Practitioner-Motivated Models for Urban Affordable Housing Development: Formulation

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Abstract:

Urban affordable housing planning and development is a challenging enterprise. Practitioners, which range from small neighborhood community development corporations to county-level agencies to nonprofit developers operating at the regional level, routinely solve problems involving multiple stakeholders, competing objectives, funding sources, production processes, strategies and outcome measures. Academic research addressing the design and evaluation of policies that address community concerns and generate significant social impacts is limited.

Using surveys and in-depth interviews with affordable housing providers in the Pittsburgh metropolitan area, we describe current practices and organizational values and test hypotheses that address the relationships between organizational characteristics, neighborhood characteristics and residential real estate development choices and methods. These findings are used to formulate quantitative planning models that address two problems faced by providers: choice of parcels to develop in order to maximize the social benefit associated with low-income housing search, and choice of parcels to develop to maximize neighborhood-level benefits.

We find substantial support for structured, prescriptive policy modeling that is evidence-based, value-focused and methodologically appropriate.

Keywords:
Affordable housing, value-focused thinking, management science, model-based planning

I. Introduction

Policy Motivation

Housing that is decent-quality and affordable (generally defined as consuming less than 30% of a family’s income) enables families to enjoy improved life outcomes on a variety of dimensions, such as household wealth, family stability, mental and physical health, labor market participation, educational achievement and neighborhood quality (Rohe, McCarthy and Van Zandt 2001). Decent and affordable housing also contributes to the improved physical, economic, environmental and social health—the sustainability—of communities. These impacts are especially important for lower-income households and other underserved populations.

Despite the general strength of the U.S. housing market (Joint Center for Housing Studies 2006), the benefits of housing, and of stable, vibrant communities, are unequally distributed. Examples of these inequalities include: shortages in affordable and “workforce” housing (Millenial Housing Commission 2002), flat or declining funding levels for public housing authorities (Joint Center for Housing Studies 2006), persistent gaps in homeownership rates by race and ethnicity (NAACP and National Association of Home Builders 2006), excessive housing and transportation burdens on working families (National Housing Conference (2006a,b,c), challenges in economic revitalization facing older urban centers (PolicyLink and Community Development Partnerships Network 2005) and displacement of the urban poor as a consequence of public housing renovation and economic renewal (Goetz 2003). The magnitude and inequities of these housing-related social outcomes provide a justification for policy interventions.

A variety of governmental and non-governmental organizations have as their mission to provide affordable housing and community development services and thereby help remedy the inequalities listed above. Examples include: Federal, state and local governments, public housing authorities, community development corporations (CDCs), commercial developers and faith-based organizations. In addition, community development partnerships (Glickman and Servon 1998) help CDCs provide housing and economic development services more effectively, and nonprofit developers often cooperate with local CDCs and other providers to leverage large amounts of development capital and technical expertise (Walker 1993).

Affordable housing development is a complex process. When embarking on such a project, developers must make many design decisions (Johnson 2006a), such as: the need for affordable
housing (demand vs. supply side subsidies), capacity/resources (types and levels of funding, in-house capabilities/staff hours), client benefits (subsidy, reduced housing expenses, family outcomes, housing quality, etc.), alternative development strategies to pursue (new, light rehab, moderate rehab, substantial rehab, purchase and warehouse, purchase and resale, etc.) land use, tenure type, structure type (renter vs. owner occupied, continuous vs. scattered site, single family vs. multi-family, high density, medium or low density, attached vs. detached, etc.), location (neighborhood, accessibility, public services, infrastructure, economic development, crime/safety) and quality (amenities, condition, design, etc.).

There is debate as to whether nonprofit community development organizations or private developers are the most effective means by which and competent at delivering on policy goals. At one extreme, non-profit developers are viewed with suspicion and are believed to be inefficient and incompetent. At the other, they are praised for being the only organizations capable of developing and implementing comprehensive community renewal strategies (Walker 1993).

Understanding the actual behavior of affordable housing providers is especially important when designing prescriptive, quantitative planning models to assist affordable housing practitioners (see, e.g. Gabriel, Faria and Moglen 2006, Johnson 2006a). However, it is difficult to justify prescriptive models without evidence that providers could stand to benefit from such models. Understanding the specific business models and larger affordable housing environment that constrain provision strategies is critical to the development of such models. There is little academic research known to us that investigates these issues.

The purpose of this paper, then, is threefold. First, we intend to better understand the actual challenges, resources and priorities of affordable housing providers using a survey. Second, we intend to identify a specific decision modeling opportunity through detailed analysis of a specific affordable housing provider’s organizational values. Third, we intend to address this decision opportunity by formulating and solving prescriptive decision models that have the potential to add value to this and similar providers.

Previous Research and Practice

Social science-based research on policy, administrative and legal barriers to or tools promoting affordable housing is wide-ranging. de Souza Briggs (2005), for example, summarizes the
challenges of housing and community development initiatives to address inequalities across class, race and ethnicity in the “geography of opportunity” linking housing, schools, employment and other services over urban space. The role that planning methods such as land-use zoning, subdivision regulation, growth management, smart growth, equitable development, and inclusionary zoning have played in inhibiting or promoting development of affordable housing are described in (Pendall et al. 2005).

Miles, Beren and Weiss (2000) provide a primer on real estate development, with some attention paid to the special needs of subsidized and affordable housing. Metropolitan Washington Council of Governments (2005) has prepared a comprehensive list of administrative, planning and policy tools for affordable housing provision.

However, there is relatively little literature regarding the actual decision-making/planning process of practitioners gathered through direct surveys/interviews. Research topics tangentially related include: nonprofit housing development trends and prospects (based on a national survey of community-based housing development organizations) (Walker 1993), a comparison of the role of nonprofit housing in Canada and the United States (Drier and Hulchanski 1993), the potential scope of housing policy in the development of public policy (Shlay 1995), and potential decision tools (Peterson 1998; PolicyLink 2002; Anselin, 1998).

There is a modest research literature regarding design of decision models to provide strategic and tactical guidance to affordable housing providers. Frech and Thyagarajan (1975) develop a linear programming model to allocate affordable housing among Census tracts in a metropolitan area. Kim (1979) uses linear programming to allocate affordable housing to meet “fair share” housing needs in New Jersey. Forgionne (1991) and Forgionne and Frager (1998) describe decision support applications to identify gaps in affordable housing provision for the U.S. Army. Gabriel, Faria and Moglen (2006) present a multi-objective math programming model to assist planning for smart growth initiatives. Johnson (2003, 2006b) and Johnson and Hurter (2000) have developed multiobjective math programming models to generate alternative provision strategies for tenant-based and project-based subsidized housing. Johnson (2006a) provides a framework, decision model and case study for affordable housing providers addressing renter- and owner-occupied housing.
Preliminary Findings

A survey of Pittsburgh-area affordable housing providers yields evidence of strong commitment to low-income homeownership and responsiveness to funding availability and local needs, but little use of analytical methods that might provide assurance that strategies pursued are Pareto-improving. Field research with an affordable housing and community development organization in Pittsburgh reinforces perceptions that even skilled practitioners understand the limits of professional methods to make best possible decisions, and clarifies values that motivate decision opportunities not pursued previously. In particular, we find support for a particular decision modeling need that is currently unmet: a model to identify specific parcels for residential development that might further goals of community revitalization.

We then formulate two extensions of location-allocation models to address this need: housing search, a “traveled-to” application of facility location models vs. community revitalization, a “delivery” application. These models incorporate spatial interaction modeling elements at two extremes: small, versus very large values for impedance/distance decay. The two extremes imply two types of math programming models: nonlinear integer facility location models incorporating spatial interactions, and linear integer facility location models similar to the well-known fixed-charge facility location problem. These models have the potential to provide improved guidance to affordable housing providers who currently solve such problems using professional expertise and administrative data only. Implementation of these models is ongoing.

