OPERATIONS MANAGEMENT IN THE NONPROFIT SECTOR

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Natalie A. Privett
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I certify that I have read this dissertation and that, in my opinion, it is fully adequate in scope and quality as a dissertation for the degree of Doctor of Philosophy.

Feryal Erhun Oguz, Primary Adviser

I certify that I have read this dissertation and that, in my opinion, it is fully adequate in scope and quality as a dissertation for the degree of Doctor of Philosophy.

Warren Hausman

I certify that I have read this dissertation and that, in my opinion, it is fully adequate in scope and quality as a dissertation for the degree of Doctor of Philosophy.

Hau Lee

Approved for the Stanford University Committee on Graduate Studies.

Patricia J. Gumport, Vice Provost Graduate Education

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Abstracts

The intersection of operations management and nonprofit studies creates valuable opportunities where similarities and differences between the for-profit and nonprofit sectors can be leveraged for both scientific and operational advances. This dissertation lies at this intersection, focusing on applying the theories and tools of operations and supply chain management in the nonprofit sector. With the nonprofit sector expanding and becoming more influential, it may be surprising that there is relatively little research, especially analytical research, involving nonprofit operations. Thus, the research described here represents some of the first efforts of what will hopefully be an emerging area within both disciplines.

Since addressing the needs of underrepresented, underserved, and vulnerable populations is the central goal of many charitable nonprofit organizations, it is naturally intertwined with community-based operations research. Chapter 2, *Operations Management in Community-Based Nonprofit Organizations*, provides an overview of literature, potential research, and opportunities for applications from this perspective. Furthermore, this chapter gives a high-level outline of this dissertation by uncoupling nonprofit supply-side, production, and demand-side.

In Chapter 3, *Efficient Funding: Auditing in the Nonprofit Sector*, we take a theoretical perspective of the relationship between funders and nonprofits and study the role of contracts in managing inefficiencies and nonprofit sector performance. In routinely scrutinizing nonprofit reports in efforts to deduce whether a nonprofit organization is efficient, funders may believe that they are, in fact, giving responsibly. However, we find that these nonprofit reports are unreliable, revealing that common funding methods do not facilitate efficient allocation of funds. In response, we develop

audit contracts that put funders in a position to enact change, benefitting funders, the population of nonprofits, and the sector as a whole. Indeed, our conclusions indicate that nonprofits may want to work with funders to increase the use of auditing, consequently increasing efficiency and impacting society as a whole.

Proceeding from this look at the nonprofit funding or supply-side, Chapters 4 through 7 examine the consumer- and production-sides by looking at local public health collaboration. Local public health departments are embedded in communities of potential partners where collaborative relationships form network links and, consequently, mobilize resources. While resources, information, and beneficiaries can flow into a local health department, they can also flow out. As such, community-based collaboration decisions become tactical operations decisions implying that local health departments can approach collaboration with specific strategies in mind, including revenue generation. From both chapters, we conclude that just as scholars must expand their concept of collaboration to incorporate setting, partners, activities, and combinations of these, practitioners must also ask "Who," "With whom," and "How?" when approaching their own collaboration portfolios. In thinking about collaboration strategically, local health department practitioners should begin strategizing with the question of "Why collaborate?" Here we offer revenue generation as a viable answer. However, we also conclude that "Who?," "With whom?," and "How?" are critical questions for getting the most from local health department collaboration portfolios in practice and genuinely understanding collaboration in future research. Ultimately, such research and practice focused on strategic collaboration may well help local health departments to leverage additional resources and better meet the needs of their communities.

While operations management has not historically been applied to the nonprofit sector, traditional operations management models and solutions cannot simply be cut and paste. Thus, the sector is ripe with opportunity for operations management research and application; this dissertation represents some of the first fruits. Such research can result in more efficient supply chains and improved decision making for all nonprofit organizations with the most important effect of changed lives.

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Chapter 1

Introduction

Nonprofit organizations (NPOs) are not only a critical and integral part of daily life in their social contributions, they are also an important and growing sector of our national economy. Such institutions are so pervasive, that in fact most people interact with at least one nonprofit organization on a daily basis. These range from professional organizations to local hospitals to educational institutions. Everyone in society benefits from the services provided by nonprofits either directly or indirectly.

This dissertation is a manuscript-style dissertation (consistent with the field), focusing on applying the theories and tools of operations and supply chain management in the nonprofit sector. With the nonprofit sector expanding and becoming a more influential part of life and economy, it may be surprising that there is relatively little research, especially analytical research, involving nonprofit operations. Thus, the research described here represents some of the first efforts of what will, hopefully, be an emerging area within both disciplines. This sector is ripe with unexplored opportunity for supply chain management research and application that can result in more efficient supply chains and improved decision making for all nonprofit organizations with the most important effect of changed lives.

The research presented in this dissertation lies at the intersection of fields, specifically operations management (OM) and nonprofit and philanthropic studies. Figure 1.1 details points of both disciplines. Operations management is an interdisciplinary

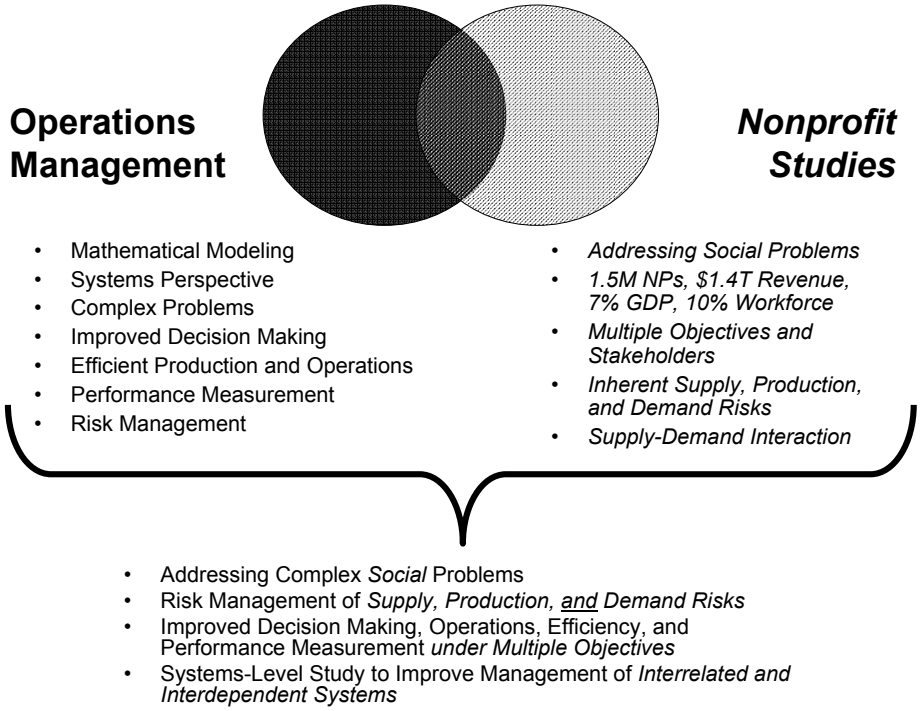


Figure 1.1: Intersection of Fields: Operations Management and Nonprofit Studies

field encompassing engineering, business, applied mathematics, economics, and statistics. It focuses on improved decision making and efficient processes for complex problems and systems. Operations management is a field grounded in theory. Researchers in this area develop generalized yet applicable mathematical models to describe systems of people, items, information, resources, etc. These models are used not only to understand these systems, but also to improve practices, decision making, and design as well as eliminate system inefficiencies.

Operations management has not traditionally been applied to the nonprofit sector, especially outside of the humanitarian/disaster relief area. However, this intersection creates valuable opportunities where similarities and differences between the for-profit and nonprofit sectors can be leveraged for both scientific and operational advances in both sectors, as further exhibited in Figure 1.1. While models and solutions cannot simply be cut and paste, there can be cross-sectoral learning with significant societal impact.

Chapter 2, *Operations Management in Community-Based Nonprofit Organizations*, approaches this intersection from the perspective of community-based operations research. Since addressing the needs of underrepresented, underserved, and vulnerable populations at a local level is the central goal of many charitable nonprofit organizations, it is naturally intertwined with community-based operations research. Through promoting and creating positive change, such nonprofits serve an integral role in their communities and impact individual lives. This chapter provides an overview of relevant literature, discusses potential research, and explores opportunities for applications centered on community-based nonprofits. Furthermore, this chapter also gives a high-level outline of this dissertation by uncoupling the supply-side (inputs), production, and demand-side (consumers, beneficiaries, etc.).

In Chapter 3, *Efficient Funding: Auditing in the Nonprofit Sector*, we take a theoretical perspective of the relationship between funders and nonprofits and study the role of contracts in managing inefficiencies and sector performance. For funders there is an increasing and pressing need to give responsibly and to ensure that society reaps the most social benefit for their money while also developing the nonprofit sector as a whole. In routinely scrutinizing nonprofit reports in efforts to deduce whether a nonprofit organization is efficient, funders may believe that they are, in fact, giving responsibly. In this chapter, however, we find that these nonprofit reports are unreliable, supporting a myriad of empirical research and revealing that common funding methods do not facilitate efficient allocation of funds. In response, we develop audit contracts that put funders in a position to enact change. Auditing, perhaps obviously, supports funders; however, we find that it also benefits the population of nonprofits. Moreover, auditing results in improved efficiency for the nonprofit sector overall. Indeed, our conclusions indicate that nonprofits may want to work with funders to increase the use of auditing, consequently increasing efficiency for the sector overall and impacting society as a whole.

While Chapter 3 looks at nonprofit funding or the supply-side, Chapters 4 through 7 examine the consumer-side and production-side looking at local public health collaboration. Local public health departments are embedded in communities of potential

partners, creating a network of resources, information and beneficiaries. It is collaborative relationships that form the links of this network, and, consequently, mobilize resources. While resources, information, and beneficiaries can flow into a local health department, they can also flow out. As such, community-based collaboration decisions become tactical operations decisions implying that local health departments can approach collaboration with specific strategies in mind, including revenue generation. Considering collaboration as a strategic lever for mobilizing resources and generating revenue for local health departments, it is critical to understand the local health department landscape of collaboration and revenues. Chapter 5 draws an empirical portrait of local health department revenues (expenditure as proxy) and collaboration, critically surveying how these factors changed between 2005 and 2008 and motivating additional research to investigate potential relationships. Then Chapter 6 aims to quantitatively evaluate the relationship between revenues and different collaboration factors and patterns, allowing these relationships to vary based on local health department urbanization. Both chapters use data from the National Association for City and County Health Officials (NACCHO) 2005 and 2008 National Profile of Local Health Departments Surveys.

In Chapter 5, while expenditure per capita rose between 2005 and 2008, changes in the collaboration landscape were only captured through analysis by partners, activities, and partner-activity combinations. Similarly, analysis by combinations revealed heterogeneous associations with expenditure per capita, which serves as a proxy for revenue. Chapter 6 gives evidence that collaboration and revenues (expenditure per capita) are related, and that collaboration portfolios can be managed strategically to gain revenue for public health. Just as collaboration is multifaceted so is this relationship across different models of collaboration, including the total number of partnerships, number of partners by activity, and specific partners.

From both chapters, we conclude that just as scholars must expand their concept of collaboration to incorporate setting, partners, activities, and combinations of these, practitioners must also ask "Who," "With whom," and "How?" when approaching their own collaboration portfolios. In thinking about collaboration strategically, local health department practitioners should begin strategizing with the question of "Why

collaborate?" Here we offer revenue generation as a viable answer. However, we also conclude that "Who?," "With whom?," and "How?" are critical questions for getting the most from local health department collaboration portfolios in practice and genuinely understanding collaboration in future research. Moreover, the diverse relationships found between revenue and collaboration models suggest that strategic management of local health department collaboration portfolios is not straightforward but of the upmost importance. We conclude that such strategic collaboration is possible, particularly for the goal of revenue generation. Ultimately, such research and practice focused on strategic collaboration may well help local health departments to leverage additional resources and better meet the needs of their communities.

Finally, we conclude in Chapter 8. This chapter not only looks back at the findings and conclusions of this dissertation research, but it also builds on these findings and conclusions in looking ahead to future research.

Chapter 2

Operations Management in Community-Based Nonprofit Organizations

2.1. Introduction

Nonprofit organizations are a vital and integral part of our society and serve as both a social and economic force in communities of every shape and size. Today perceptions point to a large and still growing awareness of community needs and responsive efforts. A 2010 poll revealed that involvement in community causes is important to individuals, especially as it relates to helping underrepresented, underserved, and vulnerable populations, which is indicative of the larger movement toward community-based action in the nonprofit sector (Berland 2010). Now more than ever, operations research has an opportunity and, perhaps, a responsibility to participate in solutions; solving problems, meeting needs, and advocating for the disadvantaged at the local level, operations researchers can leverage unique skills in the context of community-based nonprofit organizations.

To define nonprofit organizations precisely and legally, one can look under section 501 of the United States Internal Revenue Code where over 27 categories of trusts

and corporations are exempt from paying taxes on their revenues. This code further specifies "charitable" organizations within section 501(c)(3). In order to qualify for 501(c)(3) status, an organization must have a "charitable" purpose, cannot be political, and cannot benefit private shareholders or individuals.

Nonprofits provide social, leadership, and expressive opportunities, thereby influencing the depth and connectedness of communities. Their associational properties give even underrepresented community populations a voice and help individuals shape community policies and directions. Furthermore, these organizations provide services to underserved and vulnerable individuals who would otherwise not receive them, in many cases partnering with the government. Nonprofits also provide public goods for which no individual directly pays but from which all can reap benefits, such as cleaner air. All in all, community members benefit from the goods and services that nonprofits provide either directly or indirectly.

Beyond these social contributions, the nonprofit sector's economic impact should not be underestimated. In 2009, the IRS registered a growing number of 1.5 million nonprofits, which reported $1.4 billion in revenue and held $2.6 billion in assets. In 2008, the output of nonprofits serving households generated 5% of the 2008 United States gross domestic product, and, in terms of employment, it was estimated that 10% of the United States workforce is employed in the nonprofit sector (Sherlock and Gravelle 2009). Within communities, these economic contributions are even more significant and consequential. For example, Michigan cites the nonprofit sector as critical to the state's future, where 47,000 nonprofits generate $108 million of economic activity annually (Public Sector Consultants 2009).

