Community-Engaged Operations Research: Trends, New Frontiers and Opportunities

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Presentation summary

- ‘Community-engaged operations research’ is an extension of multiple OR/MS traditions to support localized impact and social change
- It applies critical thinking, evidence-based policy design, community participation and decision modeling to local interventions
- Complementary work in community OR and community-based OR provides new theory and applications in diverse domains
Acknowledgements

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**Collaborators:**
- Alma Biba (‘16), George Chichirau, Sandeep Jani, Hyun-Jung Lee, Alvine Sangang, Buki Usidame, doctoral students, University of Massachusetts Boston
- Armagan Bayram, Rachel Drew (‘14), Justin Hollander, Jeff Keisler, Gerald Midgley, Karen Smilowitz, Senay Solak, David Turcotte, co-authors
Motivation

- High levels of social problems such as poverty, food insecurity, and housing costs
  - 46.7 million Americans in poverty in 2014\(^1\)
  - 17.4 million were food insecure in 2014\(^2\)
  - 39.6 million households with at least moderate housing burdens in 2013\(^3\)

- Addressing these problems requires focus on
  - Underrepresented/isolated/vulnerable populations
  - Localized as well as national-level responses
  - Focus on recipients of social services and interventions as well as systems or physical infrastructure

\(^2\) U.S. Department of Agriculture, based on Current Population Survey Food Security Supplement
\(^3\) Joint Center for Housing Studies, Harvard University 2015
Research questions

How can OR/MS provide theory, models and applications that can improve lives of individuals and communities?
Can solution approaches balance rigor and generality with specificity and impact?
Is OR/MS as taught and practiced compatible with social change and social justice?
When can public-focused OR add value to society?

- When individuals or organizations seeking better ways to deliver goods or services define value in ways not limited to ‘profit’
  - Reduction in food insecurity
  - Preservation of biodiversity
  - Maximization of property values

- When the goods or services delivered are not primarily traded in ‘markets’
  - Public safety
  - Human security
  - Environmental quality

- When beneficiaries of goods and services provision lack political or social influence to set policy priorities
  - Racial and ethnic minorities
  - Low- and moderate-income individuals
  - Residents of socially- or geographically-isolated communities
What distinguishes an OR application for public impact?

- Multiple stakeholders
  - Client organization
  - Groups that experience externalities
  - Future generations

- Multiple objectives
  - Efficiency
  - Effectiveness
  - Equity

- Substantive engagement
  - Problem definition with, not just for, clients and stakeholders
  - Validation that solutions can generate improved social outcomes, not only improved process measures
Public-sector OR has had many successes...

- Design of policies for drug distribution to anticipate epidemic and pandemics
- Emergency management vehicle dispatch and scheduling
- Preservation of public safety against threats of terrorism
- Distribution of donated food to communities facing food insecurity
- Air transport management
- Hazardous materials distribution and storage
- Reserve management design
  (and many others, see Pollock, Rothkopf and Barnett 1994, Larson and Odoni 2007, Kaplan 2016)
But many important public are not as well-understood

- What measures of ‘resiliency’ are important to the well-being of vulnerable communities?
- How can low-income communities choose redevelopment strategies that balance opportunity and protection?
- What mix of energy development options are affordable to a wide range of populations?
- How can a school district design a lottery system for public schools that balances desires for local access and academic excellence?

Problems that are hard to define (see e.g. Rosenhead and Mingers 2001), that require a deep understanding of local needs, and whose solutions depend on active community participation can be addressed using methods referred to in this talk as **community-engaged operations research**
What are key characteristics of community-engaged OR?

- Emphasis on ‘intervention’ as opposed to observational science or methodological innovations
- Local engagement and impact
- Focus on disadvantaged and underserved populations
- Interest in problem-solving processes as well as outcomes
- Critical approach and concern for ethics
- Use of qualitative and mixed-method analytics (e.g. ‘soft OR’)
- Aim for community empowerment and social change

‘Community operational research’ (Midgley and Ochoa-Arias 2004) places greater emphasis on understanding and empowerment; ‘community-based operations research’ (Johnson 2012) places greater emphasis on analytic methods for policy, planning and operations prescriptions
What could a ‘theory’ of community-engaged OR be?