Paper Structure

Section II describes the survey of Pittsburgh-area affordable housing providers and provides preliminary descriptive statistics and hypothesis tests. Section III is a values analysis of a specific affordable housing provider to identify a novel decision modeling opportunity. Section IV presents alternative decision models for community revitalization with computational results. Section V concludes and identifies potential research extensions.
II. Survey of Pittsburgh-Area Affordable Housing Providers

Survey Design and Administration

We administered a survey on affordable housing development practice to practitioners in the Pittsburgh metropolitan area in order to better understand their goals, resources, current practices and challenges. By doing so, we are able to identify opportunities to apply decision models that are responsive to the actual needs of affordable housing providers. We know of no other survey of affordable housing providers—especially community-based providers—that has explored these particular issues. The survey has three parts: Organization Purpose and Background, intended to identify and quantify benefits that providers intend their housing to generate; Types of Developments, addressing programmatic, physical and subsidy characteristics of developments, and Decision Making, addressing the nature and role of decision models in affordable housing development decisions. Specific issues addressed include:

- how organizations assess the need for affordable housing in their service areas;
- how organizations measure program impacts on participants and neighborhoods;
- how organizations assess their technical ability to provide affordable housing;
- supply- and demand-side subsidies used to provide affordable housing;
- decision-making strategies and models used (if any) when choosing among housing alternatives;
- criteria judged most important when considering new housing developments;
- effect on provision strategies of community context, and
- type and level of collaboration with other organizations.

We applied Dillman’s Tailored Design Method (Dillman 2000) to generate questions intended to be well-motivated, easy to understand and to respond to and consistently scaled. We received assistance in survey design from three external reviewers with affordable housing expertise. The resulting survey (available at http://www.andrew.cmu.edu/user/johnson2/Affordable_Housing_Survey.pdf) was sent to 32 organizations in the Pittsburgh metropolitan area in a variety of sectors (nonprofit, private, government) and with a range of service area sizes (neighborhood, city, regional and county).
Over ten months from October 2005, our contacts with respondents included: personalized pre-notice letters sent two to three days before the survey, the survey itself, including a token financial incentive to encourage completion, a thank-you post card sent one week after the survey mailing, mailing of replacement surveys, and extensive phone follow-ups to provide technical assistance and encouragement in completing the survey. We have received 17 completed surveys, a response rate of 53%.

Administrative characteristics of affordable housing providers may be associated with specific provision strategies. To collect data on these characteristics, we performed Web searches and follow-up phone interviews. Data collected for each respondent include: Census tracts that best define service areas; funding levels; organization type (all volunteer, board-led; executive director supervising volunteer or administrative support staff; executive director supervising professional support staff with a single program mission, and executive director supervising multiple departments and offices); years of experience; average number of housing units per project, and number of employees.

Characteristics of affordable housing providers’ service areas may be associated with specific provision strategies as well. Based on direct contact with survey respondents, we defined service areas as aggregations of Census tracts. Data elements we collected include socio-demographic characteristics (race/ethnic composition, family structure, poverty rate, educational attainment, labor market participation, residential stability, crime rate), and housing market characteristics (vacancy, tenure).

We have identified gaps in the literature regarding actual behavior of affordable housing providers. We have also argued that providers may not routinely use tools and methods that enable them to make decisions about affordable housing policies and programs that represent verifiable improvements in individual and neighborhood outcomes as compared to the status quo. Thus, we propose a number of hypotheses which, if supported, may supply evidence to support our arguments:

1. Organizations tend to concentrate on one type of subsidy, due to technical requirements.
2. Smaller organizations are less likely than larger organizations to include non-residential components in their developments.
3. Organizations tend to be opportunistic in development decisions: few evaluate two or more alternatives, and funding and site control tend to dominate the development decision.

4. Few organizations assess their ability to provide affordable housing. Those that do rely in financial capacity and consistency with mission.

5. Few organizations use analytical models to choose between housing alternatives.

6. Smaller organizations are less likely than larger organizations to coordinate with others, especially at the city or regional level.

7. Organizations tend not to use quantitative measures, e.g. tools from program evaluation or cost-benefit analysis to measure and evaluate program outcomes.

Descriptive Statistics

Survey respondents (Table 1) were more likely to be neighborhood-based nonprofit organizations (i.e. community development corporations) than any other type, almost all with executive directors and paid staff. Organization size, in budget and staffing terms, was relatively large, but skewed by two comparatively large city and county housing authorities. Organizations are experienced overall, and manage large developments on average.

[Table 1: Summary Statistics, Survey Respondent Organizations]

Characteristics of respondents’ service areas are shown in Table 2. As expected, affordable housing providers (all but one of which are located in Allegheny County) serve areas that are more heavily minority and more distressed, according to measures of poverty, crime and housing vacancy than Allegheny County overall.

[Table 2: Summary Statistics, Survey Respondent Service Areas]

Respondents appeared to focus on program benefits centered on increased housing affordability and homeownership rates, rather than improved client outcomes on dimensions other than housing (Figure 1). Responses to the question on neighborhood impacts also focused on increased affordability and homeownership rates. This indicates that respondents tend to view homeownership and affordability as ends in themselves, rather than means towards some other goal like community revitalization.
In addition, 88.5% of all respondents believe that the housing units they provide to their clients are of comparable quality to somewhat or significantly more expensive market-rate units. 94% (16 of 17) respondents indicated that they sometimes or often collaborated with other organizations. As Figure 2 shows, respondents frequently accessed technical assistance from other organizations, both facilitated by information technology and through face-to-face contact at conferences. Respondents indicated a wide variety of “other” means to acquire technical assistance, for example: interactions with peers, board members and volunteers, professional publications, in-house training and informal networking.

Figure 3 indicates that respondents overwhelmingly preferred new construction as the vehicle for providing affordable housing, with rehabilitation (moderate and substantial) somewhat less preferred. Very few respondents “flip” properties, engaging in minimal redevelopment, or “warehouse” properties, waiting until market conditions become more favorable for investing for habitation. This is an expected finding: new construction (sometimes preceded by property demolition) is, financially and logistically, a simpler strategy than rehabilitation or warehousing, and one more likely to result in significantly improved unit quality than purchase and resale (a strategy more suited for gentrification). Also, the relatively low property values in the Pittsburgh area make demolition and new construction, in the absence of historical significance of the existing structure, an attractive strategy.

Figure 4 contains a summary of responses to the series of questions: what percentage of your developments are renter (as opposed to owner-occupied), …, attached (as opposed to detached). These responses indicate that housing projects are: are more likely to contain owner-occupied units than renter units; more likely to be continuous than scattered site in nature; more likely to be single family than multi-family in style, and slightly more likely to be detached than attached. These responses are consistent with a preference for separated single-family homes on adjacent property parcels; this follows from Pittsburgh’s relatively low property values and high number
of vacant and abandoned houses allowing for slightly more suburban-style developments than might be the case in larger, denser cities.

[Figure 4: Physical Development Styles]

Affordable housing may be provided using a variety of subsidy mechanisms. The first class of subsidies we consider are demand-side subsidies, that is, subsidies that enable individual households to choose the housing they most prefer. Figure 5 indicates that city and state programs and below-market-rate loans are most popular, while matched savings programs and reduced points are least popular. This is an indication that certain innovative programs such as matched savings programs focused on building household wealth do not have the visibility in Pittsburgh that they have in other, larger cities. One interpretation of the relative popularity of below-market-rate loans is that some organizations have better relationships with lenders than others.

[Figure 5: Demand-Side Subsidy Preferences of Providers]

Supply-side subsidies are those that are linked with the housing unit, rather than with the household. Low-income housing tax credits, followed by Federal grants and city/state grants are most popular, while foundation grants, and funds associated with Community Reinvestment Act policies are least popular. We interpret this finding as follows: programs that require a high degree of accountability (foundation grants) or coordination with other institutions associated with fair housing rather than affordable housing may be difficult for resource-challenged providers to pursue.