Operations research has many opportunities for application in the nonprofit sector. Similarities between community-based nonprofits and our traditional for-profit settings can be leveraged to create innovative models with new impact, improving decision making and operations for the nonprofit sector even at the local level. Yet the notable differences indicate complexities far beyond simply cutting and pasting our traditional for-profit solutions and, thus, result in provocative research questions. As such, the nonprofit sector presents our field with an unfamiliar and fertile new frontier for research. Managing and operating community-based nonprofits efficiently

and effectively is necessary in addressing localized problems, especially those issues facing underrepresented, underserved, and vulnerable populations. As such operations research in community-based nonprofit organizations is a natural extension of community-based operations research – one that offers a wealth of opportunity to researchers, practitioners, and the sector alike. As relevance of operations research will vary across this diverse sector, the applications discussed in this chapter will be more suitable for certain areas of the sector, such as service delivery, though the full range of nonprofit expression is certainly invaluable. In the remainder of this chapter, many of these areas will be further explored in the context of community-based nonprofits.

This chapter is organized from a operations supply chain perspective as illustrated in Figure 2.1, that is, topics are organized according to supply, production, and consumers. First, the supply-side or inputs of community-based nonprofits will be examined; fundraising, profits, and foundations will be surveyed in Section 2.2. Next, nonprofit production and activity, specifically the topics of objectives, centralization and organizational form, and productivity, will be explored in Section 2.3. Lastly, competition, collaboration, and performance measurement and evaluation will be delved into in Section 2.4 in order to address consumer-side outputs and outcomes.

2.2. Supply-Side Challenges

Nonprofit supply is characterized by competition and uncertainty. As funding is often viewed as the most critical nonprofit input, this section discusses operations research in the context of nonprofit fundraising and commercial profits. It also looks at the funding process from the perspective of funders and grantmakers by examining fundraising competition and foundations.

2.2.1 Fundraising

Availability of resources is a one of the most critical issues in the nonprofit sector. Nonprofits cannot raise capital by issuing stock. Loans to nonprofit organizations are not backed by shareholder investments, leading to a high cost of debt for nonprofits

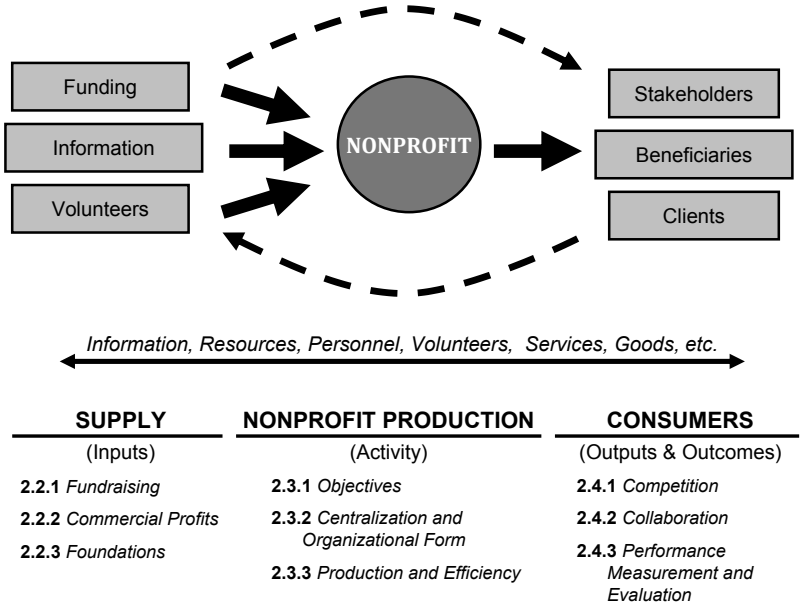


Figure 2.1: Nonprofit Operations and Chapter Organization

(Hansmann 1980). Yet, outside of these traditional for-profit capital raising methods, nonprofits can garner donations, win grants, employ volunteers, charge fees, utilize bonds, and accrue investment earnings (Steinberg 2006).

Donations

According to Hansmann (1980), nonprofit contributions are essentially a form of voluntary price discrimination. For example, consider a museum that may charge for admission. Such admission fees do not support the museum in its entirety; however, the museum solicits donations as well. Such donations are a form of voluntary self price discrimination where museum supporters contribute the value they place on the museum beyond standard admission fees. In areas where fixed costs account for a large fraction of total costs, such as performing arts, museums, and libraries, price discrimination can be the key to organization survival.

On this point, McCardle, Rajaram, and Tang (2009) use a utility-based donor model to analyze the behavior of nonprofit donations in the presence of publicized tiered fundraising structures, which they show can generate larger donations. Building

upon their model, the authors develop an Excel-based decision analysis tool combining their theoretical findings with nonprofit experience, which empowers nonprofits to utilize scenario analysis to select their best fundraising tiers. In fact, the authors provide an illustrative example using publicly available data from St. Mark's High School in Wilmington, Delaware, a private Catholic school. In this example, the authors estimate model parameters and demonstrate how the model can be used to perform scenario analysis and evaluate different tier settings. The authors use their model to compare the nine tiers implemented by St. Mark's to the case of no tiers, and estimate the nine-tier structure increased donations by $13,000. This work is an example of academic rigor and theoretic modeling blended with practice-based utility and function.

Government Funding

In 1995, Salamon noted a still true trend in government funding, namely that "government has become the single most important source of income for most types of nonprofit agencies, outdistancing private charity by roughly two to one." This is especially true for nonprofit agencies that provide local services to underrepresented, underserved, and vulnerable populations. The specific types of nonprofit assistance provided by government include service contracts, in-kind donations, and grants. Service contracts with government are further discussed from a collaboration perspective in Section 2.4.2. Grants are touched on below and further discussed in Section 2.2.3.

Grants

Both governmental agencies and non-governmental foundations award grants, which are another significant source of funding for many nonprofit organizations. Grantmaking is discussed further in Section 2.2.3 of this chapter.

Fundraising Competition

Guised as fundraising, operations researchers may recognize the dynamics of supply-side competition in the process of grant funding. These dynamics exacerbate contention over the necessary income and arguably excessive expense associated with fundraising. Cordes and Rooney (2004) wonder if greater competition for donations actually increases the donation pool or merely redistributes it, the latter inducing nonprofit fundraising expenditures that may be individually rational but collectively wasteful.

Considering the significant portion of nonprofits' resources being dedicated to raising and competing for funds, the issue of exactly how much social benefit is being lost in this competition is certainly critical. Operations researchers bring the skills and expertise to analyze such supply-side competition where nonprofits posture to compete for a fixed pool of resources. The areas of for-profit supply and capacity competition and centralized versus decentralized supply chains may provide a good base of understanding. Several authors model game theoretic, competitive capacity allocation problems (Cachon and Larivere 1999a and 1999b, Dewan and Mendelson 1990, Hartman and Dror 2005, Lippman and McCardle 1997, Mallik and Harker 2000). For example, Cachon and Larivere (1999a, 1999b) look at for-profit supply-side competition where retailers compete for scarce supplier capacity but not for customers. The basic setup of this research can be recast for the nonprofit fundraising competition scenario where nonprofits serve as "retailers," funding as "capacity," and grantmakers as "suppliers." However, one cannot underestimate the care and prudence that must be exercised as nonprofit models require more complexity and nuance than a simple change of characters. For example, in using the Cachon and Larivere model as a base, distinctive and diverse objective functions must be formulated for all parties, potentially including reputational influences, risks, and numerous stakeholder perspectives.

Future analysis of such competition may change how the funding process is viewed and operated by those in the field and may help avoid social losses resulting from supply-side competition. If the social benefit loss due to competition is found to be substantial, an exploration into mechanisms and regulations that may be imposed to

prevent this competitive waste would be valuable to the sector and most importantly to those that it serves.

2.2.2 Commercial Profits

In light of such resource scarcity, nonprofit leaders are constantly searching for financial sustainability. Since the late 1990s, this search has resulted in a surge of commercialized nonprofit strategies aimed at making profit. Such enterprising endeavors, whether Little League run concession stands or women's boutiques to benefit local domestic violence shelters, each carry with them the danger of moving an organization away from its central social mission. In fact, Foster and Bradach (2005) quote that only 32% of profit seeking nonprofits surveyed did so for predominately mission related reasons. Where Foster and Bradach are skeptical, Dees (1998) contends that success is possible, and cites particular potential in earning income from intended beneficiaries and third party payers with a vested interest. The disagreement between these authors signals that many questions still loom regarding profits in nonprofits. This section discusses such questions in the context of management and decision making; however, such commercial profits also introduce competition between nonprofits and for-profits, as is discussed further in Section 2.4.1.

Many nonprofits use a business model that blends commerce and philanthropy, subsidizing charity services with fee services, such as nonprofit hospitals that use fees from paying and insured customers to provide reduced cost or charity care to the uninsured and underinsured. In such cases of nonprofits engaged in for-profit ventures as a means to fund their mission, de Vericourt and Lobo (2009) investigate a revenue management problem, namely how to allocate funds among investments that serve revenue and mission customers. The organization's objective is to maximize its social benefit as measured by the number of mission-related customers served. The authors find that the optimal allocation strategy is a threshold policy: Resources are allocated to serving revenue customers up to the threshold amount; resources above this threshold are used to serve mission customers.

Nonprofits engaged with third party payers with a vested interest (as opposed to

beneficiaries) will need to create and maintain contracts. Contracts involving such vested parties may be unusual, involving payment for services that impact the third party in ways that may or may not be easy to quantify. Foster and Bradach (2005) state that "third parties cannot calculate with any precision the financial benefit they would receive, so structuring a deal that's attractive to them would be difficult." Such contracts are an interesting and unexplored research area. Although it may be challenging to create a general model, more application and work in this area would be notable progress. Research into quantifying these indirect benefits that third parties receive from nonprofits may also be of interest.

While nonprofits continue to find for-profit ventures tempting, researchers can bring more understanding to the conditions that create successful ventures and expose the associated trade-offs. Quantifying these trade-offs, even through simple break-even analysis, can provide valuable decision-making capability, helping nonprofits avoid being part of what Foster and Bradach (2005) believe to be the majority of nonprofit business ventures that are "ultimately wasting precious resources and leaving important social needs unmet." With such disagreement over whether business ventures are a healthy direction for the sector, operations research and management science can bring a valuable lens for analysis.

2.2.3 Foundations

Philanthropic foundations, themselves nonprofit organizations, are positioned between donors and causes, typically focused on specific impact areas. For example, the Gates Foundation focuses on the areas of global health, poverty, and education, while the Robert Wood Johnson Foundation concentrates exclusively on American health and healthcare. Community foundations are a particular foundational form concentrating on a geographic community (e.g., Silicon Valley Community and Communities Foundation of Texas, Inc.).

Following years of noteworthy grantmaking growth, the current economic downturn has had considerable effects on foundations. For the more than 75,000 U.S. foundations, assets dropped an estimated 22 percent in 2008. As more than three

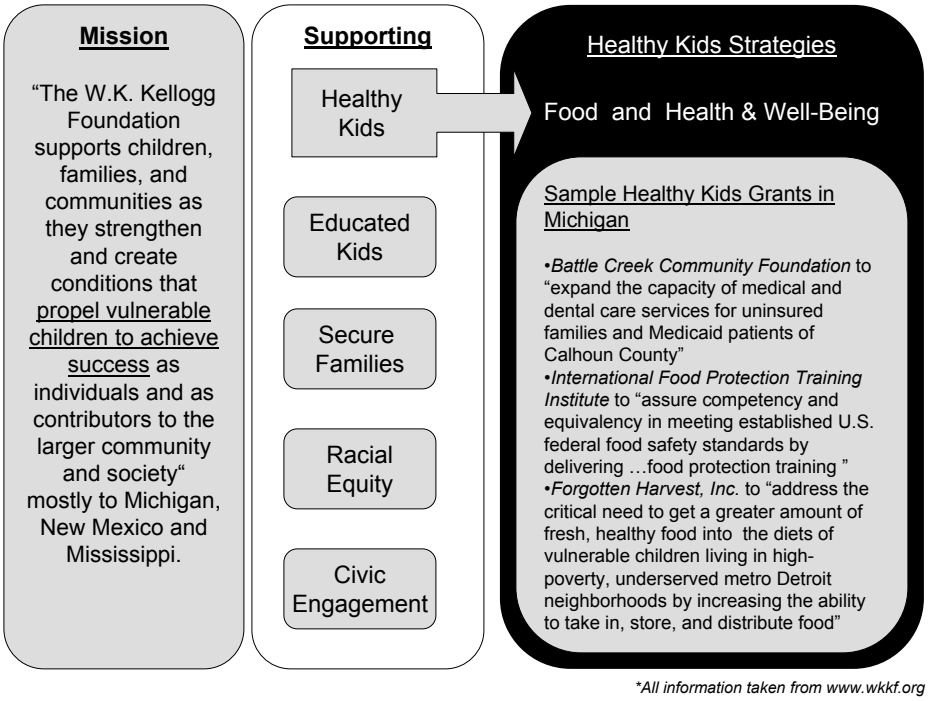


Figure 2.2: Excerpt of W.K. Kellogg Foundation Strategy

quarters of foundation leaders agreed, the silver lining of this present resource constriction is that the nonprofit sector will emerge more strategic (Lawrence 2009). This presents new opportunities for operations researchers.

Foundations should be thought of as more than funding intermediaries, especially by operations researchers and managers. Instead, foundations can be thought of as portfolio and supply chain managers. As portfolio managers, foundations seek to generate social change by managing a portfolio of grants and other activities, which may include nonprofits, businesses or governmental programs. Figure 2.2 illustrates the mission and areas of support for the W.K. Kellogg Foundation (www.wkkf.org). The figure expounds upon the "healthy kids" focus area, which looks at food, health, and wellbeing, and describes a small sample of the associated funded initiatives. It is clear that such broad social change goals require a portfolio-based approach, even for a limited geographic area. Furthermore, Figure 2.2 reveals the embedded supply chain of producing social change.

Foundations must consider the myriad factors that complicate their portfolio. Such complications include time, difficulty of measurement, and risk. In regard to time, foundations must make trade-offs in their choices of response. They may invest in prevention, mitigation, or relief, or they may choose postponement; appropriate consideration must be given to the consequences. Furthermore, social change may require long-term investment, making it difficult to measure progress. Social change is also much less tangible and its inherent risk and likelihood must be considered. Foundations are often viewed as the venture capitalists of the nonprofit world in their grants since they are largely independent and endowed. As Raymond (2004) states, "where private enterprise must minimize risk to ensure return, and where government must beware of risk in its role as the guardian of the taxpayers' purse, foundations can seize risk." Though they are largely considered risk averse in financial investment, foundations *can* be risk-takers in their grant portfolios. As such, they are likely to experience more failures in their grant portfolio. In fact, failure must be expected of foundations if they are to be incentivized to invest in novel approaches. Thus, foundation portfolios must incorporate risk appropriately and potentially reward it.