- Principles: Intervention, community engagement, critical perspective, social justice, community change, multi-methodology, mixed-methods
- Outcomes: Deepened understanding of values, problem context and data; increased community capacity to formulate and solve problems; improved measures of individual and community well-being
- Questions:
  - Are individuals and communities better off after a COR/CBOR intervention? In what ways?
  - What are the benefits and costs of COR/CBOR approaches as compared to traditional OR/analytics approaches? Or other disciplinary solutions? For what communities and problem types?
  - What types of problems and community contexts are more promising for COR versus CBOR approaches?
The process of Community-Based Operations Research

Decision modeling process could stop at any of these steps

Place/neighborhood
Community/social group
Institutions/organizations

Problem identification
Problem formulation
Problem solution

Multiple research frameworks
Multiple solution methods

Multiple stakeholders
Collaborative
Evidence-based
Social welfare/Equity emphasis
The process of CBOR, continued

- Iterative
- Problem solution
- Implementation
- Theory-building
- Organization/community impacts
- Social change
What are challenges of community-engaged OR?

- Public-serving organizations and citizens may lack expertise for data-driven problem-solving
- Understanding problem context and identifying problem opportunities may be as (or more) important than model-building
- Community engagement is expensive, difficult and time-consuming
- Many problems are situated in social and political contexts that may be confusing, contentious or alienating

Good community-engaged OR requires many skills not traditionally taught in business, operations management or industrial engineering classes (or even traditional policy, public management or urban planning)!
Emerging trends in OR subfields

- **Humanitarian logistics**
  - Adaptation of logistics principles for planning for and responding to natural and man-made crises (Çelik et al. 2014)
  - Usually concerned with systems-level understanding and quantitative modeling and solutions
  - Community-engaged OR can integrate stakeholder experiences to address on-the-ground difficulties in disaster response (Munday 2015)
Emerging trends in OR subfields

Analytics

- Composed of descriptive analytics, predictive analytics and prescriptive analytics (Liberatore and Luo 2010)
- Often seen as a ‘superset’ of OR
- Linked with explosion of data, business redesign and IT/Web innovations
- Community-engaged OR can emphasize qualitative data and methods, utility of data for individuals and communities, and role of communities in defining their own problems
New frontiers in domains outside of OR

- Urban planning and community development
  - Goal is to make homes, neighborhoods and cities better places to live for all
  - Available tools include land use management, community organizing, design of products and services to meet needs of urban neighborhoods (Hall and Tewdwr-Jones 2010; Levy 2017)
  - Community-engaged OR can connect theory and methods of planning and development with decision science principles of problem identification, formulation and solution that emphasize process learning and stakeholder impact (Johnson et al. 2015)
New frontiers in domains outside of OR

- Information systems and information technology
  - IS/IT is a well-studied field for design, development and evaluation of computerized tools and systems that crosses many disciplines
  - However, IS/IT places less emphasis on community-engaged problem solving, and community-engaged OR has placed less emphasis on IS/IT for community interventions
  - Participatory information systems, online community creation and engagement, localized applications addressing marginalized communities can be fruitful areas for community-engaged OR
New frontiers in domains outside of OR

- Big and difficult data
  - Public-sector applications of big data often reflect technocratic, consumer-focused, surveillance and enforcement concerns
  - Growing evidence of community participation in large-scale data analysis (Calvard 2016), community curation of datasets (Bertot et al. 2014) and community-driven understanding of data meaning (Couldry and Powell 2014)
  - ‘Small’ data can tax resources of community-based organizations (Johnson 2015)
  - Community-engaged OR can support development of locally-generated datasets and metrics, and data-driven decision models that embrace mixed methods
New frontiers in domains outside of OR

- Smart cities
  - Common understanding emphasizes use of large datasets to improve operations and management of government and services through advanced technologies (Caragliu et al. 2009)
  - Many applications reflect centralized, expert-driven tools and applications and centrality of surveillance state (White and Trump 2016), though recent work (Batty et al. 2012) acknowledge potential of ‘citizen science’
  - Community-engaged OR could influence design and implementation of smart city initiatives to reflect governance, digital divides and community concerns rather than technology and customer-facing applications
New frontiers in domains outside of OR

- Diversity and inclusion
  - *Diversity* addresses recognition of differences, both valued and stigmatized, that affect individual and group social outcomes; *inclusion* reflects policies that enable organizations to better reflect community diversity
  - Many D&I problems are amenable to quantitative, model-driven solutions (Shi 2015; Chen and Kesten 2016), but complex problems confront political and social barriers
  - COR’s strength in community engagement and critical approaches has resulted in multiple community-focused interventions (Cohen and Midgley 1994; Romm 2001), but more can be done to generate policies and prescriptions for organization design and service delivery
New frontiers in domains outside of OR

