5934	0.0629
	(3.1586)	(3.4601)	(2.8536)	(0.2370)
	[0.4529]	[0.6746]	[0.1079]	[0.7909]
Black	−1.2388	−4.0221+	−3.2148*	0.1190
	(2.6652)	(2.3959)	(1.4605)	(0.1172)
	[0.6422]	[0.0937]	[0.0280]	[0.3106]
Hispanic	−4.6269	−3.1356	0.3940	−0.1746
	(3.3470)	(3.1206)	(2.1058)	(0.1973)
	[0.1673]	[0.3154]	[0.8516]	[0.3766]
Other race/ethnicity	6.1061	−6.3609	1.7717	0.0732
	(5.1262)	(4.7114)	(3.0368)	(0.2418)
	[0.2340]	[0.1774]	[0.5598]	[0.7620]
Neighborhood quality	−0.3112	1.3758	−1.3493*	0.0482
	(1.4251)	(1.0419)	(0.6794)	(0.0618)
	[0.8272]	[0.1872]	[0.0474]	[0.4363]
Neighborhood danger	−1.2858	−1.6403	0.1244	−0.0222
	(1.3249)	(1.3939)	(1.1375)	(0.0983)
	[0.3322]	[0.2397]	[0.9129]	[0.8211]
Number of full-time equivalent teachers	−0.0058	0.0096	−0.0167	0.0003
	(0.0303)	(0.0227)	(0.0205)	(0.0017)
	[0.8471]	[0.6719]	[0.4165]	[0.8406]
Crimes per 100,000 population	0.0000	0.0003	0.0003	0.0000
	(0.0008)	(0.0006)	(0.0005)	(0.0000)
	[0.9750]	[0.5490]	[0.4855]	[0.3534]
Natural-amenities scale	0.2332	−0.1950	−0.0390	0.0112
	(0.3461)	(0.3043)	(0.1967)	(0.0183)
	[0.5007]	[0.5218]	[0.8430]	[0.5382]
% metro vacant housing units	−10.5554	7.8142	−17.9438	−1.7185
	(21.4334)	(26.1080)	(12.0781)	(1.1800)
	[0.6225]	[0.7648]	[0.1378]	[0.1457]
Constant	91.1781***	77.9762***	57.1570***	3.7638***
	(13.2475)	(12.4995)	(7.9738)	(0.8467)
	[0.0000]	[0.0000]	[0.0000]	[0.0000]
N	686	685	806	806
R^2	0.3146	0.2847	0.1241	0.1195

Notes:
*≤.05; **≤.01; ***≤.001.
1. Sample limited to families with incomes ≤200 percent of poverty for 50 percent or more of child's life.
2. Weighted estimates.
3. Time-varying measures averaged from child's birth to 2001.
4. Table shows regression coefficient, standard error in parentheses, and *p*-value in brackets.
5. Residual HCB = difference between actual and predicted housing-cost burden from first stage model (see Table A3).