Clearly, foundations' choices of investment are complex and multidimensional. Within portfolio management, financial institutions quantify risk, recognizing its sources so that they can be managed and controlled. While prudence is appropriate in defining risk in such social change settings, risk modeling efforts are worth their while. This is because if the risk of a portfolio can be measured, then the main risk contributors can be identified, the portfolio can be reallocated accordingly, and, thus, potential loss can be minimized (Rachev *et al.* 2008). Fabozzi *et al.* (2007) outline the stages of a "robust quantitative investment framework," which are reframed for the foundation context below:

1. Robust Estimation: Reliable and robust estimations of parameters are necessary to minimize aggregated error in the final stage.

2. Robust Portfolio Allocation: Optimization frameworks and sensitivity analysis make this one of the most important parts of the process. How risk and return are defined must be carefully and thoughtfully considered, especially in regard

to often intangible social returns.

3. Portfolio Rebalancing: While achieving socially effective asset allocation is critical, so is obtaining good and consistent performance. "Portfolio managers need to decide how to rebalance their portfolios efficiently to incorporate new views on expected returns and risk" as factors, such as policy or knowledge, change. It is this step that incorporates time dynamics, "successfully combining long-term and short-term views on the future direction and changes in the markets," even markets of social change.

Thus, portfolio management offers expertise on decision making under risk, however its fundamental concepts must be challenged to incorporate the distinctions of social change.

As foundation executives Brest and Harvey (2008) state, "Sometimes a philanthropist may have a project in mind that requires bringing together the capacities of several different actors. In these cases, you can think of the philanthropist as a combination of architect and general contractor, hiring disparate subcontractors... and coordinating their work to get the job done." This metaphor of a nonprofit as a "seller" of services to a funder captures a lot about the funder-nonprofit relationship and lends naturally to viewing grant agreements as contracts; funders have goals and contract with nonprofits to perform the activities necessary to, in part, achieve these goals. Chapter 3 models this contractual relationship, claiming that granting agencies such as foundations can more effectively allocate funds. These authors find that current grant methods are not efficient in themselves, but that auditing has the potential to increase grant allocation efficiency and utilities for both the funder and the non-profit population. The authors claim that auditing positions funders to initiate efficiency improvements for the sector overall.Further research in this vein could prove fruitful. For example, long-term or multiyear contracts are becoming increasingly common and the use of such contracts may provide incentives through future allocations. Issues such as commitment, renegotiation, and breach of contract will need to be considered when analyzing such contracts.

Viewing foundations as portfolio or supply chain managers lends naturally to

exceptional applications of operations research. Foundation portfolio optimization and contracts are merely two examples of academically interesting and practically relevant applications drawing from for-profit theory with a social change perspective.

2.3. Production

Nonprofit organizations take such supply inputs and transform them into a variety of goods, services, and expressions. Thus, production is still fundamental to nonprofit operations, albeit nontraditional in its own right. This section discusses nonprofit objectives, centralization, and productivity and efficiency as they relate to the nonprofit production process.

2.3.1 Objectives

At the most basic level, both for-profit and nonprofit organizations use inputs to produce goods and services; however, nonprofit objectives are much less straight-forward as compared to a bottom-line profit. Unlike a for-profit corporation that distills the objectives of their shareholders, managers, employees, and clients into one quantifiable profit measure, "the nonprofit has no single primary interest group that is invariably and clearly defined, homogenous with respect to interests, and whose goals are easily expressible and transferable into the organization for assessment of alternative courses of action" (Speckbacher 2003). Due to this varied abundance of stakeholders and purposes, quantifying and modeling the objectives of a nonprofit organization can be ambiguous and controvertible. Theorists, modelers, and practitioners each offer insight and experience that must be heeded and somehow reconciled in operations management models for the nonprofit sector. Example nonprofit objective functions are listed in Table 2.1.

Organizations may have multiple shared or conflicting objectives (Steinberg 1986, Weisbrod 1998). Such multiplicity in objectives and stakeholders involves trade-offs. Accordingly, Speckbacher states, "The organization cannot realize all the desirable objectives of key stakeholders nor fulfill all of their implicit claims" (Speckbacher

Example Nonprofit Objectives	Example References
Quantity Maximization	Chapter 3, De Vericourt and Lobo (2008), Harrison and Lybecker (2005), Liu and Weinberg (2004)
Quality Maximization	Harrison and Lybecker (2005)
Budget Maximization	Steinberg (1986), Niskanen (1971), Tullock (1966)
Behavior Change	Steinberg (2006)
Collective Goods Provision	Steinberg (2006)
Fundraising and Donations	McCardle, Rajaram, and Tang (2009), Chapter 3
Effort Minimization	Chapter 3
Social Return Maximization	Brest and Harvey (2008)
Failure Risk Minimization	Brest and Harvey (2008)

Table 2.1: Example Nonprofit Objectives

2003). Instead, strategic philanthropy "calls for choosing whatever mix of approaches will best achieve your philanthropic objectives" (Brest and Harvey 2008), yet "there is no simple measure of the efficiency of the trade-offs being made among goals" (Weisbrod 1998).

Specifying such objective functions, especially within modeling contexts, may necessitate goal programming or multi objective optimization, both pertaining to the achievement of a collection of goals. (See Ignizio 1978, Baum and Carlson 1974, and Ehrgott 2005.) for reviews.) Group ranking and decision making research (e.g., Klamroth and Meittinen 2008, Hochbaum and Levin 2006, and Baucells and Sarin 2003). can also be leveraged to integrate and operationalize the numerous varied stakeholder objectives of nonprofit organizations. For instance, Tavana (2003) does just this by using multi-criteria research to evaluate and prioritize projects at NASA, where the author develops an implementable system with a rigorous backend. Such undertakings in community-based nonprofits can even be less involved while still achieving similarly significant gains.

Much of the nonprofit work mentioned in this chapter offers examples of possible nonprofit objective functions, as detailed in Table 2.1. Future nonprofit sector

research using the modeling and methods of operations research is sure to further develop nonprofit objectives, which in itself is a noteworthy contribution to the existing body of research.

2.3.2 Centralization and Organizational Form

Mergers, organizational structures, and collaboration are potential mechanisms for coordination and centralization in the nonprofit sector. Like the for-profit sector, the nonprofit sector struggles with coordination. In operations research, Li and Wang (2007) provide a comprehensive review of centralization and coordination literature. The nonprofit sector presents a new sphere to study the value and limits of such fundamental concepts.

Mergers

Mergers represent the most extreme form of centralization and coordination, offering the combined organization time tested operational benefits. Though mergers are still debated and infrequent in the nonprofit sector, those organizations that do consider merging offer a variety of reasons, such as size, clout, influence, leadership, competitive advantage, and financial sustainability (Gottfredson, Schaubert and Babcock 2008, Gammal 2007, and Singer and Yankey 1991). However, the strongest motivations remain financial, particularly financial sustainability (Singer and Yankey 1991). However, in studying the frequency and outcomes of nonprofit mergers, Gammal (2007) concludes that money is not the right reason to merge. Instead, it may be mission and/or geographic overlap (Gammal 2007, Nee 2007).

The benefits that nonprofits perceive are indeed true to the theories of centralization, such as visibility, economies of scale, power, and capacity (Gottfredson, Schaubert and Babcock 2008). Some organizations have already gained such benefits. For example, Crittenton Women's Union (CWU) is the result of a merger between Crittenton and the Women's Union, both well-established nonprofits each with a mission to serve Boston area low-income women. "Following the merger, CWU has raised its visibility in the community and among potential donors, and lowered

its service delivery costs – turning an operating loss of more than $500,000 into an operating surplus of more than $200,000" (Gottfredson, Schaubert and Babcock 2008). While maximum centralization has strong appeal to operations researchers, community-based nonprofits often dismiss mergers, unwilling to relinquish control and independence (Haider 2007). In such cases, centralization may also be achieved using organizational form.

Organizational Forms

Organizational form is another, less extreme instrument for coordination in the nonprofit sector. While most nonprofit organizations incorporate, some nonprofit organizations, such as the Girl Scouts, utilize the franchise structure with local chapters. Others, such as United Way and Planned Parenthood, utilize a federated or affiliation structure where mission, brand, and program model are shared while local affiliates remain legally independent. Both of these organizational forms offer some degree of centralization for such multisite organizations, although deciding the extent is certainly important and particularly difficult.

Oster (1996) studies the existence and justification of franchise relationships, while O'Flanagan and Taliento (2004) investigate the federated nonprofit organizational structure as a very formal collaborative structure that provides nonprofits with an equivalent to mergers and acquisitions. Overall, the authors conclude federations can be a powerful means of uniting nonprofits, though not without struggle. In fact, Grossman and Rangan (2001) cite key sources of tension between headquarters and affiliates that are well known to operations researchers familiar with supply chain coordination issues: payments and value of headquarters, allocation of resources, and governance of system, which we now explore in detail.

Payment and Value of Headquarters. When headquarters demonstrate value and support to their affiliates, payments to headquarters are not a significant issue. Yet, as O'Flanagan and Taliento (2004) note, managing and providing value to local affiliates is not an easy task. Grossman and Rangan (2001) mention several

levers for headquarters to create value, including brand name creation, expert assistance, economies of scale, program standardization, and fundraising centralization. For example, headquarters can leverage economies of scale to gain cost advantages for their networks. Such economies of scale can manifest as purchasing power, which is the case for Planned Parenthood National's quantity price discounts for contraceptives. Oster (1996) notes that "franchises are particularly prevalent in nonprofits with monitoring problems, strong use of volunteers and large capital needs," findings that may illustrate value that headquarters' can demonstrate and that operations researchers can effectively structure in studying centralization.

Allocation of Resources. Tensions regarding the allocation of resources typically center around centralization of resources and ownership of donations. Most nonprofit work and service delivery occur at the local level, and most donation dollars are raised at the local level. In many federated structures, however, national offices manage the allocation of all donations across the system. This ability to centralize fundraising functions has powerful potential. At the local level, nonprofit fundraising is often thought to be a problem of the commons, where many local entities compete for limited funding in a restricted geographic area without any incentives or mechanisms in place to prevent overuse of the common potential funding pool. The associated tragedy is that the common pool will be overused and ultimately depleted due to individual incentives. Both inter- and intra-firm resource allocations, which have been topics of operations research. More recent literature has focused on information and incentive problems in capacity and resource allocation. Inter-firm capacity allocation among retailers with private demand information is studied by Cachon and Lariviere (Cachon and Lariviere 1999a, 1999b). In contrast, Karabuk and Wu (2005), Rajan and Reichelstein (2004), and Harris, Kriebel, and Raviv (1982), explore intra-firm allocation problems. For example, Karabuk and Wu (2005) use bonus payments and participation charges to align incentives for capacity allocation among managers with private demand information. Centralization of fundraising can be studied through such resource allocation problems in the context of various nonprofit organizational structures, where findings can significantly reduce the problem of the commons while

increasing brand power to affiliates.

Whether a merged organization or federation, nonprofit structures must strike a delicate balance in system governance, namely the degree of decision making coordination. Centralized systems can offer standards and consistent quality across the organization. However, since most nonprofit work and services are delivered at the local level, decentralization offers flexibility close to the client in local delivery. While centralization is certainly familiar territory for operations researchers, the unique challenges of the nonprofit sector brings less explored tension between centralization and decentralization. As discussed previously, nonprofits face heterogeneous and varied objectives compared to the more homogenous profit objective, objectives that can vary even between affiliates. In related for-profit research, Chang and Harrington (2000) look at innovation in multisite organization of heterogeneous retailers and find value of *de*centralization in the presence of sufficient market diversity. These findings illustrate that the appropriate and best extent of centralization is still undecided for alternative and heterogeneous objectives.

2.3.3 Productivity and Efficiency

Nonprofit organizations must still be concerned with using their "resources to achieve the greatest possible impact." In strategizing, nonprofits often use logic models that outline "a theory of change [that] is fundamentally an analysis of the causal chain that links your philanthropic interventions to the goals you want to achieve" (Brest and Harvey 2008). Thus, such logic models are production process maps, detailing the conversion of inputs to outputs and outcomes using specific processes. Although a basic logic model is a great first step, nonprofit operations planning often stops there. Even enhancing such a model to incorporate risk, alternatives, probability, redundancy, and allocation can help to ensure the nonprofit's goals. Such a production process map presents operations researchers excellent opportunities for further understanding of the nonprofit sector as well as lending their operational expertise to the production of social change and public goods. The application of clean drinking water presented in this chapter is an excellent example of operations research skills

Producing Clean Water

Clean drinking water is an excellent example of a public good: once it flows from taps, it is nearly impossible to prevent someone from using it and yet one person's consumption does not affect that of others. In the United States, the Environmental Protection Agency, American Water Works Association and Department of Homeland Security are just a few of the organizations involved in producing and ensuring safe drinking water. Recently, a team of operations researchers lent their expertise to this vital cause, developing a water contamination warning system. Particularly critical for operations researchers working in the nonprofit sector, these researchers recognized the distinct complexities of their public sector setting and let these determine their techniques. For example, the researchers developed limited memory optimizers capable of analyzing networks of over 20,000 junctions using only the available 32-bit computing stations. Overall, the project's resultant 75% cost reduction translated into saving millions of dollars per utility. Yet, this number quantifies only one of many multifaceted impacts, which span economic, security, safety, policy, operational, educational, and academic effects. In the researchers' own words, "operations research has changed the direction of water security in the United States," an achievement fitting of its Franz Edelman Award in Operations Research (Murray *et al.* 2009).

applied to the production of a necessary public good: safe drinking water.

Nonprofit operations face not just the traditional risk of stochastic demand but also that of stochastic supply (e.g., resources, funds, volunteers). While this naturally brings donations and funding to mind, even staffing, particularly volunteers, is uncertain, erratic, and, consequently, difficult to manage. Thus, even nonprofit personnel is stochastic, creating compounded forecasting and scheduling problems. Staffing and scheduling present interesting research applications as nonprofits rely on a mix of paid staff and volunteers.

A further complication is the interdependence of this supply and demand, that is, interdependencies of revenue sources, production costs, outputs, volunteer inputs, and mission achievement. Nonprofit stakeholders are frequently both supplying and consuming the organization's output. Foundations are an example, supplying nonprofit funding but also serving as major stakeholders assessing nonprofit output. Additionally, limited inputs – constrained nonprofit resources and restricted access to capital – cause nonprofits to respond very slowly to demand changes. All in all, the nonprofit

sector is plagued by unusually high and interconnected risks in its production process, from supply to demand with staffing in between. Due to these coupled supply and demand risks, improved forecasting has double potential and multiplied complexity that presents interesting problems for operations research both in theory and application. Also understanding how these issues, particularly those related to capital and capacity, manifest in supply response is an interesting research problem that can contribute to literature on capacity and supply issues.