- Indigenous people’s issues
  - ‘First nations’ populations struggle to achieve economic stability, cultural preservation and political empowerment in the face of cultural imperialism and exploitation by researchers (Smith 1999)
  - COR has increasingly recognized issues of identity and indigenous problem-solving methods but struggled with conflicts between cultural norms (Midgley et al. 2007; Bishop 1996) that can inhibit Western-style research
  - Community-engaged OR can deepen understanding of co-creation of problems and solutions and support development of culture-specific theories, methodologies and practices
Current CBOR-related projects: Hits and misses

- Foreclosed housing development
  - What foreclosed properties should a community-based organization purchase to revitalize neighborhoods?

- Housing vacancies and municipal shrinkage
  - To what alternative uses can property currently or likely to be vacant be put to ensure municipal stability?

- Community data analytics for economic development
  - What performance metrics are best aligned with goals for local development across neighborhoods and stakeholders?

Common themes: Diverse solution approaches, evidence development, community engagement, multidisciplinarity
Foreclosed housing: Policy motivation

- **Aggregate effects:**
  - Over 4 million homes lost to foreclosure
  - 30% decline in house prices
  - $7 trillion in home equity lost

- **Socio-geographic concentrations:**
  - High-priced areas that overbuilt
  - Economically struggling cities with high rates of subprime lending
  - Lower-income and minority households

- **Social and economic consequences of foreclosures:**
  - Residential stability
  - Personal well-being
  - Spill-over effects

(Source: Joint Center for Housing Studies 2013; Immergluck 2010; McKernan et al. 2014)
Foreclosed housing: Analytic response

- Focus on community-level foreclosure response: acquisition, management, rehabilitation, disposition of distressed properties
- Value-focused thinking: clarify objectives, attributes, decision opportunities
- Analytics: quantify impacts of foreclosure responses
- Stochastic dynamic programming: design bidding strategies and manage housing portfolios
- Multiobjective math optimization: identify acquisition and redevelopment opportunities
Foreclosed housing: Selected findings

Use value-focused thinking to identify decision strategies for diverse community partners
Foreclosed housing: Selected findings, continued

Use estimates of foreclosure response impacts to solve multiobjective optimization problem for property acquisition.
Was this a successful CBOR application?

- Our goal was to use qualitative, community-engaged methods to identify solution opportunities, then solve empirical problems.
- In practice, VFT applications yielded great insight, but quantitative analysis proceeded in parallel with qualitative analysis.
- Funding limitations prevented solution implementation and community outcomes evaluation.
Shrinking cities and vacant land management: Policy motivation

- Symptoms:
  - 30 cities with 500,000 or more residents have lost 8.61% of their populations on average
  - Number of vacant housing units has increased by 44%
  - Eight cities facing population declines have incurred $23 billion in debt before declaring bankruptcy

- Causes:
  - Urban deindustrialization
  - Federal policy supporting out-migration to suburbs
  - Foreclosed housing crisis and the Great Recession

- Traditional remedies:
  - Investments in housing, employment and physical infrastructure

(Sources: Popper and Popper 2002, Hollander et al. 2009)
Shrinking cities and vacant land management: Analytic response

- Classify vacant or abandoned parcels in blighted neighborhoods for multiple non-traditional uses
- Apply multi-objective optimization to select aggregations of parcels for new uses
- Evaluate actual decisions of planners for test data to infer values structures
Shrinking cities and vacant land management: Findings

Multi-objective optimization: objective space vs. decision space
Shrinking cities and vacant land management: Findings, cont’d

Values structures inferred from planner decisions using sample neighborhood data

<table>
<thead>
<tr>
<th>Theme</th>
<th>Why Important</th>
<th>Criteria</th>
<th>Metrics</th>
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<tbody>
<tr>
<td>Strategic demolition and rehabilitation</td>
<td>Support existing homeowners and bolster redevelopment efforts</td>
<td>Blight elimination</td>
<td>Crime hotspots</td>
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<tr>
<td></td>
<td>Improve quality of life for Baltimore residents</td>
<td></td>
<td>Code enforcement problem areas</td>
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<tr>
<td></td>
<td>Stabilize neighborhoods</td>
<td></td>
<td>Proximity to areas with current redevelopment projects</td>
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<tr>
<td>Budgetary constraints and challenges</td>
<td>Apply limited funding in an equitable and maximally effective way</td>
<td>Equitable distribution of funds</td>
<td>Blocks with high vacancy concentration</td>
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<tr>
<td></td>
<td></td>
<td>Targeted investment</td>
<td>Proximity to areas with high owner-occupancy</td>
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<td>Proximity to areas with current redevelopment projects</td>
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<td></td>
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<td>Proximity to areas with high owner occupancy</td>
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<td></td>
<td>Areas with high vacancy concentration</td>
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<td>Housing market typology (distressed categories)</td>
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</tbody>
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Minimal acquisition
Minimal relocation
Minimal need for structural supports
Request from the community/community organizers/city councilmen, etc.
Historic value/preservation
Was this a successful CBOR application?