[Figure 6: Supply-Side Subsidy Preferences of Providers]

We now move to survey questions assessing the decision processes that organizations use to provide affordable housing. While nearly all respondents claim to assess their internal capability to provide affordable housing using all means listed in the survey—staffing support, financial capacity, professional experience, consistency with mission and strategic planning—there is more variety in the self-assessed means by which developers determine the level of demand for their products (Figure 7). While most respondents indicated market demand as a key indicator of the potential popularity of their products, when explaining their choices less than half of the respondents mentioned quantitative criteria such as Census data. In addition, it is striking that
while most respondents pointed to funding availability and site availability as key determinants of demand for housing, few mentioned measures of net social benefits. Notwithstanding the fact that “net social benefits” is an economic notion that resource-constrained organizations may have difficulty operationalizing (see e.g. Johnson, Ladd and Ludwig 2001 for evidence regarding such impacts for housing mobility programs), it appears that providers are rather opportunistic in their decisions regarding housing provision. One possible explanation for this outcome is a great excess of perceived demand for affordable housing over supply; this would induce suppliers to secure funding and sites for housing on the assumption that the housing they will eventually develop will be occupied.

[Figure 7: Criteria by Which Developers Assess Need for Affordable Housing]

By what means could providers determine which particular sites, or particular funding mechanisms, will result in affordable housing development that makes the best use of limited resources to generate improvements in individual and community outcomes? Figure 8 indicates that affordable housing providers consider ongoing economic development strategies when determining where and what types of housing to build. This is consistent with an earlier finding of a high level of cooperation with other organizations, and a desire to use affordable housing as a means to community stabilization and revitalization. But, results shown in Figure 7, above, raise questions as to the extent to which knowledge of economic development strategies affect specific housing development decisions.

[Figure 8: Consideration of Ongoing Economic Development Strategies]

76.4% (13 out of 17) developers evaluate two or more distinct housing provision strategies when considering a development initiative. However, only 23.5% (4 out of 17) developers use analytic models when choosing between 2 or more strategies. This is another indicator that affordable housing providers may be making suboptimal development decisions. However, individual responses show some sophistication in thinking about “models”. For example, a respondent who does claim to use analytical models refers specifically to financial proformas to determine the best mix of affordable housing. A respondent who claims not to use analytical models nevertheless uses data to determine market need and tailor projects to meet the need. Another respondent who answered affirmatively to this question uses financial analysis or review of market studies based on demographics, unit production, and unit absorption, while a respondent
who answered negatively cites funding availability, site control and resource availability as constituting their fundamental decision process. We believe that this is likely to be the process that the majority of developers follow.

Figure 9 shows that developers appear to examine two or more criteria when choosing whether a particular development strategy. The most important criterion is funding availability, then site availability, and then demand for product. Net social benefits came in fourth, but as mentioned above it was not clear if the organizations that chose these criteria understood what this term means.

[Figure 9: Criteria Most Important when Developing New Housing]

Finally, many respondents listed a wide variety of factors they thought were not mentioned elsewhere in the survey as influencing their decision to provide affordable housing. These factors include: neighborhood revitalization, expanding and stabilizing the residential and commercial market, politics and community pressure, and new housing as a means to displace residents who engage in socially undesirable behavior.

Hypothesis Tests

The descriptive analysis presented above is supportive of hypotheses 4, 5 and 7 and partly supportive of hypothesis 3. Affordable housing providers tend to consider two or more alternative development strategies but use professional expertise, rather than analytical models, to do so. This professional expertise is reflected in their assessment of their organization’s financial capacity, and the need for site control and funding in-place before making specific affordable housing development decisions rather than estimates of the net social welfare impact of the development choice under consideration. This is consistent with findings from a previous student-led study on vacant properties and residential redevelopment in Pittsburgh (Hua 2005): even well-trained developers acknowledge the need to ‘make the numbers work’ or ‘make the project happen’ and to rely on professional intuition, independent of the conclusions of analytical models.

However, we find that organizations tend to rely on two or more subsidy strategies, and the strength of this reliance is only modestly associated with increasing organization size (Table 3). Thus, there is only weak support for hypothesis 1.
Also, the likelihood with which respondents include non-residential components in their affordable housing developments (retail, recreation, supportive services, etc.) increases only slightly as a function of provider size. Thus, there is only weak support for hypothesis 2.

Finally, the frequency with which respondents claim to collaborate in provision of affordable housing with other entities (agencies, CDCs, local governments or other organizations) is fairly high, on average, across affordable housing provider size and region (Table 4). Thus, hypothesis 6 is not supported.

Conclusion

Our survey of Pittsburgh-area affordable housing providers yields valuable insight into the role that quantitative decision models might play in assisting affordable housing providers to make better development decisions. These providers appear to have well-defined preferences regarding the type of housing they wish to develop, the funding tools by which this is done, and the policy goals they expect this housing to help achieve. While these providers appear to evaluate two or more development alternatives in order to choose a most-preferred course of action, they tend not to use well-defined analytical models that might provide evidence of whether a particular development is worth pursuing. Hypotheses that organization size, a proxy for technical resources, positively influences the likelihood that organizations use two or more subsidy mechanisms, or include non-residential components in their developments, or coordinate with other organizations to develop provision strategies are supported only weakly (the first two) or not at all (the last).

This suggestive evidence of sub-optimal behavior motivates our next step in field research: close examination of an affordable housing provider’s organizational values. Such an exercise will help us understand what decision problems the provider solves, explicitly or implicitly, and which decision models they do not solve but would like to, in order to deliver their services more efficiently and effectively.
III. Values Analysis of a Community-Based Affordable Housing Provider

Value-Focused Thinking

Traditional expositions of operations research/management science (OR/MS) modeling have as a first step: “formulate the problem” (Winston and Venkataraman 2003, p. 5). While the tasks associated with this step are straightforward (e.g. “specify the organizations objectives and the parts of the organization that must be studied before the problem can be solved”, Winston and Venkataraman, p. 5) it is not clear how these tasks are to be actually performed. An overview of public-sector OR/MS (Gass 1994) provides more specific guidance in problem formulation that accounts for the ambiguous, multi-objective, multi-stakeholder, political nature of public-sector problems. However, there is little information on exactly how a decision problem is to be formulated.

We have argued in the previous section that there may be opportunities to design decision models that might help these organizations achieve their goals more efficiently, that is, by increasing net social welfare by the greatest extent possible. But what specific decision problems should we propose? One technique that can help us is called “value-focused thinking” (Keeney 1992). This qualitative method is based on two notions. The first is that the problem we are given to solve may be different from the one that we (or our client) feels we ought to solve, in order to effect change consistent with our values and ethics. This is called a decision opportunity. The second is the notion that problems to be solved that rely on pre-defined alternatives from which we might choose one most-preferred course of action (“alternatives-oriented thinking”) may result in suboptimal decisions as compared to a process that considers a variety of objectives to be optimized and settles on a few, based on our own preferences, that may imply a very different set of alternative strategies from which to choose one that is most-preferred.

Briefly, “value-focused thinking” relies on three constructs that clarify our understanding of a problem and hence identify a decision opportunity. The first is strategic objectives. These are objectives an organization wishes to achieve in the long run, and they are the reasons an organization exists. Fundamental objectives represent the important values, or ethics, that motivate our interest in a given problem domain. They allow strategic objectives to be quantified and made explicit. Fundamental objectives may be organized in a hierarchy that allows analysts
to decompose “core” fundamental values into components that answer the question “along which dimensions is this value, or objective important?” The root of a fundamental objectives hierarchy is an objective that is closely related to one or more strategic objectives. The leaves of a fundamental objectives hierarchy represent specific objectives for which progress towards achieving them can be measured using well-defined metrics.

Means objectives represent specific ways in which fundamental objectives can be achieved. They often represent actual tactical or operational goals for which standard administrative or analytical methods may be applied to generate strategies that meet these goals to some extent. Means objectives may be organized in a network that represent the relationship between an objective that we are initially given, or is of initial interest to us, and other, more general objectives that answer the question “why is this objective important?”. Alternatively, the means-ends network allows one to ask of a particular objective, “in what way(s) could this goal be better achieved?” in order to identify objectives that are more closely associated with fundamental values. The root(s) of a means-ends objectives network represent fundamental objectives. The leaves of a means-ends objectives network represent specific strategies or decisions which if made, can to some extent satisfy the need to achieve progressively more general objectives.

By identifying strategic, fundamental and means objectives, and creating a fundamental values hierarchy and a means-ends network, one can define a decision problem whose solution provides the decisionmaker with alternative strategies that are as closely aligned with her core beliefs as possible.