Lack of sufficient competition and earnings ownership is postulated to lead to inherent nonprofit production inefficiency. In practice, nonprofit organizations do lag in improvements relative to the for-profit sector. However, as nonprofits become mature, established, and accepted in their communities, there is an expectation that nonprofits will operate efficiently (Werther and Berman 2001). In one of the first operations management models of nonprofit production, Chapter 3models production as a concave function of effort, resources, and "efficiency," i.e., the ratio of funds going directly toward mission-related work. Their model illustrates direct and practical ways that nonprofits can increase production by increasing efficiency, reducing costs, and increasing resources and effort.It can also be used as a foundation for incorporating nonprofit production into future operations research.

Profit-seeking behavior and commercialization discussed earlier in the chapter can be a positive force when considered in this realm of production inefficiency. Nonprofits must deliver efficiently when competing in mixed markets due to the forces of competition. This is likely to drive nonprofits toward professionalization and business-like techniques at least in their production and delivery of revenue generating services (Tuckman 1998). Thus, when considering efficiency, nonprofit commercialization "should not just be dismissed as inefficient and counter productive. It offers real advantages; despite the problems it poses" (Weisbrod 1998). How and to what extent competition creates incentives and brings about production improvements is an area lacking analytical research. Research here can enhance our understanding of competition and its effects more in mixed market settings

In terms of cost, Hansmann (1987) states that nonprofits will generally produce any good or service at a higher cost than a for-profit firm, though cost reduction is

an obvious way to increase efficiency. Purchasing practices, staffing decisions, inventory excess, indirect costs, and resource waste are just a few areas for improvement where progress can made employing mechanisms such as collaboration, coordination and organizational form as discussed in Section 2.3.2. Each of these involves some sort of agreement and equilibrium, which has become a significant area of research in operations management. In fact, the recent trend in operations management literature of simple yet efficient contracts (Kayis, Erhun, and Plambeck 2009, Lariviere and Porteus 2001), such as price-only contracts, certainly complements the nonprofit sector, though these models cannot be directly applied.

The concept of increasing efficiency must be considered in trade-off with the nonprofit's mission. Mandell (1991) demonstrates multicriteria programming methods to facilitate decision making incorporating trade-offs between output (efficiency) and equity in allocating resources among delivery sites. Allocation of new books among public library branches is used as an illustrative example. Even simple cost-benefit analyses can enrich decision making by quantifying and comparing alternatives, possibly exposing unnecessary actions and ineffective systems.

Even nonprofits must be concerned with production and production improvements, especially as they strive to achieve the greatest possible impact under notorious ambiguity. Evaluation and measurement are also a critical part of such improvements and are further discussed in Section 2.4.3.

2.4. Consumers and Markets

Nonprofit "consumers" or stakeholders are many and can include funders, donors, government, employees, board members, and the end-consumer beneficiaries. This section first discusses both consumer-side competition and collaboration, which especially relate to the assortment of consumer markets that nonprofits find themselves. Nonprofits' heterogeneous consumer base is then considered in performance measurement and evaluation.

2.4.1 Competition

Profit ventures and service related missions thrust nonprofits into for-profit and mixed markets, such as health care, social services, and education. Ritchie and Weinberg (2003) discuss nonprofit competition, collaboration, and combinations. They assert that literature on nonprofit competition does not appropriately consider the fundamental differences between for-profits and nonprofits, citing two critical differences: "(1) nonprofits are motivated by non-monetary goals that often dominate financial considerations and (2) diversity in the nature of these goals means that a nonprofit and its rivals may be motivated by very different objective functions." They describe the broad factors that will determine the nature of competition that will emerge in a given market. However, the authors neither analytically model nor empirically examine their ideas, thus leaving room for future research to explore both the consequences of varied nonprofit goals and nonprofit competitive settings.

Harrison and Lybecker (2005) provide an example of such research, as they examine the effects of the nonprofit motive in price competition between non-profit and for-profit hospitals. They model the nonprofit objective function as a weighted linear combination of profit and nonprofit motive, specifically quantity, charity, and quality, with the main result that nonprofit motive has great importance and impact in competition between nonprofit and for-profit hospitals. In these heterogeneous markets where for-profits and nonprofits compete, contention can arise over supposed nonprofit regulatory and tax advantages. Liu and Weinberg (2004) use game theory to analyze these supposed advantages by modeling nonprofits as quantity maximizers and conclude that it is not these advantages, rather the difference in firm objective functions that causes the observed competitive behavior.

Varied objectives of nonprofits cause nonprofits to compete on similarly diverse dimensions. Diverse and less traditionally explored competitive factors have been the subject of some recent for-profit operations literature. For instance, Tsay and Agrawal (2000) examine coupled service and price competition, specifically looking at strategy drivers and consequences in sales, market share, profit and coordination, while So (2000) investigates coupled price and time guarantees. Customer service, customer loyalty, and quality competition are a few additional examples of for-profit operations

competition aspects with appeal in nonprofit dynamics (Boyaci and Gallego 2009, Gans 2002).

Bridging such operations research work with that of Ritchie and Weinberg (2003) might involve models of nonprofit competition with for-profits or nonprofits in homogeneous or mixed markets. Furthermore, such research can also inform nonprofit decision making. An individual nonprofit organization must look at their strategic trade-offs associated with each choice of activity and program as well as the corresponding resource requirements of engaging in competition, collaboration, both, or neither. By better understanding nonprofits' dynamics of competition, such complicated trade-offs can be further elucidated.

Both competition and corresponding nonprofit strategy invite operations research and serve as merely examples of research possibilities in this area, where the nontraditional setting of the nonprofit sector presents many unique challenges that have not been effectively analyzed nor thoroughly understood. For instance, due to the unique nature of nonprofit objectives, nonprofit competitive scenarios can consider the unusual option of subordinating to competition because of a common cause, which may in fact present the best social option. Extending competition models to objectives beyond just profit can also illuminate interactions among firms competing on multiple bottom lines.

2.4.2 Collaboration

Literature regarding collaboration is rich and multi-disciplinary, as one can find both research and practice literature related to a wide-range of potential collaborators from government to businesses to other nonprofit organizations, each with distinct dynamics. Increasingly, community-based nonprofits must see themselves embedded within communities of potential collaborators, creating a network of resources, information, and beneficiaries where collaboration decisions become strategic production and operations decisions.

Government

Today, community-based nonprofit organizations are the primary deliverers of public services. As Salamon (1995) noted, "For better or worse, cooperation between government and the voluntary sector is the approach this nation [United States] has chosen to deal with many of its human service problems. [...] This pattern of cooperation has grown into a massive system of action that accounts for at least as large a share of government funded [nonprofit] human services as that delivered by government agencies themselves." Thus, community-based nonprofit organizations serve as mediators between the government and citizens, especially by providing critical local services to underrepresented, underserved, and vulnerable populations. For example, Chapters 4-7 examine collaboration between community-based nonprofits and local public health departments, which provide critical health services in localized jurisdictions. From the perspective of the local public health department, she examines the relationship between such collaborations and revenue, seeking to recommend collaboration strategies for revenue generation to local health departments. Their research "sheds light on how nonprofits shape their communities and the delivery of local health services."

A parallel can be drawn between such government contracting to these community-based nonprofit organizations and business outsourcing. Competitive processes award government contracts for public supportive services to specific community-based nonprofit organizations, "which in turn serve specific neighborhoods and individuals" (Marwell 2004). Necessarily, such contracting frameworks were initiated due to tension in the government-nonprofit relationship, where concerns mostly center on control and independence (lack of control). Yet, the absent voice within this contracting framework – the public voice – is no less important where concerns of inflated costs and undermined public objectives may result (Salamon 1995).

Business

The growth of government service outsourcing and subsequent nonprofit expansion has also brought businesses into these new areas. These circumstances give rise to

Collaboration Form	Example
Corporate foundations	See Section 2.2.3 of this chapter for discussion.
Cause-related marketing	(RED) campaign products
Joint projects	Build awareness through advertising (Andreasen 1996)
Advertising	Nonprofit distributes business flyers with their services
Donations	Cash, excess inventory or equipment
Employee volunteers	Business staff teams sort food at local food pantry
Service purchases	Business employs using nonprofit job placement center
Accreditation	Nonprofit certifies businesses as "climate conscious" (Vernis *et al.* 2006)
Licenses	Fee for use of nonprofit name/logo (Andreasen 1996, Vernis *et al.* 2006)
Loans	Loans to nonprofit below the market rate (Andreasen 1996)

Table 2.2: Nonprofit-Business Collaboration Forms

both competition and collaboration between business and nonprofit organizations. Such competition is discussed in Section 2.4.1; such collaboration takes various forms and grows from an assortment of motivations.

Today, corporate social responsibility continues to gain momentum. Such programs typically involve nonprofit collaborations for purposes of marketing, human resources, and employee satisfaction. Additionally, some businesses find operational opportunities and efficiencies through collaboration with nonprofits. Some forms of nonprofit-business collaboration are detailed in Table 2.2. Many warrant contracting to varying degrees. Important to consider in such frameworks, the primary nonprofit collaboration driver remains resources, although exposure, communications, knowledge expansion, and influence are also motivating factors (Vernis *et al.* 2006). Furthermore, as Andreasen (1996) cites, these partnerships pose several risks to nonprofits, such as reduced donations, loss of reputation, and/or reduced effectiveness. These risks not only provide further avenues for investigation but also interesting extensions to the contracting framework. An example of such nonprofit-business interactions occurs in life sciences collaborations, which involve academic institutions, industry partners, research institutes, hospitals, and government laboratories. From

the perspective of the nonprofit university, such collaborations "offer ample opportunities for universities to diversify their funding base and to contribute to both the advancement of life-sciences research and the development of powerful new medicines that will be of considerable benefit to society" (Powell and Owen-Smith 1998).

Nonprofits

The benefits of collaboration just within the nonprofit sector are overwhelming. Apart from collaboration as instrument for coordination, which is discussed further in Section 2.3.2, nonprofits can improve efficiency, share experience, amplify impact, gain economies of scale, avoid effort duplication, employ multiple approaches, address more complex issues, expand their expertise, increase leverage, synergize, gain skills, improve their social position, etc.

Overall, many community-based nonprofits are small and lack sufficient capacity and resources, yet collaborations enable synergies and coordination that can optimize their limited and scarce resources (Vernis *et al.* 2006). For example, collaborative procurement, which has been studied by Keskinocak and Savasaneril (2008) in the for-profit context, has the potential to benefit nonprofits through economies of scale by leveraging combined needs as opposed to individual needs, as exemplified in the case of Chicago Public Schools (see inset), where such horizontal collaboration resulted in significant cost reduction. Thus, collaboration can be viewed by operations researchers as a type of strategic operations decision where the benefits of collaboration must exceed additional production and participation costs (Hill and Lynn 2003). Such collaborative operations often poses collective action and contractual problems that can be explored analytically, and, as Vernis *et al.* (2006) implore, innovative collaboration mechanisms, specifically contracting mechanisms, must be devised for these cross-sector relationships.

While scholars have offered general suggestions regarding government-nonprofit contracting and even novel ideas, such as challenge grants that reward volunteer use and private sector fund generation (Salamon 1995), operations and efficiency focused contracting mechanisms are open applications for operations research. Likewise, each

Chicago Public Schools:
Collaborative Procurement and Internal Markets

Chapman and Hardt illustrate the latent opportunities for operations management in the nonprofit sector, finding that "bringing better discipline to purchasing and supply management can save school systems" 10 to 35 percent - annual savings of $30 to $40 million for large urban districts. Figure 2.3 displays the breakout of these savings for Chicago Public Schools. Analysis found that, "of almost 13,000 titles the district had bought more than once, 44% had been purchased at different unit prices. Because nearly 30% of the orders were for fewer than ten books, the school district hadn't captured the best of those prices by getting volume discounts, and it had incurred extremely large administrative costs." Furthermore, "a surprising number of teachers have expressed interest in coordinating their purchases" through collaborative procurement or internal markets, which may indirectly benefit the district by enabling communication between teachers across the district on textbooks, curriculum, and education. This is an excellent example of the potential impact relatively simple operations management methods and techniques can provide to improve the nonprofit sector (Chapman and Hardt 2003).

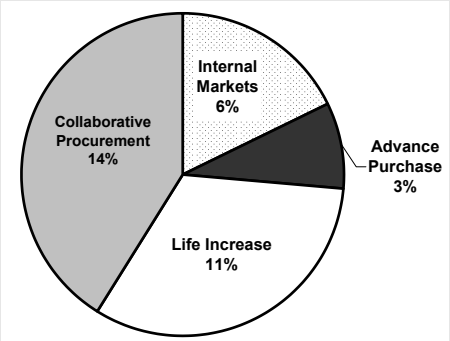


Figure 2.3: 33% Textbook Savings

type of aforementioned business alliance warrants investigation from a contracting perspective, such as licensing contracts, which have been a topic of interest in operations research (e.g., Kulatilaka and Lin 2006, Lin and Kulatilaka 2006, Crama *et al.* 2008). Erhun and Keskinocak (2007) and Erhun (2009) both provide general reviews of collaboration from an operations management perspective, which can serve as a strong basis for research encompassing nonprofits. These authors delineate both inter and intra firm collaboration and coordination, which are applicable to the above government, business, and nonprofit collaboration contexts previously mentioned. Also, Cachon (2003) gives a review of methods and literature focused on for-profit contracting and coordinating mechanisms. The novel nonprofit context offers opportunities to explore the dynamics of objective functions, power, nonprofit incentives, service contracting, and public social consequences in a new light.

2.4.3 Performance Measurement and Evaluation

Nonprofit organizations continue to experience a growing demand for performance measurement and evaluation from the government, foundations, and donors (Carman 2007). It is difficult to determine the performance of an organization or any of its particular activities given the diverse and complex nature of nonprofit objectives. As modelers, operations researchers understand the importance of identifying performance measures for assessment, decision, improvement, and, ultimately, realization of goals and greatest impact.

In academia, there exists a large, multidisciplinary body of literature on nonprofit evaluation relating to many facets of the topic. For example, Stufflebeam (2001) identifies, describes, and assesses 22 different nonprofit evaluation approaches including many different ways of measuring program outputs and outcomes. Martin and Kettner (1996) put such performance measurement into perspective by delving into the nuances of its practice. Aimed towards the nonprofit practice audience, Newcomer (1997) gives an overview of both design and use of evaluation and performance measures.

By examining the body of academic research, Baruch and Ramalho (2006) provide a review and analysis of business, nonprofit and mixed organization effectiveness and performance literature. Through this analysis, the authors find common ground between business and nonprofit measures, which supports the idea that for-profit and nonprofit effectiveness and/or performance are not differentiated enough to be considered entirely distinct constructs.