- The Tufts/UMB researchers were prevented by our Baltimore partners from engaging with community stakeholders
- Planners observed to act in name of residents
- Not sure if findings can translate to sustainable, localized strategies
Local economic development: Policy motivation

- Devolution in American governance has resulted in public-private partnerships to deliver important services.
- Thousands of Main Streets organizations partner with municipalities to support local economic development.
- In the city of Boston, 20 Main Street Districts are required to report process and outcome data through a monthly survey to their primary funder, the Department of Neighborhood Development.
- Generally, MSDs feel that the data they must report are not those that they feel reflect the real nature of their work or measures of impact.

Sources: (Ketti 2000; Robertson 2004; Seidman 2004)
Local economic development: Analytic response

- Perform multi-site case study across multiple Boston Main Streets districts
- Use value-focused thinking to identify values structures for multiple stakeholder groups
- Identify commonalities, differences over groups and geographies
- Generate practical recommendations for new metrics and decision opportunities
Local economic development: Preliminary findings

Values structures: alternatives vs. attributes, insurance broker
Local economic development: Preliminary findings, continued

Client, stakeholders have different views on success metrics

<table>
<thead>
<tr>
<th>BMS directors’ perspective:</th>
<th>Stakeholders’ perspective:</th>
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<tbody>
<tr>
<td>o Place-making and branding</td>
<td>o Socio-economic sustainability</td>
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<tr>
<td>- Visual appeal of storefronts and streets</td>
<td>- Diversity of clientele and of merchants</td>
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<tr>
<td>- Distinctive visual cues demarcating Main Street district</td>
<td>- Cultural accommodation</td>
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<tr>
<td>o Shopping opportunities</td>
<td>- Community efficacy</td>
</tr>
<tr>
<td>- Stores at different price-points</td>
<td>- Economic opportunity</td>
</tr>
<tr>
<td>- Diversity of products</td>
<td>- Strength of social institutions</td>
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<tr>
<td>o Safety</td>
<td>- Sense of mutual responsibility</td>
</tr>
<tr>
<td>- Loitering</td>
<td>o Business sustainability</td>
</tr>
<tr>
<td>- Panhandling</td>
<td>- Access to local business expertise</td>
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<tr>
<td>- Traffic</td>
<td>- Access to business skills training</td>
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<tr>
<td>o Local business health</td>
<td>- Focus on specific products and services</td>
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<td>- Business ‘churn’</td>
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<tr>
<td>- Vacancy rate</td>
<td></td>
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<tr>
<td>- Attractiveness to shoppers inside and outside the district</td>
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<td>- Access to capital resources</td>
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Can this be a successful CBOR application?

- Close collaboration with community-focused partners
- Primary data collection across stakeholder groups and geographies
- Insights about values may be at least as important as recommendations for metrics and decision opportunities
- Opportunity to combine qualitative and quantitative methods
Conclusion

- Community-engaged OR is an emerging sub-discipline with ties to diverse research traditions and demonstrated organizational and social impacts.
- Community OR and community-based OR can bridge gap between the success of ‘hard-OR’ in addressing well-defined and analytically complex quantitative problems, and the challenges of ‘wicked’ problems that require more inductive, collaborative and mixed-methods approaches.
- Research rigor may come from theory-building and testing, novel methods of data gathering, support for impacts, creative development of appropriate decision technologies.
- Promising community-engaged OR applications exist in diverse application areas within and outside of traditional OR domains.
Next steps

- Publish more COR/CBOR studies in traditional, prestigious OR/MS outlets:
  - *European Journal of Operational Research*
  - INFORMS journals

- ...as well as scholarly outlets less-commonly used in OR/MS
  - Urban, community and regional planning
  - Policy and urban studies
  - Race, ethnicity and gender studies

- Deepen the theoretical understanding of COR/CBOR
  - Political economy of OR/MS
  - Increased use and justification of multi-methods
Selected references