Data Collection

Between July 2005 and July 2006, we conducted seven interviews with business analysts and professionals at a community development corporation in the East Liberty neighborhood of Pittsburgh. East Liberty is a blighted, though historically important, and revitalizing neighborhood, with minority population levels, poverty rates and crime rates that substantially those of the city of Pittsburgh. We refer to this CDC as ‘East Liberty Revitalization’ (ELR).

This CDC’s mission, posted on its website, is as follows:

“…to foster the revitalization of the East Liberty community. Working in collaboration with community stakeholders, [ELR] acts as a catalyst for positive change by providing leadership in the areas of planning, advocacy, image building, and investment.”
ELR has performed a comprehensive community plan, used this plan as a basis for selecting residential parcels for redevelopment, executed large-scale demolition of high-rise subsidized housing and subsequent reconstruction, performed commercial development that has brought in national retailers and worked as a partner providing project management assistance other community development corporations.

Given our experience with the affordable housing survey, which we distributed to Pittsburgh-area affordable housing providers at about the time we began the interviews with ELR (ELR has not completed the survey as of this writing), and in spite of ELR’s expertise in residential and commercial development, and substantial financial support from the city of Pittsburgh’s Urban Redevelopment Authority, we believe that it might benefit from research-based assistance to better fulfill its mission. ELR’s staffers agreed with our assessment, and participated in a series of interviews by which we would better understand the community redevelopment implications of its mission, and identify one or more decision opportunities that might add value to ELR’s projects.

To prepare for the interviews, we reviewed ELR’s mission statement and goals and reviewed previous Heinz School field research on ELR addressing residential vacancies and mixed-use development (Hua 2005). We then prepared a script by which we would elicit information about specific strategies ELR is currently pursuing to improve East Liberty. This script included probing questions such as “what are the fundamental objectives of ELR”? “How can these objectives be attained through community planning and development strategies?” “What barriers might prevent ELR from achieving its goals?” “What tradeoffs exist between alternative strategies?

Tape-recorded and hand-written notes from the interviews with ELR staff (Hogan 2005, Jester 2005) yielded voluminous data on objectives, strategies and resources, which are reproduced in Appendix I. These qualitative data were inputs to the value-focused thinking process, in which we prepared a fundamental values hierarchy and means-ends objectives network. We shared our interim results with ELR staffers, who generally confirmed our insights.

Values Structures

Based on our interviews with ELR staffers, we identified three strategic objectives:
- Develop a physically and socially sustainable community
- Promote private investment for economic revitalization
- Make best use of subsidies for residential and community development

We then identified a fundamental objective that might provide high-level guidance regarding development options: “maximize the social welfare of East Liberty” (Figure 9). By continually asking ourselves, and the client, “what are the dimensions along which this goal might be achieved?” we were able to identify three specific related fundamental objectives: “Maximize the social benefit of nonprofit and services development”; “Maximize the social benefit of commercial development”, and “Maximize the social benefit of residential development.”

Because the focus of this research project is affordable and subsidized housing, we subsequently examined only the last of these more specific fundamental objectives in detail. Thus, we classified residential development outcomes along two dimensions: “neighborhood development” and “housing development”. “Neighborhood development” refers to the collective impact of multi-unit developments and related on-site services; “housing development” refers to housing unit and household-level outcomes.

[Figure 9: High-Level Fundamental Objectives of Local Affordable Housing Developer]

Our analysis of fundamental objectives related to neighborhood development resulted in more detailed structures (Figure 10) related to affordable/low-income housing and market-rate housing: socio-economic diversity and integration, beneficial outcomes for program participants and beneficial outcomes for program non-participants.

[Figure 10: Fundamental Objectives: Maximize the Social Benefits Associated with Neighborhood Development]

Our analysis of fundamental objectives related to housing development resulted in more detailed structures (Figure 11) related to the physical and economic characteristics of individual housing units, such as: physical design, tenure type, subsidy level, provision costs and effects on local housing and commercial markets.

[Figure 11: Fundamental Objectives: Maximize the Social Benefits Associated with Housing Development]
Next, we focused on the fundamental objective of maximizing the cost-effectiveness of housing development and identified means objectives associated with it that might represent actionable strategies (Figure 12). Three of these, for example, are: “increase sales price”, “maximize quality level” and “maximize the lifespan.” Each of these means objectives, in turn, generated even more specific means objectives that might be associated with specific decision problems.

[Figure 12: Means-Ends Network: Maximize the Cost-Effectiveness of Housing Development]

Thinking about the kinds of problems that practitioners at ELR might routinely solve, or wish to solve more effectively, even without the benefit of analytic models, we identified two from Figure 12:

a. What type of residential construction is necessary to maximize housing quality given available financial and organizational resources?

b. Which residential parcels should be chosen for development in order to maximize revenues and minimizing subsidy levels?

ELR agreed with us that choosing housing units to build or redevelop in order to affect local markets was the problem most closely aligned with ELR’s strategic goals and fundamental objectives and an ongoing development task, yet hardest to quantify in a decision modeling framework. That is, ELR believes that its property acquisition strategies have the effect of ‘moving the market’, yet they do not know the extent to which this is so, and do not have a means to standardize its decision-making process, which currently relies on extensive property development and project management expertise.

ELR is currently engaged in what might be termed an “outside-in” strategy by which specific residential parcels are chosen for redevelopment in order to move strong housing markets from affluent neighborhoods adjacent to East Liberty into East Liberty’s interior (Figure 13). This strategy is in contrast to an “inside-out” strategy in which resources are focused on the most distressed housing units in order to stabilize fragile neighborhoods. This latter strategy would be most appropriate for blighted communities with very weak housing markets located relatively far from more stable communities.

[Figure 13: “Outside-In” Residential Development Strategy]
How would certain housing units in East Liberty be chosen for development to best leverage market forces from outside the neighborhood? This could be done by assuming that the social benefits associated with redeveloping certain candidate parcels are a function of proximity to nearby housing markets, and that all things equal, choosing candidate parcels to develop that are closer to higher-quality housing markets will be most likely to generate positive local externalities. Thus, our decision problem is to choose parcels to develop that represent most-desirable tradeoffs between proximity to high-value local residential markets and development costs.

Conclusion

We have performed a values analysis of a neighborhood-based community development corporation to identify potential decision opportunities. In contrast to a conventional decision problem—should a particular parcel be acquired, or developed, or not, and if so, in what way—we have identified a decision opportunity: choosing a set of residential parcels to strengthen local real estate markets to the greatest extent possible. This analysis reveals a much more nuanced assessment of organizational goals than was apparent in the affordable provider survey described in the previous section. In the next section, we will develop alternative decision models to achieve this goal.

IV. Decision Models for Urban Affordable Housing Development

We have argued, based on field research in the previous section, that a fundamental policy goal of one affordable housing developer is maximizing net social benefits associated with a community revitalization-oriented residential development strategy. In particular, the provider’s goal is to maximize benefits associated with choosing residential parcels for redevelopment that are most likely to result in extending the boundaries of healthy real estate markets from the borders of the service area adjoining more-affluent neighborhoods towards the core of the service area.

Social scientists usually represent the process of producing long-term outcomes of an affordable housing initiative as triggered by improved housing quality and neighborhood quality and measured by life outcomes and community outcomes. It is difficult to represent long-term
improvements in participant and non-participant outcomes in a prescriptive model reliably. Data from evaluations of affordable housing initiatives such as the Moving to Opportunity experiment (U.S. Department of Housing and Urban Development 2003) and the HOPE VI program (Popkin et al. 2004) are still the subject of intense study.

We simplify the problem of representing longer-term program outcomes by assuming that perceptions as well as objective measures of housing quality and neighborhood quality influence outcomes of interest, and that these measures can be represented by the proximity of affordable housing to improving nearby commercial and residential housing markets. By “market” we mean a collection of residential and commercial units that are contiguous and which represent a commonly-understood locus of economic activity, as measured by property values or levels of retail business. Note that residents of affordable housing do not actually have to patronize stores in nearby markets, or visit local neighborhoods for various recreational purposes in order to enjoy proximity-related benefits. Social costs of affordable housing can be represented in the short term by the subsidies required to provide high-quality, low-cost housing in areas where the local housing market has not done so.