Such similarity highlights opportunities for cross-sectoral learning where the nonprofit setting can benefit from the depth of for-profit experience in process improvement, while also bringing the challenge of multiple, often less tangible, objectives. Multi-goal and multi-objective approaches must be utilized to integrate performance measures and the numerous varied stakeholder objectives of nonprofit organizations. Once measures are established, operations management applications might include integrating operational measures into programs and establishing benchmarks that appropriately incorporate multidimensionality. For example, Athanassopoulos (1998) develops a target-based model combining performance measurement and resource

allocation. Methodologically, he incorporates a principal-agent model with goal programming. The goal programming formulation, composed of operating productivity, individual performance contributions, and equity measures, is characterized by its interactive representation of the trade-offs between these three objectives.

Another evaluation framework, social cost-benefit analysis, can be applied as a public sector decision making tool that, at its most basic level, values projects, programs, etc. as the net social benefit minus the net social cost where all impacts must be monetized (Boardman *et al.* 2006). Its purposes are to help social decision making, facilitate efficient resource allocation, and provide an efficiency measurement framework. Alternatively known also as cost-effectiveness, cost-utility, or cost-feasibility analysis, Boardman *et al.* (2006) and Levin and Smith (1983) and both provide reviews.

Considering just a few of the nonprofit complexities, such as multiple stakeholders, lack of profit goal, and clear societal weight, it is not surprising that studying nonprofit performance, evaluation and effectiveness might be considered more difficult than analogous research in the business sector (Baruch and Ramalho 2006). Such complexities present operations researchers with uncommon challenges where rigorous research and more embedded applications can result in significant impacts. Operations research applications in this area, such as measurement design and system development, can have considerable effects at the community level by extending expertise and capability as evaluation training is unusual among community-based program administrators (Carman 2007). Such research can also broaden our knowledge of performance, evaluation, and operations in for-profit situations of multiple bottom lines.

2.5. Conclusion

From giving voice to the underrepresented to delivering to the underserved and supporting the vulnerable, a remarkable portion of localized problems are addressed by community-based nonprofit organizations. As this chapter has demonstrated, there exist both similarities and differences between the traditional for-profit settings of

operations research and those in the nonprofit sector. These similarities yield a potential for relevance and value of operations research techniques applied in the nonprofit sector, while the differences expose a fertile frontier for future research where our traditional solutions are no longer directly applicable.

Insights gained from exploration of these new nonprofit lines of research can further inform our traditional research lines as well. For example, advances in understanding supply-side risk have value in venture funded firms; investigation of the interplay between supply and demand broadens our understanding of how products and services can shape firm inputs. Adapting even conventional research for multiple, distinct objectives can produce robust models for multiple bottom lines. Recognition of the more elaborate nonprofit concept of consumers can result in new avenues of research regarding technology-based companies. For example, nonprofit volunteers both produce and consume nonprofit output; similarly, Apple consumers create apps (products) that affect the value of the iPhone.

Thus, while the traditional solutions of operations research are not merely exportable to the nonprofit sector, expanding our research to the nonprofit setting will surely deepen and enhance even our for-profit research lines. The nonprofit sector is ripe with opportunity for operations research and application, where advances will ultimately lead to a better economy, increased social welfare, and, perhaps, most importantly, changed lives. Considering these substantial impacts, the movement toward community-based action in the nonprofit sector will hopefully capture our attention as operations researchers, perhaps right in our own neighborhoods.

Chapter 3

Efficient Funding: Auditing in the Nonprofit Sector

3.1. Introduction

At the interface of operations management and public sector application lies a wealth of untapped research possibilities. Nonprofit operations in particular have not been traditionally considered within the realm of operations management research; however, recent trends in nonprofit organizations call for more substantial investigation (Brest and Harvey 2008; Bradley, Jansen, and Silverman 2003). In light of these discussions, this paper seeks to examine the relationship between a funder and nonprofits as contractual in nature to address the following key issues:

1. Do common funding methods facilitate the efficient allocation of funds?
2. How can audit contracts be implemented in the sector? What effects do these contracts have on both the funder and nonprofits?
3. Can auditing be used to improve the performance of the nonprofit sector as a whole?

Nonprofit organizations are a significant and growing segment of the economy apart from their critical societal contributions. Nonprofits provide services to those

who otherwise would not receive them, in many cases partnering with the government. They provide the opportunity for individuals to volunteer and give back to society, which has become a prominent part of many cultures. Nonprofits also provide a large amount of public goods that no one directly pays for but from which everyone reaps benefits, such as cleaner air. Beyond these social contributions, the nonprofit sector's economic impact should not be underestimated. In 2005, the Internal Revenue Service (IRS) registered a growing figure of approximately 1.4 million nonprofit organizations. Of these, the more than half a million large enough to report formally (those collecting more than $25,000) accounted for approximately $1.6 trillion in revenue and $3.4 trillion in assets (Blackwood, Wing, and Pollak 2008). In addition, the nonprofit sector employs 12.5 million people, which accounts for 9.5% of total employment in the United States (Jalandoni *et al.* 2002) apart from the 12.9 billion hours volunteered by 26.7% of adults in the U.S. (Blackwood, Wing, and Pollak 2008). Globally, The Comparative Nonprofit Sector Project at Johns Hopkins University found operating expenditures of $1.6 trillion when studying 37 nations in 2002 (Zakaria 2006).

There are many entities that sustain the nonprofit sector financially. Foundations, themselves nonprofit organizations, and governments both act as key grant-making institutions. In 2007, the Bill and Melinda Gates Foundation alone paid approximately two billion dollars in grants, funding nonprofits working in global health, poverty, and education, while the National Science Foundation, a United States government entity, distributed billions of dollars to scientific research and educational activities. Worldwide, foundations have continued to grow and expand, most dramatically in the United States where more than 72,000 grant-making foundations granted a record $42.9 billion in 2007 (Foundation Center 2008; Prewitt 2006). Since funders want assurance that their donations are used wisely, efficiency is a critical measure. In the nonprofit sector, efficiency is about getting "[more] mileage out of the money [nonprofits] spent" (Herzlinger 1996). The most common cost-centered operational definition of efficiency measures *the ratio of expenses directly forwarding the mission to total expenses*, numbers that can be drawn from the organization's publicly available IRS Form 990.

Funding methods, particularly grants, are in essence contracts exchanging money for some societal return where nonprofit organizations act as "sellers" of certain societal activities or deliverables (Brest and Harvey 2008). To allocate grants, many funders scrutinize financial statements and public reporting forms, such as the IRS 990, in efforts to deduce whether a nonprofit organization is operationally efficient (Frumkin and Kim 2001). In doing so, funders may believe that they are, in fact, funneling funds to the highest-return organizations. This research describes and examines this common funding situation, which is based merely on the nonprofit's reported cost-centered operational efficiency and the funder's allocation. However, under these very basic terms, our analysis shows that these nonprofit efficiency reports are unreliable. This result of a lack of efficiency reliability and its causes are well documented (e.g., Quality 990; Schwinn and Williams 2001; Frumkin and Keating 2003; Trussel 2003; Jones and Roberts 2006; Krishnan, Yetman, and Yetman 2006; Gordon *et al.* 2007; Keating, Parsons, and Roberts 2008), confirming that our results accurately describe the common, real-world situation where funders are unable to effectively distinguish between efficient and inefficient organizations. Regardless of the basis for the unreliability, this theoretical result leads to the conclusion that a simple contract based solely on funds allocated in response to an efficiency report is not effective. Thus, in response to our first research question, we show that *common funding methods, in fact, do not facilitate efficient allocation of funds.*

While efficiencies are unreliable as they are currently reported, a 2008 study on the nonprofit marketplace confirms that they indeed are verifiable (The William and Flora Hewlett Foundation and McKinsey & Company 2008). Thus, in response to the second question, we develop audit contracts that can be implemented within the funder-nonprofit relationship. In these contracts, the funder has the option to audit the nonprofits' efficiencies after awarding them funds. In case there is a discrepancy between the efficiency that the nonprofit reports and its true efficiency observed after auditing, the funder may ask the nonprofit to pay a penalty back. *We find that using audit contracts, the funder can guarantee truthful efficiency reports from the nonprofits and thus attain operational transparency. The nonprofit population also prefers these audit contracts.* As a result, we may see funders and nonprofits working together to

increase auditing within the sector and improve their respective situations. This can be seen at work in both the nonprofit sector push to increase voluntary self-auditing and legislative efforts requiring audits, such as the California Nonprofit Integrity Act of 2004 (California Government Code 2007).

The implementation of audit contracts can also improve the performance of the nonprofit sector overall. More specifically, the funder's choice of penalty positions the sector anywhere between the current, inefficient situation and the transparent, efficient situation. This implies that through implementation of audit contracts with appropriately chosen penalties, benchmark performance can be achieved for the nonprofit sector as a whole. Thus, the use of auditing may put funders in a position to enact change in the nonprofit sector and increase overall sector efficiency.

The remainder of this paper is organized as follows: the next section, Section 4.3, reviews related literature followed by Section 3.3, which describes the general model framework. Then, Sections 3.4 and 3.5 develop the contracts, where incentive and reliability issues are explored in theoretical detail. Section 3.6 investigates the effects of these different contracts through both theory and numerical examples. In Section 3.7, results are extended to the cases of constrained budget, uncertainty in production, and cost of auditing. Finally, Section 3.8 concludes by reviewing this work in light of the original research questions presented in the introduction. All proofs are presented in an addendum for expositional simplicity. Throughout the paper, the operator $E_x[.]$ is used as the expectation over random variable x and vectors are represented with **boldface**.

3.2. Literature Review

With the nonprofit sector expanding in size and influence, it may be surprising that there is relatively little research, especially analytical research, involving nonprofit operations.

Operations Management in the Nonprofit Sector. McCardle, Rajaram, and Tang (2009) use a utility-based donor model to analyze the behavior of nonprofit donations in the presence of publicized tiered fundraising structures. Their model can

be used by organizations to make effective decisions regarding the implementation of tiered fundraising structures, which they show to generate larger donations. de Vericourt and Lobo (2009) investigate the revenue management problem encountered by nonprofits engaged in for-profit ventures as a means to fund their mission, more specifically how to allocate funds among investment, serving revenue customers, and serving mission customers. Harrison and Lybecker (2005) explore such price (Bertrand) competition between nonprofit and for-profit hospitals, and show that the nonprofit motive has great importance and impact in this competition. In these heterogeneous markets where for-profits and nonprofits compete, contention can arise over supposed nonprofit regulatory and tax advantages. Liu and Weinberg (2004) analyze these supposed advantages and conclude that it is not these advantages, but rather the difference in the objective functions of the firms that cause the competitive behavior we observe. Verheyen (1998) examines the allocation of nonprofit internal budgets, specifically university and hospital budgets. The author discusses these allocation issues in the context of several different principal-agent models, but does not develop or solve such models. Our research enlarges this body of literature by applying the principal-agent framework to the funder-nonprofit relationship as well as examining the role of information, incentives, and auditing, all of which have been identified as critical research areas (Zaric and Brandeau 2007; Laffont 1994), yet are unexplored in nonprofit operations.

Nonprofit Evaluation. There is a large, multidisciplinary body of literature on nonprofit evaluation, which provides many different techniques for measuring outputs (i.e., more easily measured, tangible returns) and outcomes (i.e., less clearly measured, less tangible returns). For example, Stufflebeam (2001) identifies, describes, and assesses 22 different nonprofit evaluation approaches, while Martin and Kettner (1996) put such performance measurement into perspective by delving into the nuances of its practice. Aimed towards the nonprofit practice audience, Newcomer (1997) gives an overview of both design and use of evaluation and performance measures. Herzlinger (1996) calls for increased accountability to restore public trust, particularly through *financial* evaluation. She details four questions to perform financial assessment, which are implemented in The Boston Foundation's assessment of and call to action for the

fiscal health of Massachusetts nonprofits (Keating *et al.* 2008). As a more holistic financial evaluation framework, social cost-benefit analysis values projects, programs, etc. as the net social benefit minus the net social cost where all impacts must be monetized; Boardman *et al.* (2006) and Levin (1983) both provide reviews. Our research draws on these methods in developing the funder's perspective of nonprofit contribution. Beyond this, our modeling of the funder's utility, particularly the portions derived from the nonprofits funded, extends the theory and understanding of how these methods can be incorporated into strategic decision making and theoretical modeling.

Capacity and Resource Allocation. Allocation is widely studied in both operations management and economics literature. More recently, researchers have tackled information problems in capacity and resource allocation, specifically the inefficiencies created due to incentive misalignments (e.g., Harris, Kriebel, and Raviv 1982; Cachon and Lariviere 1999a, 1999b; Rajan and Reichelstein 2004; Karabuk and Wu 2005), which are most in line with the goals of this paper. Cachon and Lariviere (1999a, 1999b) study *inter-firm* capacity allocation problems where a single supplier is allocating capacity among retailers with private demand information. Karabuk and Wu (2005), Rajan and Reichelstein (2004), and Harris, Kriebel, and Raviv (1982), on the other hand, examine *intra-firm* capacity and resource allocation problems. Karabuk and Wu (2005) study incentive alignment for a single decision maker allocating capacity to managers with private demand information using bonus payments and participation charges. Rajan and Reichelstein (2004) and Harris, Kriebel, and Raviv (1982) model a common resource being allocated among divisions where the output of each division is an increasing function of allocation along with productivity and managerial effort, both of which are the divisional managers' private information. Transfer pricing mechanisms are found optimal. Our funding model is certainly in line with these streams of literature; it presents an allocation of funds among horizontal agents with private cost information in the form of an efficiency ratio. In addition, our decision maker has outside opportunities and we seek to use *auditing* mechanisms to resolve asymmetric information. Due to the nature of the utilities in our model, our objective function incorporates the funder's as well as part of the nonprofits'

objectives making the solution more socially optimal. Therefore, we are examining a problem with both shared and conflicting objectives between the principal and agent(s).

Incentives. In seeking to align incentives and resolve problems due to asymmetric information, many researchers rely on complex contracts. For example, under asymmetric cost information, Ha (2001), Corbett (2001), Corbett and de Groote (2000), Corbett, Zhou, and Tang (2004), and Lutze and Özer (2008) all design optimal contracts (i.e., contracts that include contingencies for each possible cost value) that may be arbitrarily complex, making them difficult to write, implement, and administer in practice. Recently, we observe a trend in operations management literature where simple (in terms of the number of contingencies included) yet efficient contracts, such as price-only contracts, are studied as an alternative to complex optimal contracts (e.g., Lariviere and Porteus 2001; Kayis, Erhun, and Plambeck 2009). In a similar spirit, we also do not work with complex optimal contracts, but develop simple, implementable audit contracts that can be applied given the current state of the nonprofit sector.

Auditing. A wealth of economic literature exists around auditing, particularly in relieving incentive issues, and we focus on only a few representative pieces here. Baron and Besanko (1984) explore the use of auditing in the context of regulation of firms, specifically in cost reporting, where the regulator can order consumer refunds in the case of overstated firm costs. The authors particularly explore auditing as a means to structure firm incentives for truthful cost reporting under asymmetric information. Using a related model, Laffont and Tirole (1986) analyze incentive contracts, both regulatory and procurement, with the addition of a moral hazard component, which prevents the regulator from rewarding high costs. Our scenario, however, is not regulatory in nature. Though we study auditing in the spirit of this literature, we do not discuss the details of performing such audits. Tools, methods, and examples of performing audits in the nonprofit sector can be found in Bridge, Murtagh, and O'Neill (2009) and Carman (2009). Our funder is seeking her own objectives, which, in fact, are *both* conflicting and shared with the nonprofits. These shared objectives between the funder and nonprofits complicate the situation and produce

unique results. We also do not merely look at optimal contracts that achieve first-best performance as we examine the funder's perspective, the nonprofit perspective, and the sector efficiency perspective. Instead, we devise alternative contracts to improve efficiency the situation for all parties and the sector.

3.3. Model Definition

The relationship between nonprofits and the funders who support them is not trivial. The funder supplies resources to nonprofits in the form of grant allocations with the expectation that these nonprofits produce returns in the form of social output or outcome. An example of *output* for WorldVision, a nonprofit humanitarian organization, might be the number of shelters distributed following a natural disaster. However, increased appreciation and education regarding the environment might be an *outcome* for the Sierra Club, a nonprofit environmental organization. These examples demonstrate that output can be both generally measured and agreed upon, while outcome may not be as easily evaluated. However, as discussed in Section 4.3, there is a growing body of literature on nonprofit evaluation, which provides many different techniques for measuring program outputs *and* outcomes. Considering this literature and our model framework, we treat output and outcome equivalently. Accordingly, in the remainder of the paper, we use the term "output" to include both output *and* outcome.

While both the funder and the nonprofits aim to maximize this social output, they each have other, possibly conflicting, components of their respective objectives. More specifically, the funder looks to maximize the value for her dollar while nonprofits look to maximize the dollars they receive (i.e., their allocation). Each nonprofit has both an unobservable *efficiency type* and an unobservable *effort*. These unobservables are in tension with the funder's objectives of giving responsibly and fulfilling a duty to the sector. Note that efficiency is characterized as a type as opposed to a decision variable for the nonprofit because, while nonprofits can increase their efficiencies, these changes "don't *just* happen" (Neuhoff and Searle 2008).

The scenario that we analyze consists of one funder and $N \geq 1$ nonprofits. All

parties are expected utility maximizers. The funder does not know the true efficiency types of the nonprofits with certainty, but knows that each true efficiency type, θ_i, is distributed with probability density function $f_i(\theta_i)$ and cumulative distribution function $F_i(\theta_i)$, $i = 1, ..., N$. Since the efficiency is a ratio as described in Section 3.1, the support of the distribution is $[0, 1]$[1]. Note that the efficiency definition adopted here describes only part of how effectively the nonprofits accomplish their mission; as such, it is a simplification of a complex concept. Nonprofit organizational effectiveness is multidimensional and, therefore, cannot be encapsulated in a single measure (Herman and Renz 1999). Yet this ratio is the most common cost-centered operational definition of efficiency in the literature and is also commonly employed by auditors, accreditors, media, and charity oversight analysts "to compare the operations of organizations with similar missions, with the goal of determining which organizations have the leanest operations" (Frumkin and Kim 2001); for example, see Chabotar (1989), Herzlinger (1996), Hager and Flack (2004), Krishnan, Yetman, and Yetman (2006), Gordon *et al.* (2007). For many analysts, this definition translates into accountability by providing insight into management and administration spending (Hager and Flack 2004), production costs, and translation of "the supply-chain into financial values through recording and analyzing the costs associated with products/activities undertaken" (Bagnoli and Megali 2009). It communicates a relative financial condition, highlighting similarities in financial goals while controlling for differences over time and across nonprofit organizations (Chabotar 1989), thus enhancing understanding of these organizations and helping to create informed decisions about financial support.

Nonprofit i's utility, u_i, and production (output), y_i, are determined by

$$u_i = A_i - \frac{e_i^2}{2} + y_i \qquad \text{(Nonprofit Utility)} \tag{3.1}$$

$$y_i = 2\sqrt{e_i \theta_i A_i} \qquad \text{(Nonprofit Output Production)} \tag{3.2}$$

[1]An efficiency type of one does not necessarily mean that the nonprofit is channeling *all* of its funds to mission critical activities. Of course, some funds may be used for fundraising, overhead, etc. Any upper bound can be normalized to one to accommodate other limits.

where A_i is the allocation made from the funder to nonprofit i, e_i is nonprofit i's effort, and θ_i is the true efficiency type of nonprofit i. The nonprofit's utility is increasing in the allocation he receives from the funder and in his output and is decreasing in the effort he exerts.[2] For their survival nonprofits depend on funds; therefore, the nonprofit's utility is increasing in the allocation he receives. The nonprofit gains utility in output because output supports the nonprofit's mission. While the nonprofit would like to support his mission, he prefers to do this with the least effort. This may be so that the effort, such as volunteer time, can be spread over other programs. The production function in Equation (3.2) indicates that the nonprofit must have positive effort, efficiency, and allocation in order to produce output; without any one of these variables, no output will be produced. Furthermore, the nonprofit production function is concave in effort, e_i, efficiency type, θ_i, and allocation, A_i, signifying diminishing returns and boundedness of production. We initially assume that output can be measured unambiguously; we later relax this assumption and study production uncertainty in Section 3.7.2.

The funder's expected utility, U_f, is

$$U_f = \sum_{i=1}^{N} E_{\theta_i}[c_i y_i] + \alpha \left(B - \sum_{i=1}^{N} E_{\theta_i}\left[A_i\right] \right), \tag{3.3}$$

where $c_i > 0$ is the funder's monetary valuation of each unit of nonprofit i's output, α is the return on an outside opportunity, and B is the funder's budget. The first term of the funder's utility, $\sum_{i=1}^{N} E_{\theta_i}[c_i y_i]$, is the total expected value from the nonprofits' output. The funder would like to maximize each nonprofit i's output, y_i, and each output is worth some amount c_i. The c_i term is individualized to each nonprofit and may incorporate the extent to which the work of nonprofit i supports the mission of the funder. The funder only observes the output, y_i, and efficiency report, $\hat{\theta}_i$, of each nonprofit, but does *not* observe the nonprofit's effort choice, e_i, nor true efficiency, θ_i.

[2]For expositional clarity, we assume that allocation A_i and production y_i have the same weight, which we normalize to 1, in nonprofit i's utility function. Giving allocation and production different weights, e.g., assigning a positive weight to production, does not change our main results. As expected, the allocations under different contracts will now be a function of this multiplier as well as other problem parameters.

The second term of the funder's utility, $\alpha\left(B - \sum_{i=1}^{N} E_{\theta_i}\left[A_i\right]\right)$, represents an outside opportunity. While the funds allocated may increase the nonprofits' output, these funds too are valued by the funder considering that they could be used for other opportunities. In fact, the funder may decide that the outside opportunity is worth more than the (social) return of investing that money into a particular nonprofit. For example, de Vericourt and Lobo (2009) investigate using this money in a for-profit venture or investing it in order to supplement the income stream.

Unlike a for-profit corporation that distills the objectives of their shareholders, managers, employees, and clients into one quantifiable profit measure, "the nonprofit has no single primary interest group that is invariably and clearly defined, homogenous with respect to interests, and whose goals are easily expressible and transferable into the organization for assessment of alternative courses of action" (Speckbacher 2003). Due to this varied abundance of stakeholders and purposes, quantifying and modeling the objectives of a nonprofit organization can be ambiguous and contentious. Our formulations are thus some first attempts to model the dynamics of nonprofit operations and were developed through an understanding of the field, which we gained through personal communication (Foundation Center 2009; Philanthropy and Civil Society Research Workshop 2010; Meredith 2009), field reports, and academic and trade publications. Furthermore, our modeling assumptions, such as funder utility increasing in output and effort (Equation (3.3)) and efficiency modeled as asymmetric information, are consistent with relevant economics literature (e.g., Easley and O'Hara 1983). Similar to related models in the operations management literature (Cachon 2003), we express effort cost as a convex function (Equation (3.1)) because it is progressively more difficult to increase the effort, which is limited by capacity.

The funding sequence of events for a given contract is as follows: (i) The funder announces some allocation scheme, possibly based on types, $A_i(\theta_i)$, for each nonprofit i. (ii) Nonprofit i announces an efficiency, $\hat{\theta}_i$, perhaps through an application process. These efficiency types are also typically available through IRS data submitted by the nonprofits, such as the IRS 990 Form. This announcement may or may not be truthful. (iii) The funder allocates resources within the contractual framework to maximize her utility considering the nonprofits' announcements and any constraint

on her budget. (iv) Each nonprofit chooses an effort to maximize his utility based on this allocation. Based on this sequence, the nonprofit problem is solved first followed by that of the funder by backwards induction. The nonprofit i maximizes his utility based on the given allocation:

$$\max_{e_i \geq 0} \; u_i = \max_{e_i \geq 0} \left\{ A_i - \frac{e_i^2}{2} + y_i \right\} \quad \textit{where} \quad y_i \; = \; 2\sqrt{e_i \theta_i A_i}.$$

Substituting the production function, we obtain $u_i = A_i - e_i^2/2 + 2\sqrt{e_i \theta_i A_i}$. The effort, e_i^*, that maximizes the nonprofit i's utility can easily be found as $e_i^* = (A_i \theta_i)^{1/3}$. Through substitution of e_i^*, reformulations of the nonprofit i's utility and output functions as well as the funder's utility function are obtained.

$$u_i^* \; = \; A_i + \frac{3}{2}(A_i \theta_i)^{2/3}, \qquad \text{(Nonprofit Utility)} \qquad (3.4)$$

$$y_i^* \; = \; 2(A_i \theta_i)^{2/3}, \qquad \text{(Nonprofit Output)} \qquad (3.5)$$

$$U_f \; = \; \sum_{i=1}^{N} E_{\theta_i} \left[2c_i (A_i \theta_i)^{2/3} - \alpha A_i \right] + \alpha B. \qquad \text{(Funder Utility)} \qquad (3.6)$$

In this paper, we do not work with complex contracts in the traditional sense of principal-agent. The idea here is to understand the situation and develop contracts that can be applicable given the current operational policies, practices, and trends of the nonprofit sector. This principal-agent model is different from others in that it incorporates both shared and conflicting portions of the respective objectives of the principal and the agents as well as unobservable characteristics. The utility and objective functions here in the nonprofit setting differ from those more familiar functions of the for-profit world. Our nonprofit objective function incorporates several perspectives: allocation from a managerial financial sustainability perspective, effort from an employee perspective, and production from the client and funder perspective. This heterogeneity of interests and objectives, partly shared with the principal or funder, is indeed a new avenue of exploration for both nonprofit research and "supplier-manufacturer" type game theoretic models. However, it is these differences that lead to unique results.

In the model analysis and remainder of the paper, we first assume an unconstrained budget in Sections 3.4-3.6. That is, we assume $\sum_{i=1}^{N} A_i < B$ so that we omit the budget terms in the above formulations. In Section 3.7.1, we explore and extend our results to the case of budget constraint, i.e., $\sum_{i=1}^{N} A_i = B$. In the following section we begin investigating the funder-nonprofit relationship in order to answer our originally posed research questions. We start by describing the common funding situation with the Report-Based Contract as well as establish a benchmark, first-best contract for comparison purposes. These will motivate us to study audit contracts in Section 3.5.

3.4. Report-Based Contract

The funder would like to make the most of her money and, therefore, would like to allocate funds based on the efficiency types of nonprofits, i.e., $A_i(\theta_i)$. Given Equations (3.4) and (3.6) and using the Revelation Principle (Laffont and Martimort 2002) as is common in such models, the funder's problem can be formulated as follows:

$$\max_{A_i(\theta_i)} U_f = \max_{A_i(\theta_i)} \left\{ \sum_{i=1}^{N} E_{\theta_i} \left[(2c_i(A_i(\theta_i)\ \theta_i)^{2/3} - \alpha A_i(\theta_i)\ ) \right] \right\} \tag{3.7}$$

subject to

$$u_i^*(\theta_i) \geq 0 \qquad \forall i; \forall \theta_i \in [0,1] \qquad \text{(IR)} \tag{3.8}$$

$$u_i^*(\theta_i|\theta_i) \geq u_i^*(\hat{\theta}_i|\theta_i) \qquad \forall i; \forall \hat{\theta}_i, \theta_i \in [0,1] \qquad \text{(IC)} \tag{3.9}$$

$$A_i(\theta_i) \geq 0 \qquad \forall i; \forall \theta_i \in [0,1] \qquad \text{(Non-negativity)} \tag{3.10}$$

where θ_i is nonprofit i's true efficiency type, $\hat{\theta}_i$ is nonprofit i's announcement of efficiency type, and $u_i^*(\hat{\theta}_i|\theta_i)$ is nonprofit i's utility when his true efficiency type is θ_i but his announced efficiency type is $\hat{\theta}_i$; $u_i^*(\hat{\theta}_i|\theta_i) = A_i(\hat{\theta}_i) + 3/2(A_i(\hat{\theta}_i)\theta_i)^{2/3}$. The individual rationality (IR) constraints ensure nonnegative utility for each nonprofit within the contract. The incentive compatibility (IC) constraints constrain each nonprofit to truthfully report their efficiency type by use of a utility-based incentive. Consequently, the funder's problem is expressed as an adverse selection problem where the

funder cannot observe the amount of effort, e_i, the nonprofit i will exert nor the nonprofit i's efficiency type, θ_i. Note that in this formulation the funder allocates funds in response to the nonprofits' reported efficiencies. Thus, the resulting Report-Based Contract describes the common situation where the nonprofits' efficiency types are not verified:

Theorem 1. *The* Report-Based Contract *takes the form* $A_i^R(\theta_i) = A_i^R = \frac{64}{27}{\phi_i}^3 E[{\theta_i}^{2/3}]^3$ *where* $\phi_i = c_i/\alpha$ *and* $i = 1, ..., N$.

This solution indicates an instinctive relation: in a scenario where the true efficiency type is unknown, the funder would want to allocate more funds to the nonprofit that is more likely to be a higher efficiency type. The result also indicates that the funder is *unable* to differentiate among the nonprofits' efficiency types as she bases her allocation solely on her expectation of each nonprofit's type, the only reliable information she possesses. The nonprofits do not have incentive to truthfully report their type, and, therefore, their reports are unreliable. The Report-Based Contract, which is based merely on reporting without verification, consequently offers the funder no observability of efficiency types and no operational transparency within this contracting context. Theorem 1 is intuitive in yet another way: nonprofit i will receive more funding as the funder values his output more (i.e., as c_i increases), but will receive less funding as the outside opportunity becomes more lucrative (i.e., as α increases). In other words, when the outside opportunity is more valuable compared to nonprofit output, the funder will choose to allocate less funds to the nonprofit in order to gain from the outside opportunity.