Suppose that nearby markets are indexed \( i = 1, 2, \ldots, n; I = \{i\} \). The attractiveness of market \( i \) is given by \( b_i \), which measures a bundle of amenities. For the purposes of this note let \( b_i \) be a function of the value of residential properties in market \( i \). This assumes that improvements in business activities are capitalized into residential property values.

Suppose that potential locations for affordable housing are indexed by \( j = 1, 2, \ldots, m; J = \{j\} \). Affordable housing can be classified along a variety of dimensions according to tenure type, development strategy, nature of subsidy and others (Johnson 2006a). For the purposes of this paper we will assume that all affordable housing to be located is of a single type (single-family detached owner-occupied units, say), produced according to a single strategy (e.g. intensive rehabilitation of existing structures) and differing only in size (e.g. number of bedrooms, square footage). The subsidy associated with developing a unit of affordable housing at site \( j \) is \( c_j \). The size of the affordable housing unit to be developed at site \( j \) is \( s_j \). The social benefit associated with developing a unit of affordable housing of size \( s_j \) is \( v_j \).

Assume that potential residents of affordable housing at sites \( j \in J \) are drawn from markets \( i \in I \). Let \( d_{ij} \) be the distance between local market \( i \) and a potential site of affordable housing \( j \).
How can we measure the aggregate impact of a proposed affordable housing development strategy? We adapt research on the location-allocation problem (LA; see e.g. Cooper 1963), in which the goal is to choose the locations of facilities to provide goods and services to spatially-dispersed customers, and to assign customers to sited facilities to optimize a suitable objective. In public LAs, facilities provide goods and services that patrons use, either for free or reduced rates; in private LAs, patrons pay market rates. Patrons can visit the facilities (“user-attracting systems”; Leonardi 1980), or the facilities can deliver goods and services to patrons (“delivery systems”). We assert that the process of affordable housing location for community revitalization has elements of both systems: households visit housing units to choose one to move to permanently; over time, the housing units (and the neighborhoods in which they are located) deliver benefits to households in-place as well as the program non-participants (through neighborhood upgrading effects).

One approach to solving the location-allocation problem, based on the classical Weber problem (Cooper 1963) is to propose that consumers choosing among alternative service facilities to visit, choose the one that is closest to them, all else equal. Using this behavioral assumption, the P-median problem (Hakimi 1964), for example, chooses the locations of P identical facilities serving identical spatially dispersed customers, both modeled as nodes of a network, to minimize the average (or total) cost as measured by demand-weighted distance. An alternative model, the fixed-charge facility location problem (Balinski 1964), chooses the location of facilities (the number of which is endogenous to the model) to minimize the sum of fixed location costs and variable transportation costs.

Another approach, summarized in Fotheringham and O’Kelly (1989) assumes that customers may choose the facility to visit that is not the closest one, based on the attributes of the facility or the product consumed as well as the distance to the facility. The strength of influence of distance as a factor in travel for service is called “impedance” (Fotheringham and O’Kelly 1989) or “distance decay” (Hodgson 1981). Higher levels of impedance or distance decay correspond to an increased willingness of consumers to visit the closest facility and for facilities to be associated with distinct service areas; lower levels correspond to an increased willingness of customers to visit more distant facilities and for facilities to have client populations that overlap in spatial terms. Spatial interaction models use data on travel from spatially dispersed origins to spatially dispersed destinations to infer structural parameters of models, including impedance,
that allow prediction of trips. These models use as a key component the probability that a
customer at \(i\) will patronize a facility at \(j\). The spatial interaction model has been used as the
basis for formulations of the (non-competitive) location-allocation problem in continuous space

Neither of these modeling approaches correspond exactly to affordable housing planning. This is
because the roles of various components of affordable housing policy design differ greatly from
those of service facility planning. Figure 14 shows the two contrasting conceptions of traditional
location-allocation models, and housing location models.

[Figure 14: Location of Conventional Service Provision Facilities versus Affordable Housing]
The left panel represents the conventional location-allocation model. Demand points \(d_i, i = 1, \ldots, 5\)
are characterized by the level of demand \(O_i\); facility locations \(p_j, j = 1, 2\) are characterized by
the fixed cost \(c_j\) of locating at each node and the general attractiveness of each facility to
consumers \(A_j\). The problem is to locate facilities to minimize total travel cost between demand
nodes \(d_i\) to facility nodes \(p_j\) or minimize total cost, including fixed facility location costs. The
emphasis in the conventional LA is on routine, repeated travel between customers and facilities.
Location-allocation models with spatial interaction components recognize that customers do not
always visit the closest facility, and total demand at node \(i\) can be split between multiple
facilities. Thus, they minimize generalized social costs of travel or maximize consumer surplus
of travel.

The right panel represents the affordable housing location problem. Market points \(m_i, i = 1, \ldots, 5\)
are characterized by general attractiveness \(b_i\), and demand for affordable housing \(O_i\). Affordable
housing locations \(p_j, j = 1, 2\) are characterized by the fixed subsidy \(c_j\) and unit size \(s_j\). Each
affordable housing unit is also characterized by an attractiveness measure \(v_j\). This measure can
represent the anticipated sales price, which incorporates the value of housing-unit and
neighborhood amenities.

Potential residents of affordable housing make a limited number of trips between market points
\(m_i\) and housing locations \(p_j\) (not necessarily the closest to them) to choose the housing to
purchase or rent. The infrequent and time-limited nature of this travel is denoted by dashed
arrows. Once in the housing, residents may benefit from the amenities of nearby markets \(m_i\). A
resident may visit one or more markets often, sometimes or rarely, and the markets from which
they derive benefits may not be the closest one to them. They also derive benefits from the units in which they live. The potentially more-frequent and long-lasting nature of travel from housing units to nearby markets is denoted by solid arrows.

One approach to formulating a decision model for affordable housing location given consumer behavior as illustrated above is to adapt a conventional location-allocation framework. In this framework, we focus on consumers’ trips from their origin neighborhoods to purchase housing, the value of which is derived from its own market and proximity to nearby markets. Another approach is to ignore the trips consumers make to purchase housing and instead focus on the net social benefits associated with proximity of sited subsidized housing units to nearby markets. This view is relevant because trips associated with housing search occur much less often than trips (actual or desired) between housing actually occupied and nearby markets.

*Location Models for Housing Search*

We develop models for affordable housing search based on the presentation in Fotheringham and O’Kelly (1989). Consider the production-constrained spatial allocation model

\[
S_j = \frac{O_i v_j \exp(-\beta d_{ij})}{\sum_{j=1}^{n} v_j \exp(-\beta d_{ij})},
\]

(1)

where

- \(S_j\) = proportion of demand at market \(i\) serviced by an affordable housing unit at location \(j\)
- \(O_i\) = proportion of demand originating at \(i\)
- \(v_j\) = attraction at \(j\)
- \(\beta\) = “impedance” or “distance decay” factor
- \(d_{ij}\) = distance between market \(i\) and housing unit at location \(j\)

Note that as \(\beta \to 0\), \(S_j \to \frac{O_i v_j}{\sum_{j=1}^{m} v_j}\), i.e. transportation costs do not influence the decision to consume housing at location \(j\). As \(\beta \to \infty\), the potential affordable housing resident travels to the nearest housing site, and non-travel cost considerations are irrelevant.
In addition, define

\[ Y_j = 1 \text{ if a housing unit is located at } j, \ 0 \text{ otherwise} \]

\[ f_j = \text{fixed provision cost associated with developing a housing unit at } j \]

\[ B = \text{total budget available for all housing development} \]

Then the production-constrained spatial interaction model with endogenous facility location is:

Min

\[
\frac{1}{\beta} \sum_{j=1}^{m} Y_j \sum_{i=1}^{n} S_{ij} \ln(S_{ij} - 1) + \sum_{i=1}^{n} \sum_{j=1}^{m} Y_j S_{ij} d_{ij} + \sum_{j=1}^{m} f_j Y_j
\]

s.t.

\[
\sum_{j=1}^{m} Y_j S_{ij} = O_i \quad i=1, ..., n
\]

\[
\sum_{j=1}^{m} f_j Y_j = B
\]

\[
\sum_{i=1}^{n} S_{ij} \leq Y_j \quad j=1, ..., m
\]

\[
0 \leq S_{ij} \leq 1 \quad \forall i, j
\]

\[
Y_j \in \{0, 1\} \quad \forall j
\]

Objective function (2) can be interpreted as the negative of consumer’s surplus (the first two terms; Fotheringham and O’Kelly 1989, p. 155) plus the total subsidy associated with locating the housing. The first term in (2) is the negative of a measure of locational benefits; the second term is a measure of the average interaction costs in the system. As the distance decay term \( \beta \) becomes large, objective function (2) becomes the objective of a conventional fixed-charge facility location problem and a solution to (2) – (7) will allocate families to the nearest unit.

Constraints (3) ensure that the total outflow from each origin to all open facilities must equal the known level of demand \( O_i \). Constraint (4) ensures that the total development cost of all affordable housing units does not exceed the available budget of the housing provider.

Constraints (5) prevent allocations of demand from node \( i \) to location \( j \) unless a facility is located at \( j \). Constraints (6) and (7) ensure the appropriate bounds of the allocation variables, and the
binary nature of the location decision variables, respectively. The nonlinear version of this integer program can be solved using Lagrangean relaxation (Fotheringham and O’Kelly 1989, p. 155 – 157); the linear version of this model is more tractable than the nonlinear version and can be solved using techniques such as variety of conventional methods, such as heuristics, branch-and-bound and Lagrangean relaxation.

A major drawback to model (2) – (7), with or without spatial interaction terms, is that its behavioral motivation is based entirely on the travel of households looking for affordable housing to the affordable housing units. This is done only a few times before purchase of the units, whereas, having moved into the housing units, households derive utility from proximity to multiple housing markets for the duration of their residence in the housing units.

Location Models for Community Revitalization

Models that focus on individual and neighborhood benefits derived by housing residents, and ignoring the process by which they choose units in which to live, can be derived as follows. We will treat local markets $i$ as “demand attractors” rather than “demand points” in conventional location-allocation models, and we treat potential locations of affordable housing $j$ as facility locations at which consumers may (or may not) visit local markets.

Suppose we are given neighborhoods $i$ that represent potential destinations (actual or perceived) for families living in owner-occupied housing at sites $j$ built by affordable housing providers. We assume that families in such housing put value on proximity to high-amenity neighborhoods, and may even visit them, for shopping or recreation. Since a family at site $j$ can visit multiple neighborhoods or none, we use a probabilistic allocation framework to formulate travel shares, as per Fotheringham and O’Kelly (1989).

Each neighborhood $i$’s attractiveness, or amenity level, is a function of the value of all residential properties $k$ in the neighborhood, $v_{ik}$. Suppose we rank the values $v_{ik}$ for all neighborhoods $i$ into percentiles. Then a property whose value $v_{ik}$ is at or above a certain percentile of the property value distribution for the entire study area is defined as a “high-value” property. Define $O_i$ as the percentage of all properties in the study area contained in neighborhood $i$ that are high-value.

We re-interpret the production-constrained spatial interaction model of (1) as follows:
\[ S_{ij} = \frac{O_{ij} \exp(-\beta d_{ij})}{\sum_{i=1}^{n} Y_{j} \exp(-\beta d_{ij})}, \quad (8) \]

where \( S_{ij} \) is the proportion of visits to neighborhood \( i \) made by a household at location \( j \). As the travel impedance parameter \( \beta \) increases, the term

\[ \frac{Y_{j} \exp(-\beta d_{ij})}{\sum_{i=1}^{n} Y_{j} \exp(-\beta d_{ij})}, \quad (9) \]

approaches the value \( X_{ij} \), where \( X_{ij} = 1 \) if neighborhood \( i \) is closer to location \( j \) than all other locations and \( X_{ij} = 0 \) otherwise. In other words, as \( \beta \) increases, neighborhood \( i \) is visited only by the housing location that is closest to it. This implies that \( S_{ij} \) converges to \( O_{ij}X_{ij} \) and locations are allocated to neighborhoods consistent with the P-median model. However, as \( \beta \) decreases, then it is less likely that a family at location \( j \) will visit a closest neighborhood \( i \), and the assumptions of spatial interaction models become more salient.

Thus, we may define the production-constrained spatial interaction model with endogenous facility location as arising from an optimization problem solved by the affordable housing provider that is, in fact, identical to the housing search model (2) – (7). Refer to this model as the community revitalization problem with spatial interaction terms (CR-SA).

Based on our discussion above, we have that as the impedance parameter \( \beta \) becomes large, CR-SA becomes a variant of the fixed-charge facility location model. The details of this model follow.

Define the following decision variables:

\( X_{ij} = 1 \), if a household in affordable housing at location \( j \) visits (or derives proximity-based benefits) from neighborhood \( i \)

\( = 0 \), otherwise

\( Y_{j} = 1 \) if a unit of affordable housing is sited at location \( j \),

\( = 0 \) otherwise

The housing location problem solved by the affordable housing provider is:
Min \[ \sum_{i=1}^{n} \sum_{j=1}^{m} O_{ij} \cdot d_{ij} \cdot X_{ij} + \sum_{j=1}^{m} s_{j} \cdot Y_{j} \]  

(10)

s.t. \[ \sum_{j=1}^{m} f_{j} \cdot Y_{j} \leq B \]  

(11)

\[ X_{ij} \leq Y_{j} \quad \forall i, j \]  

(12)

\[ \sum_{i=1}^{n} X_{ij} = 1 \quad \forall j \]  

(13)

\[ X_{ij} \in \{0,1\} \quad \forall i, j \]  

(14)

\[ Y_{j} \in \{0,1\} \quad \forall j \]  

(15)

Objective function (10) is the sum of amenity-weighted distance between housing units sited at \( j \) and local markets at \( i \) (a measure of consumer dissatisfaction at traveling to spatially dispersed markets) and the total subsidy associated with a particular housing development plan. Constraint (11) ensures that the total provision cost of the housing development plan does not exceed the available budget \( B \). Constraints (12) ensure that a household in an affordable housing unit at \( j \) cannot enjoy amenities of nearby market \( i \) unless a housing unit is actually sited at \( j \). Constraints (13) ensure that the total fraction of all visits of a household in affordable housing sited at \( j \) and all markets \( i \) sums to 1. Constraints (14) and (15) ensure that the decision variables take on binary values (since distance decay is large, no household will visit any nearby market except the closest one). Refer to model (10) – (15) as the community revitalization model with fixed costs (CR-FC). CR-FC is a linear integer program with binary decision variables and can be solved using a variety of conventional methods, such as heuristics, branch-and-bound and Lagrangean relaxation.

**Model Solution**

Implementation of models CR-SA and CR-FC is ongoing. Problem instances will be derived based on experience with the affordable housing provider ELR. Data to measure neighborhood attractiveness (within the officially-designed neighborhood that ELR serves, as well as portions of surrounding neighborhoods) will be derived from residential property assessments provided by the Allegheny County Office of Property Assessment. Neighborhoods that serve as attractors
are modeled as smaller regions that correspond to the conventional notion of urban micro-regions whose characteristics can change quickly over small distances. They will be defined as Census blocks. Property assessment data will be aggregated to the block group level.

CR-SA will be coded using the math programming language AMPL (ILOG-CPLEX Division 2006a; Fourer, Gay and Kernighan 2003). Initially, we will solve CR-SA using publicly-available nonlinear integer programming solvers (e.g. MINLP; Optimization Technology Center 2003, Leyffer 1999). Clearly, for large instances, customized solution algorithms such as the Lagrangean Relaxation method of Fotheringham and O’Kelly (1989) will be necessary. CR-FC will be coded using AMPL as well, and solved directly using CPLEX 10.0 for AMPL (ILOG-CPLEX Division 2006b).