The Report-Based Contract succeeds in modeling the common funding situation where there is no reliability in efficiency reports and no transparency in nonprofit operations. Bradley, Jansen, and Silverman (2003) find nonprofits misreporting their efficiencies in situations where potential funders are investigating this measure to make decisions about giving and fund allocation. Misreports of efficiency may be due to managerial motivation, executive compensation incentives, use of efficiency in funding decisions, charity ratings, media attention, or reputational pressures (Frumkin and Keating 2003; Trussel 2003; Jones and Roberts 2006; Krishnan, Yetman, and

Yetman 2006; Keating, Parsons, and Roberts 2008). A myriad of other literature related to unreliable IRS data and expense shifting also supports our theoretical result of a lack of observability and reliability of efficiency types in the current funding situation. The IRS Form 990 is the chief source of the financial data from which the efficiency measure is derived. However, the 990 is typically not verified. In fact, Schwinn and Williams (2001) assert that the IRS only examined 1.3% of 990s in 1999. Furthermore, the IRS Form 990 allows nonprofits to record certain administrative and fundraising costs as offsets to revenue rather than as expenses. As a result, nonprofits may portray their operations as more efficient in the Form 990 (Frumkin and Keating 2003). Jones and Roberts (2006) report that charities do indeed employ expense shifting to "offset 16 to 28 percent of potential changes in program ratio [efficiency]." Herzlinger (1996) claims that this nonexistence of accountability perpetuates ineffective and inefficient organizations as well as other problems. Froelich and Knoepfle (1996) summarize that overall, "the nonprofit situation [is] characterized by extensive reporting, but very weak monitoring." This underlines the lack of reliability and, consequently, the need to make the relationship between the funder and nonprofits more reliable through stronger monitoring. More than a decade later, the situation has not changed considerably. Even today, by and large, "funders have influence, but not control [over nonprofits]" (Meredith 2009). Therefore, with our next set of contracts detailed in Section 3.5, we will consider monitoring by funders as a way to increase accountability in the nonprofit sector.

Before moving into the next section, we analyze a special case of the Report-Based Contract, which is a benchmark model where efficiency types, θ_i, are *observable*. While this perfect observation of efficiency types is unrealistic, it is for this reason the funder's first-best solution as it eliminates the ineffectiveness due to the information asymmetry and allows for complete transparency.

Corollary 1. *The* first-best contract *takes the form* $A_i^{FB}(\theta_i) = \frac{64}{27}{\phi_i}^3\theta_i^2$ *where* $\phi_i = c_i/\alpha$.

We note that the funder allocates to all nonprofits with a non-zero efficiency ($\theta_i > 0$). Each nonprofit's allocation is based on his efficiency type; if the nonprofit

is of a very low efficiency type, his funding is negligible.[3]

3.5. Audit-Based Contracts

While the first-best contract supposes the funder can observe *all* nonprofit efficiency types (complete transparency), the Report-Based Contract results in the funder observing *none* of the nonprofit efficiency types (no transparency). Now we turn our attention to investigating contracts that will enable the funder to position herself anywhere between and including both the first-best and Report-Based Contracts in terms of both observability of nonprofit efficiency types as well as contract performance. In this setting, the funder allocates her funds to the nonprofits based on their announced efficiency type. However, we know from the analysis of the Report-Based Contract in Section 3.4 that the funder will not be able to differentiate; i.e., a nonprofit's announcement of efficiency type is not reliable. In this auditing scenario, the funder can verify the nonprofit's efficiency type by auditing *after* allocating funds and then impose a penalty upon nonprofits who misreport. Note that dealing with ex-post auditing is different from dealing with ex-ante observable efficiency types since the funder must provide an incentive (here a penalty) to the nonprofits to observe their efficiency within the auditing framework.

The funder's objective does not change from that formulated in Equation (3.7) in Section 3.4. In particular, an auditing cost is not included in the funder's objective function because there are several situations where this would not be appropriate. For example, nonprofits may choose to self-audit using a credible third-party auditor. Also, funders may not have specific auditing costs or may have auditing costs and budgets separate from the contracts themselves. However, in Section 3.7.3 we extend this analysis to include auditing costs. The constraint set also continues to include the same IR and non-negativity constraints found in Equations (3.8) and (3.10) of

[3]This situation of allocating money to every nonprofit may be unrealistic as allocating a few dollars would certainly not be worth the administrative costs. However, the funder may pre-screen nonprofit applications, assigning $c_i = 0$ to nonprofits with too low of an efficiency report. Also the funder may want to have a minimum funding level where she only funds nonprofits whose allocations surpass this level, thus excluding some nonprofits from consideration.

our original model. However, the IC constraint in Equation (3.9) is *updated* for the audit contracts. It now incorporates an imposed penalty, $P_i \geq 0$, for misreports, and is as follows for all i and for all $\hat{\theta}_i, \theta_i \in [0,1]$:

$$u_i^*(\theta_i|\theta_i) \quad \geq \quad u_i^*(\hat{\theta}_i|\theta_i) - P_i \; A_i(\hat{\theta}_i) \qquad \text{(Audit IC)} \qquad (3.11)$$

The left-hand side of the Audit IC constraint is still the nonprofit utility when reporting truthfully. However, the right-hand side is the nonprofit utility from misreporting minus a penalty imposed on the nonprofit's allocation. We saw in Section 3.4 that without this penalty modification, the nonprofit has no incentive to report truthfully. Consequently, the goal of this penalization for misreporting is to create an incentive for the nonprofit to report truthfully.

The funder has two levers she can use to guarantee nonprofit incentive compatibility: she can adjust allocation, $A_i(\theta_i)$, or penalty, P_i. Accordingly, she will offer contracts including both allocation and penalty, which take the form $(P_i, A_i(\theta_i))$. The best situation for the funder is to attain first-best allocations with incentive compatibility for all efficiency types. We first characterize the optimal penalty that will achieve this in the following lemma.

Lemma 1. *The optimal penalty for an audit contract is* $P_i^* = 1 + \frac{3}{4\phi_i\sqrt{\frac{8}{3}\phi_i+3}}$ *where* $\phi_i = c_i/\alpha$.

The optimal penalty enforces incentive compatibility for all possible efficiency types of nonprofit i. The optimal contract, which utilizes this optimal penalty and first-best allocations to achieve first-best performance and observability, is outlined in Theorem 2.

Theorem 2. *The* optimal Audit-Based Contract *takes the form* $\left(P_i^*, A_i^{FB}(\theta_i)\right)$ *where* P_i^* *and* $A_i^{FB}(\theta_i)$ *are defined by Lemma 1 and Corollary 1, respectively.*

The optimal Audit-Based Contract enforces incentive compatibility by setting a high penalty ($P_i^* > 1$) for all types and decreasing the right-hand side of Equation (3.11). As the penalty P_i^* is greater than 1, each nonprofit will need to repay *more than* what was originally granted to them in the event that they misreport. This

arises since the nonprofit not only values the allocation but also the output he would get with that allocation; hence, he should be penalized accordingly. However, this penalty can also be thought of as, at least in part, a loss of future funds due to a loss of reputation. The optimal penalty intuitively decreases in $\phi_i = c_i/\alpha$. As the funder values nonprofit output more, she penalizes less severely – again reflecting her increased regard for even the less-efficient nonprofit output. We summarize these observations in Corollary 2 below.

Corollary 2. *The following are true for the incentive compatibility enforcing penalty,* P_i^**:*

i. $P_i^* > 1$.

ii. P_i^* *is decreasing in* $\phi_i = c_i/\alpha$.

While the optimal contract's penalty, P_i^*, enforces incentive compatibility for all types and achieves benchmark performance, it may have undesirable, if not unrealistic, characteristics. Under this contract, the funder is required to audit *all* types of nonprofits, which may create implementation problems. Furthermore, since the funder imposes a penalty greater than 1 and thus requires the nonprofits to repay *more than* the amount granted to them, there may be credibility issues. Instead, the funder may want to specify a less severe penalty, $P_i \leq 1$, to implement and as a result may choose not to audit low types. Factors such as funder preference, policies or auditing resources may dictate this penalty choice. An example of such a policy might be to fund lower efficiency nonprofits with larger than necessary grants to enable them to survive and improve their efficiency. Another factor might be auditing costs, which are further explored in Section 3.7.3. In such situations, the funder does not use penalty to enforce incentive compatibility, but instead can adjust allocations. Since the lower efficiency types have the greatest incentive to misreport, the funder must now compensate these types to prevent such misreports and guarantee incentive compatibility.

Thus, the Audit-Based Contract with a specified penalty P_i allows a more liberal choice of penalty, $0 < P_i \leq 1$, and uses the lever of allocation to enforce incentive

compatibility. We define the efficiency type $\theta_i^*(P_i)$ as a *cut-off* type for a given penalty P_i for which the incentive compatibility constraint in Equation (3.11) holds with equality when implementing first-best allocations; i.e., for $\theta_i \geq \theta_i^*(P_i)$ the incentive compatibility constraint will hold and for $\theta_i < \theta_i^*(P_i)$ it will not. The following lemma shows that a cut-off efficiency type, $\theta_i^*(P_i)$, always exists.

Lemma 2. *Given a penalty $0 < P_i \leq 1$, the cut-off efficiency type of nonprofit i, $\theta_i^*(P_i)$, is*

$$\theta_i^*(P_i) = \sqrt{\frac{1}{\eta_i^9}\left(9\eta_i^6\upsilon_i^{1/3} - \upsilon_i^{5/3} + 8(1-P_i)\eta_i^5\left(\eta_i^3 + \upsilon_i^{2/3}\right)\phi_i\right)}$$

where $\phi_i = c_i/\alpha_i$, $\eta_i = 9 + 8\phi_i$, and $\upsilon_i = 4(1-P_i)\eta_i^5\phi_i + \sqrt{\eta_i^9\left(16(1-P_i)^2\eta_i\phi_i^2 - 27\right)}$.

Utilizing a sub-optimal penalty requires the funder to exercise her other lever of allocation to enforce incentive compatibility. The following Audit-Based Contract employs the cut-off type, $\theta_i^*(P_i)$, and allows the funder to specify a less severe penalty, $0 < P_i \leq 1$.

Theorem 3. *The* Audit-Based Contract *with a specified penalty P_i takes the form*

$$\left(P_i^A, A_i^A(\theta_i)\right) = \begin{cases} \left(P_i, A_i^{FB}(\theta_i^*(P_i))\right) & \text{for} \quad \theta_i < \theta_i^*(P_i) \\ \left(P_i, A_i^{FB}(\theta_i)\right) & \text{for} \quad \theta_i \geq \theta_i^*(P_i) \end{cases}$$

where $\theta_i^*(P_i)$ and $A_i^{FB}(\theta_i)$ are defined by Lemma 2 and Corollary 1, respectively.

Using her lever of allocation, the funder gives efficiency types below the cut-off $\theta_i^*(P_i)$ a constant allocation to induce incentive compatibility while high types receive first-best allocation. Due to this constant allocation, the funder loses some utility and observability in over-allocating funds to nonprofits with low efficiency types. The extent of this loss is dictated by $\theta_i^*(P_i)$ and ultimately the funder's choice of penalty P_i. The funder can recover utility by exploiting the lever of her penalty choice to position herself. Specifically, as she increases her penalty P_i (lowers $\theta_i^*(P_i)$), the funder increases the range of types she can observe as well as her utility. However,

when the penalty is poorly chosen and insufficiently high, this contract can result in negative utility for the funder, which would indicate that she would not use this contract under the particular conditions. Despite this, the Audit-Based Contract with a specified penalty may still be a preferred option for funders as it does not over-penalize any nonprofits yet still rewards the higher efficiency nonprofits with first-best allocations. This preference and its associated conditions are further explored in Section 3.6. Following from Lemma 2, we can make two observations on the behavior of the cut-off type:

Corollary 3. *The cut-off type, $\theta_i^*(P_i)$, is*

i. decreasing in the penalty, P_i, and

ii. decreasing in $\phi_i = c_i/\alpha$.

The first point is intuitive: as the funder imposes a more harsh penalty, this larger penalty enforces incentive compatibility for more nonprofit efficiency types. Thus, fewer types need to be cut off. Since $\phi_i = c_i/\alpha$ measures the value the funder places on nonprofit i's output compared to her outside opportunity, as the funder values nonprofit i's output more, she cuts off fewer nonprofit efficiency types reflecting her increased regard for even the less-efficient nonprofit output.

In summary, the optimal Audit-Based Contract employs a strict but optimal penalty, in fact penalizing all types to repay amounts beyond their original grant, which enables first-best allocations for *all* types. The Audit-Based Contract with a specified penalty, on the other hand, allows the funder to specify a more lenient penalty. However, the funder pays for her leniency with a limited loss of observability and performance. The lenient penalty causes only efficiency types above a cut-off, $\theta_i^*(P_i)$, to be incentive compatible. Thus, types below $\theta_i^*(P_i)$ gain rent as they are allocated increasingly inefficient allocations the further they are below $\theta_i^*(P_i)$. The choice of penalty does allow the funder to at least position herself in terms of observability and utility with a higher penalty moving her closer to the first-best situation by decreasing the cut-off $\theta_i^*(P_i)$.

3.6. Effect of Contract Type on Performance

Using our theoretical results with numerical examples as illustration, we investigate the effect of each contract on the funder, the nonprofits, and the nonprofit sector overall. In our numerical examples we make some restrictions: we look at a symmetric population of nonprofits with efficiency types the funder believes are uniformly distributed, $\theta_i \sim U[0,1]$, $c_i = c$, and $P_i = P$ for all i.[4] All results are in expectation, and thus, the results labeled as nonprofit are indeed the results for the *population* of nonprofits. We focus on the Audit-Based Contract with a specified penalty (Theorem 3), since the optimal Audit-Based Contract always achieves first-best. We define $\mathbf{P} = (P_1, ..., P_N)$, $\tilde{\mathbf{\Theta}} = (\tilde{\theta_1}, ..., \tilde{\theta_N})$, and $\mathbf{\Theta}^*(\mathbf{P}) = (\theta_1^*(P_1), ..., \theta_N^*(P_N))$. We use superscripts FB, R, and A to denote the first-best contract, the Report-Based Contract, and the Audit-Based Contract, respectively.