V. Conclusions and Next Steps

The goal of this paper is to develop decision models for affordable housing development and community revitalization that are policy-relevant, consistent with affordable housing provider resources, preferences and development strategies and which represent novel extensions to the research literature in operations research/management science, geography, and housing and urban affairs. A survey distributed to affordable housing providers in the Pittsburgh metropolitan area has yielded valuable information regarding the outcomes that providers say are important for evaluating the efficacy of their programs, the types of housing units and subsidies they actually use, and the extent to which their decision-making process is consistent with best practices. The survey supports the notion that prescriptive decision models may help organizations make housing development decisions more effectively. Field research at a particular affordable housing provider in the city of Pittsburgh has enabled us to develop values structures that provide insight into the decision problems that the provider solves currently, or would like to solve in the future. In particular, we have identified a novel decision opportunity: the choice of residential parcels to develop to maximize the potential of redeveloped housing units to leverage the strengths of nearby residential markets. We have translated this decision opportunity into multiple decision models that, if solved, could provide tangible, detailed impacts on affordable housing providers and the communities in which they work. Solution of these decision models using neighborhood-level data is ongoing.
This paper has resulted in a number of research contributions. First, we have learned about affordable housing providers’ business models, values and resources—knowledge which is not readily available in the research literature. Second, we have demonstrated a methodology for prescriptive model-building that combines qualitative and quantitative methods in such a way as to provide confidence that the models reflect and address the real needs of affordable housing providers. Last, we have developed new decision models for affordable housing development that represent examples of policy-relevant linkages between discrete Weber-type location-allocation models and mixed-integer spatial interaction models, and between “user-attracting systems” and “delivery systems.”

The top priority for this research is to efficiently solve the decision problems listed above using real-world data, and derive policy insights from sensitivity analyses. Next, we hope to identify other decision opportunities for CDCs including: choice of parcels to acquire and develop under uncertainty and over time (see e.g. Johnson 2001a for policy planning for tenant-based subsidized housing under uncertainty); joint location and design of affordable housing (see e.g. Aboolian 2002 for a presentation of the private-sector facility location-design problem), and decision support systems to enable CDCs to evaluate multiple community development strategies (see e.g. Johnson 2001b for spatial decision support for tenant-based subsidized housing policy design).

Acknowledgements:

This research was funded by the National Science Foundation Faculty Early Career Development (CAREER) Program, “CAREER: Public-Sector Decision Modeling for Facility Location and Service Delivery”, SES-0134890. We thank three anonymous reviewers of the affordable housing provider survey for their time and expertise. Any remaining flaws of the survey are ours alone. We are deeply appreciative to East Liberty Development, Inc. for their cooperation. We thank Philip Akol, Changmi Jung, Patrick Mallory and Ying Xiong for their research support.
References:


ILOG-CPLEX Division. 2006a. AMPL Version 10.0. Incline Village, NV.

ILOG-CPLEX Division. 2006b. CPLEX 10.0 for AMPL. Incline Village, NV.


Appendix:

Preliminary Objectives Derived from Interviews with East Liberty Revitalization (ELR)

I. Integration of community

For commercial development: To reverse “Urban Renewal”
1. To build pedestrian-friendly commercial districts
   a. To slow down fast lane traffics by putting 4 lane streets to 2 lanes
   b. To put more red lights and stop signs to slow the traffic
   c. To build handicap access
   d. To reconnect streets that are disconnected
2. To tear down vacant parking lots around Penn Circle that separates the community
3. To pursue smart design, a replication of old urbanism
   a. To subsidize smart design
   b. To provide low interest loan and guidelines to commercial builders engaged in smart design

For residential development:
1. To buy and renovate abandoned housings in the neighborhood
2. To integrate with existing commercial district as well as with new development in the commercial district
3. To maximize efficient living by encouraging mass transit from residential to commercial district
4. To reengineer demographics of neighborhood
   a. Rental housing program
      (1) To require credit background check
      (2) To provide with credit counseling services: 80% of residents are rental
      (3) To diversify socio-economic level by mixing market-rate with affordable housing opportunities
      (4) To create for safe and clean neighborhood by prohibiting residents engaged with drugs and prostitution
   b. For-sale housing program
      (1) To sell to residents and potential buyers committed to keeping the property as single-family housing
      (2) To provide with credit counseling services
      (3) To diversify socio-economic level by mixing market-rate with affordable housing opportunities
      (4) To create for safe and clean neighborhood by prohibiting residents engaged with drugs and prostitution

II. Promotion of Private Investment

To promote private investment on commercial development:
1. To pursue partnership with private real estate developers, e.g. Liberty Bank Building
   a. To facilitate private investment and development of neighborhood
      i. To make low interest loan resources to private real estate developers
      ii. To assist paperwork so that other projects can be approved with other grand sources
      iii. To charge them a fee for having which support ELR operating management
   b. To entice private investors to focus on community’s goals & objectives with incentives
      i. To make low interest loan resources to private real estate developers
      ii. To assist paperwork so that other projects can be approved with other grand sources
      iii. To charge them a fee for having which support ELR operating management
2. To chose private investment partners sharing same community vision and development; approval of community-building pedestrian-friendly commercial district-is important
   a. To facilitate private investment and development of neighborhood
      i. To make low interest loan resources to private real estate developers
      ii. To assist paperwork so that other projects can be approved with other grant sources
      iii. To charge them a fee for having which support ELR operating management
   b. To entice private investors to focus on community’s goals & objectives with incentives
      i. To make low interest loan resources to private real estate developers
ii. To assist paperwork so that other projects can be approved with other grand sources
iii. To charge them a fee for having which support ELR operating management

To promote private investment in residential development:
1. To draw the market force to East Liberty from Shadyside and Highland Park by replicate the quality of those neighborhoods; to seek opportunities to invest e.g. by building near working market near by
   a. To provide a safe neighborhood
      i. To remove adverse market conditions from the neighborhood
2. To achieve efficient quality in design high quality and to meet the resources to match the quality
   a. To increase quality level of affordable housing with less subsidy
3. To cooperate with private developers: Developer does not want to risk money upfront and acquire a property on his own. ELR takes a certain percentage of risk to attract private investors.
   a. To do the site acquisition and pre-development work; it requires house by house negotiation which requires time and labor
   b. To get a demo and hire an architect to get preliminary sketches
   c. Then to sell to the private developer
4. To reverse urban decline: Housing value declined with suburbanization, therefore ELR is trying to capitalize to develop an urban neighborhood
   a. To board up and cut grass to show somebody cares the neighborhood
   b. To buy abandoned housings and revitalize the playground of prostitution and drug dealers starting from boarding up and cutting grass to show somebody cares, then with time the neighborhood doesn’t look like such a slum, and rate of breaking-in reduces
5. Provide access to the loans to the prospective home owners
6. To identify changing markets and opportunities for private investment
   a. To hire market researchers
   b. To extend beyond market researchers’ conservative recommendations
   c. To anchor and play with market demographics to decide where do they invest
7. To target residents to decide how much subsidy to use and what renovation level to pursue

III. To optimize resources
   a. To increase sales price, thus decreasing subsidy
      i. To build close to strong markets
      ii. To change character of street
   b. To increase quality level to achieve under given conditions
      i. Designing newly built homes with Green Building technology
      ii. To renovate high-quality exiting housing
   c. To maximize the life span of affordable housing built
      i. Designing newly built homes with Green Building technology
      ii. To renovate high-quality exiting housing

IV. Property Redevelopment
1. To redevelop property
   a. To reduce the cost
      i. To allow the city to own property as management of purchased property costs resources-
         “city land bank”
      ii. To acquire site control through “option agreements,” thus incurring no maintenance costs
   b. To find and transfer to responsible landlords
   c. To transform property
      i. To mothball
      ii. To fully renovate and push to the market value
      iii. To look at the original conditions of building structures in the neighborhood to decide on the level of renovation or demolition
   d. To lay-out combination of housing in a parcel changes in mix of development options
   e. To market property
      i. “Flip”
      ii. “Test-drive”
### Tables and Figures:

#### Organization Attributes

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<td>Funding</td>
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#### Service Region

- County: 2; Region: 5; City: 2; Neighborhood: 8
- Type:
  - Organization Type: Nonprofit:12; Government Agency/Enterprise: 4; Private: 1
  - Structure Category:
    - Type 1 (all-volunteer; board-led): 1
    - Type 2 (Executive Director plus volunteer or administrative support staff): 0
    - Type 3 (Executive Director plus professional support staff – single mission): 8
    - Type 4 (Executive Director plus professional support staff – multiple departments or sites): 8

N = 17 responses

#### Service Area Attributes

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<td>63.28%</td>
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<td>% Single Family Household w/Female w/Kids†</td>
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<td>3.69%</td>
<td>16.50%</td>
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<td>% of Persons 16 years old + employed†</td>
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<td>36.84%</td>
<td>59.43%</td>
<td>5.15%</td>
<td>57.40%</td>
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<td>% Black†</td>
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<td>1.72%</td>
<td>58.78%</td>
<td>16.13%</td>
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<td>11.60%</td>
<td>6.35%</td>
<td>22.19%</td>
<td>4.43%</td>
<td>8.66%</td>
</tr>
<tr>
<td>% of Housing Units Owner Occupied†</td>
<td>56.56%</td>
<td>30.90%</td>
<td>77.12%</td>
<td>14.55%</td>
<td>67.02%</td>
</tr>
<tr>
<td>% Persons 5yr+ in Same Neighborhood†</td>
<td>59.34%</td>
<td>35.54%</td>
<td>68.85%</td>
<td>9.16%</td>
<td>64.55%</td>
</tr>
<tr>
<td>Crime Rate (Part I, per 100 residents)†</td>
<td>5.25</td>
<td>0.07</td>
<td>8.90</td>
<td>2.42</td>
<td>3.23</td>
</tr>
</tbody>
</table>

N = 17 responses

Household/Life Benefits

- improved family outcomes
- decreased burden, increased affordability
- increased homeownership rate
- reduced destructive family behaviors
- other

[Figure 1: Primary Anticipated Benefits of Organization Services]

Technical Assistance Sought

- email/list serve
- websites
- conferences
- other

[Figure 2: Technical Assistance Sought]
[Figure 3: Development Type Preferences]
Respondent Development Types

[Figure 4: Physical Development Styles]
Figure 5: Demand-Side Subsidy Preferences of Providers
[Figure 6: Supply-Side Subsidy Preferences of Providers]
Assessing Need

[Figure 7: Criteria by Which Developers Assess Need for Affordable Housing]

Consideration of On-going Econ. Dev’l Strategies

[Figure 8: Consideration of Ongoing Economic Development Strategies]
Criteria Most Important in Developing New Housing

[Figure 9: Criteria Most Important when Developing New Housing]
### Table 3: Average Number of Affordable Housing Subsidy Strategies, by Respondent Size

<table>
<thead>
<tr>
<th>Organization Size*</th>
<th>Demand-side</th>
<th>Supply-side</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td>2.00</td>
<td>3.00</td>
</tr>
<tr>
<td>Medium</td>
<td>2.25</td>
<td>2.50</td>
</tr>
<tr>
<td>Small</td>
<td>1.75</td>
<td>2.88</td>
</tr>
<tr>
<td>All</td>
<td>1.94</td>
<td>2.82</td>
</tr>
</tbody>
</table>

*“Small” = less than 10 employees; “Medium” = 10 – 49 employees; “Large” = 50 or more employees
Response values: Number of subsidy types rated by respondent as used “often” or “almost always”
N = 17 responses

### Table 4: Likelihood of Including Non-Residential Components in Affordable Housing Development, by Respondent Size

<table>
<thead>
<tr>
<th>Organization Size*</th>
<th>0.80</th>
<th>0.75</th>
<th>0.75</th>
<th>0.76</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Medium</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Small</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*“Small” = less than 10 employees; “Medium” = 10 – 49 employees; “Large” = 50 or more employees
Response values: “1” = “Real estate developments include non-residential components; “0” otherwise
N = 17 responses

### Table 5: Frequency of Collaboration by Affordable Housing Providers with Other Affordable Entities, by Respondent Size and Service Region

<table>
<thead>
<tr>
<th>Affordable Housing Provider Region**</th>
<th>Organization Size*</th>
</tr>
</thead>
<tbody>
<tr>
<td>City</td>
<td>City</td>
</tr>
<tr>
<td>County</td>
<td>County</td>
</tr>
<tr>
<td>Other</td>
<td>Other</td>
</tr>
<tr>
<td>All</td>
<td>All</td>
</tr>
<tr>
<td>Large</td>
<td>5.00</td>
</tr>
<tr>
<td>Medium</td>
<td>3.50</td>
</tr>
<tr>
<td>Small</td>
<td>4.71</td>
</tr>
<tr>
<td>All</td>
<td>4.54</td>
</tr>
</tbody>
</table>

Response codes: “5” = “almost always”; “4” = “often”; “3” = “sometimes”; “2” = “Seldom”; “1” = “Never”
*“Small” = less than 10 employees; “Medium” = 10 – 49 employees; “Large” = 50 or more employees
** “City” = City of Pittsburgh only; “County” = Allegheny County (possibly including city of Pittsburgh);
“Other” = Outside of Allegheny County
N = 17 responses

[Table 3: Average Number of Affordable Housing Subsidy Strategies, by Respondent Size]
[Table 4: Likelihood of Including Non-Residential Components in Affordable Housing Development, by Respondent Size]
[Table 5: Frequency of Collaboration by Affordable Housing Providers with Other Affordable Entities, by Respondent Size and Service Region]
Maximize the social benefit of nonprofit/services development
Maximize the social benefit of committed development services
Maximize the social benefit of regional commercial attractions
Maximize the social benefit of local commercial attractions
Maximize the social benefit associated with neighborhood development (A)
Maximize the social benefit associated with housing development (B)

Maximize the social benefit of residential development

Maximize the social welfare of East Liberty

Maximize the social benefit of commercial development

[Figure 9: High-Level Fundamental Objectives of Local Affordable Housing Developer]
Maximize the social benefit of residential development

Maximize the social benefit of affordable/low-income housing development

Maximize the social benefit of market-rate housing development

Maximize beneficial outcomes for program participants

Maximize beneficial outcomes for non-program non-participants

Maximize positive property value impacts

Maximize the cost-effectiveness of housing development

Maximize socio-economic diversity and integration

Ensure both existing resident and new buyers co-exist in the neighborhood

Ensure residents in low-, moderate-, high-income level live in the same neighborhood

Ensure residents in mix of white, black, Hispanic, and other ethnicity live in the same neighborhood

Maximize housing consumption-related indirect benefits

Maximize housing consumption-related direct benefits

Maximize neighborhood related outcomes

Community "efficacy"

visual appeal

crime

services

[Figure 10: Fundamental Objectives: Maximize the Social Benefits Associated with Neighborhood Development]
Maximize the social benefit of residential development (A)

Maximize the cost-effectiveness of housing development (B)

- Improve physical design
  - Interior
  - Exterior

- Diversify tenure type
  - owner
  - Renter

- Diversify of housing options
  - Single-family
  - Multi-family
  - Subsidy based
  - Non-subsidy based

- Increase resources

- Reduce cost
  - Materials
  - Labor

- Maximize market force near by
  - Housing market
  - Commercial market

[Figure 11: Fundamental Objectives: Maximize the Social Benefits Associated with Housing Development]
Build in a combination of diversified housing options

Fully renovate

Test-drive

Flip

Push to the market value, look at the original conditions of building structures in the neighborhood

Demolish and reconstruct

Mothball

Set height and width of housing structure with continuity as the ones next door

Build on "smart design"

Keep the physical exterior continuity of the neighborhood

Achieve efficient quality in design and to meet the materials to match the quality

Maximize quality level to achieve under given amount of resources

Maximize the lifespan of affordable housing built

Maximize the cost-effectiveness of housing development

Increase sales price, thus decrease subsidy

Renovate on the basis of exiting high-quality Victorian housing

Set quality level standard to the existing Victorian housing units in the neighborhood

Design newly built homes with Green Building technology

Draw the market force to East Liberty from Shadyside and Highland Park by replicating the quality of those neighborhoods

Build on the border of East Liberty and Shadyside and Highland Park

[Figure 12: Means-Ends Network: Maximize the Cost-Effectiveness of Housing Development]
[Figure 13: “Outside-In” Residential Development Strategy]
[Figure 14: Location of Conventional Service Provision Facilities versus Affordable Housing]