3.6.1 Funder Expected Utilities

Examining the funder's expected utility from Equation (3.7) reveals the following conclusions:

Proposition 1. *Regarding contract effects on the funder's expected utility, U_f:*

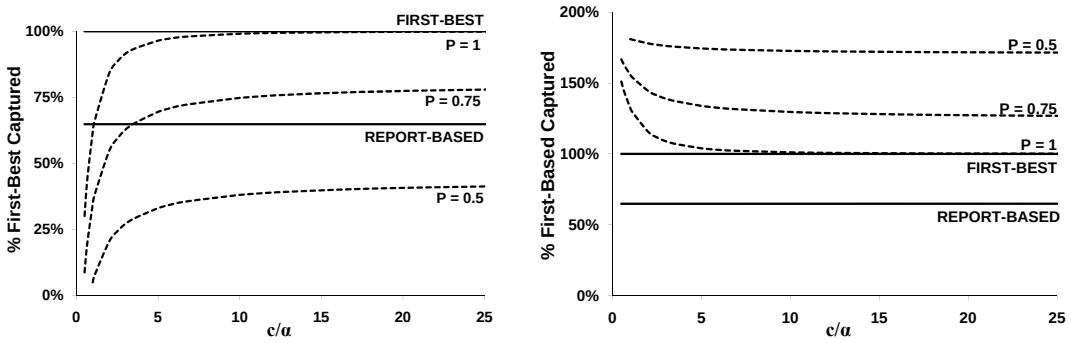
i. $U_f^{FB} \geq \max\left\{U_f^R,\ U_f^A\right\}$.

ii. There exists a threshold $\tilde{\mathbf{\Theta}}$ such that $U_f^A \geq U_f^R$ for $\mathbf{\Theta}^*(\mathbf{P}) \in [\mathbf{0}, \tilde{\mathbf{\Theta}}]$ and $U_f^R \geq U_f^A$ for $\mathbf{\Theta}^*(\mathbf{P}) \in (\tilde{\mathbf{\Theta}}, \mathbf{1}]$.

iii. U_f^A is decreasing in the cut-off type, $\mathbf{\Theta}^*(\mathbf{P})$, and increasing in the penalty, $\mathbf{P}$.

These conclusions are illustrated in Figure 3.1, which shows the percentage of first-best (benchmark) utility captured by each contract. This expected percentage of first-best captured is plotted over c/α, which describes how the funder values the nonprofit output over the outside opportunity.

[4] The results remain unchanged for heterogeneous nonprofits, i.e., $c_i \neq c_{-i}$, $P_i \neq P_{-i}$, and varying type spaces. For interested readers, such analysis is available from the authors.



(a) Funder (b) Nonprofits

Figure 3.1: Percentage of Expected First-Best Captured: Shows the percentage of first-best (benchmark) utility captured by each contract. The Audit-Based Contract is indicated by dashed lines while the solid lines show the Report-Based Contract and first-best.

In Figure 3.1(a) two regions can be identified for the funder. While the percentage of expected first-best captured is always higher than that of the Report-Based Contract and Audit-Based Contract (Proposition 1(i)), below the Report-Based line lies a region where the funder prefers the Report-Based Contract to the Audit-Based Contract. This is largely due to the choice of penalty being too low and a low value of c/α. Between the Report-Based and first-best lines lies a second region where the Audit-Based Contract is preferred to the Report-Based Contract. These regions illustrate Proposition 1(ii). We also note that, consistent with Proposition 1(iii), the funder's percentage of expected first-best captured and thus expected utility under the Audit-Based Contract are increasing in the penalty, P. Finally, we observe that for reasonably large values of c/α, the optimal penalty (Lemma 1) is almost 1.

3.6.2 Nonprofit Population Expected Utilities

Likewise, examining the nonprofit population's expected utility derived from Equation (3.4)

$$u_N = \sum_{i=1}^{N} E_{\theta_i}\left[A_i + \frac{3}{2}(A_i\theta_i)^{2/3}\right] \qquad \text{(Nonprofit Population Utility)}$$

reveals the following conclusions:

Proposition 2. *Regarding contract effects on the nonprofit population's expected utility,* u_N*:*

i. $u_N^A \geq u_N^{FB} \geq u_N^R$.

ii. u_N^A *is increasing in the cut-off type,* $\mathbf{\Theta}^*(\mathbf{P})$*, and decreasing in the penalty,* $\mathbf{P}$.

The Audit-Based Contract gives a larger, constant allocation to the low efficiency types (i.e., types below the cut-off $\theta^*(P)$) while also giving first-best allocations to high efficiency types (i.e., types above the cut-off $\theta^*(P)$) as shown by Theorem 3. That is, compared to the first-best, the nonprofits are awarded higher allocations by the Audit-Based Contract, which is why the percentage of first-best captured utilities greater than 100% can be observed with the Audit-Based Contract in Figure 3.1(b). Consistent with Proposition 2(i), a very intuitive nonprofit preference for the Audit-Based Contract is therefore clear. However, this preference is decreasing as the penalty increases (Proposition 2(ii)); that is, as the cut-off $\theta^*(P)$ decreases and more types are forced to report truthfully and are awarded first-best allocation instead of the larger, constant allocation.

An important conclusion drawn here is that high efficiency type nonprofits clearly prefer the Audit-Based Contract over the Report-Based Contract because they receive efficient allocations. In fact, these higher efficiency type nonprofits may want to work with funders for cultural changes to increase auditing and thus increase utility for themselves. This can be seen at work in the nonprofit sector push to increase voluntary self-auditing and legislative efforts. Considering the government as a prominent funder, legislation aiming to elevate the standards of accountability and auditing are certainly evidence of funders seeking to create Audit-Based Contract situations. An example of such legislation is the California Nonprofit Integrity Act of 2004, which requires larger nonprofits to conduct objective, regular audits (California Government Code 2007).

3.6.3 Sector Expected Efficiency

Turning attention to the nonprofit sector as a whole, sector expected efficiency is defined as $\Pi = E\left[\frac{\sum A_i\theta_i}{\sum A_i}\right]$. This is the expected percentage of allocations going towards the production of output for the nonprofit sector as a whole, which is consistent with the definition of efficiency discussed in Section 3.1.

Proposition 3. *Regarding sector expected efficiency,* Π*, assuming a common distribution over nonprofit types,* θ_i*, and* $0 \leq \mathbf{P} \leq \mathbf{P}^*$*:*[5]

i. $\Pi^{FB} \geq \Pi^A \geq \Pi^R$.

ii. As $\boldsymbol{\Theta}^*(\mathbf{P}) \to \mathbf{0}$, $\Pi^A \to \Pi^{FB}$ *and as* $\boldsymbol{\Theta}^*(\mathbf{P}) \to \mathbf{1}$, $\Pi^A \to \Pi^R$.

iii. Π^A *is decreasing in the cut-off type,* $\boldsymbol{\Theta}^*(\mathbf{P})$*, and increasing in the penalty,* $\mathbf{P}$.

Figure 3.2 plots the expected sector efficiency against the cut-off $\theta^*(P)$. This figure illustrates that through the choice of penalty ($0 \leq P \leq P^*$) the funder can position the efficiency of the entire sector just as Proposition 3(ii) states. In fact, the sector can be positioned anywhere between and including both the first-best and Report-Based Contract scenarios as made explicit by the equality possibilities in Proposition 3(i). Thus, the Audit-Based Contract with penalties up to the optimal penalty, P_i^*, has significant potential to improve the efficiency of the sector overall.

In review, the funder prefers the Audit-Based Contract under reasonable parameters and well-chosen penalties and can, in fact, achieve first-best performance. The nonprofit population strictly prefers the Audit-Based Contract. In particular, high efficiency type nonprofits are clearly better off by the Audit-Based Contract because they receive efficient allocations. They may want to work with funders for nonprofit sector cultural change to increase auditing, thus increasing their own utility. Through expected sector efficiency analysis, it was observed that the Audit-Based Contract also has significant potential to improve the efficiency of the nonprofit sector overall. Since funders, nonprofits, and the sector may favor auditing under appropriate conditions, auditing and efficiency increases can and may become an industry effort.

[5]For penalties $1 < P_i \leq P_i^*$, $\theta_i^*(P_i)$ *does* exist; however, it has a different close-form expression than the one presented in Lemma 2.

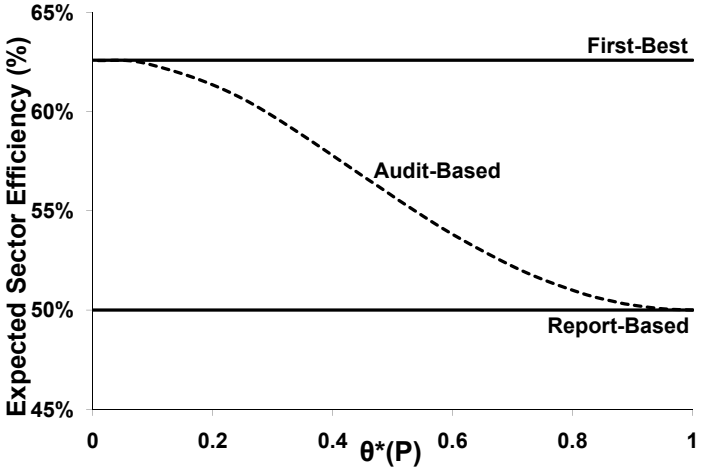


Figure 3.2: Expected Sector Efficiency: Through the choice of penalty, $0 \leq P \leq P^*$, that dictates the cut-off point, $\theta^*(P)$, funders can position the nonprofit sector as a whole anywhere between and including first-best and Report-Based Contract performance.

3.7. Extensions

In this section, we study three extensions of our original model. We first extend the results of this paper for the setting with a budget constraint in Section 3.7.1. We then analyze uncertainty in measuring output in Section 3.7.2. Finally, in Section 3.7.3, we study a setting with audit costs.

3.7.1 The Budget Constrained Case

When funders face limited budgets, strategic allocation is even more critical. As Brest and Harvey (2008), two foundation executives state, "whether you are giving away $100,000 or $1 billion a year, your funds are not unlimited, and a good strategy can multiply their impact many times over." In this section, we extend our model to incorporate a budget constraint for the funder. Now the funder must allocate her resources to maximize her utility within the contractual framework considering both the nonprofits' efficiency announcements *and* the constraint on her budget. The

funder's objective function from Equation (3.7) is updated as follows:

$$\max_{A_i(\theta_i)} U_f = \max_{A_i(\theta_i)} \left\{ \sum_{i=1}^{N} E_{\theta_i} \left[(2c_i(A_i(\theta_i)\ \theta_i)^{2/3} - \alpha A_i(\theta_i)\ ) \right] + \alpha B \right\} \tag{3.12}$$

with the constraints detailed in Equations (3.8)-(3.10) of our original model plus the additional budget constraint of

$$B - \sum_{i=1}^{N} A_i(\theta_i) \ \geq \ 0 \qquad \forall \theta_i \in [0,1] \qquad \text{(Budget)} \tag{3.13}$$

In the rest of this section, we will extend the results of this paper for the setting with a budget constraint. Note that for this extension we define a "constrained budget" as $\sum_{i=1}^{N} A_i = B$; otherwise the system effectively operates with an unlimited budget. We use superscripts FBC, RC, and AC to denote the first-best contract, the Report-Based Contract, and the Audit-Based Contract, respectively, under a constrained budget.

Report-Based Contract

The problem formulation of the Report-Based Contract follows the formulation of the problem outlined above and previously in Section 3.4 with the funder's objective function found in Equation (3.12) and constraints detailed in Equations (3.8)-(3.10) and (3.13).

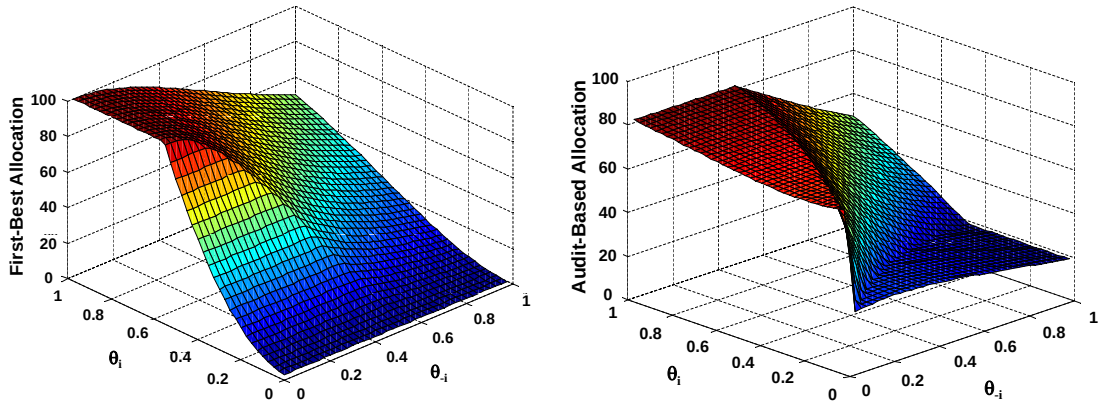
Theorem 4. *The* Report-Based Contract *under a constrained budget takes the form* $A_i^{RC}(\mathbf{\Theta}) = A_i^{RC} = \frac{B}{\Omega} c_i^3 E[{\theta_i}^{2/3}]^3$ *where* $\Omega = \sum_{i=1}^{N} c_i^3 E[{\theta_i}^{2/3}]^3$ *and* $i = 1, ..., N$.

This solution results in the same conclusions drawn from Theorem 1 where the funder is *unable* to differentiate among the nonprofits' efficiency types and bases her allocation solely on her expectation of each nonprofit's type. Thus, the Report-Based Contract still offers the funder no observability of efficiency types and no operational transparency within this contracting context.

For this budget-constrained case, we again analyze the first-best, benchmark model where efficiency types, θ_i, are *observable*, resulting in Corollary 4:

Corollary 4. *The* benchmark first-best contract *under a constrained budget takes the form* $A_i^{FBC}(\boldsymbol{\Theta}) = \frac{B}{\Gamma} c_i^3 \theta_i^2$ *where* $\Gamma = \sum_{i=1}^{N} c_i^3 \theta_i^2$ *and* $i = 1, ..., N$.

We note that the funder still allocates to all nonprofits with a non-zero efficiency ($\theta_i > 0$) based on their efficiency types. Notice also that under a constrained budget, the allocation is dependent upon the efficiency types of *all* nonprofits. Therefore, each nonprofit introduces an externality to the others by his efficiency type, which can be observed in Figure 3.3(a) for the budget-constrained first-best allocation of nonprofit i with $N = 2$ nonprofits. Since the two nonprofits in this figure share the funder's tight budget, note that the first-best allocation to nonprofit i decreases as the other nonprofit's type, θ_{-i}, increases.



(a) First-Best Allocation (b) Audit Allocation with $P_i = 0.75$

Figure 3.3: Budget Constrained Allocations: These allocations illustrate the externality introduced by the other nonprofit $(-i)$ to nonprofit i's allocation when there are two nonprofits both with efficiency types $\theta_i \sim U[0, 1]$, $c_i = 5$, $\alpha = 1$, and $B = 100$. Note that the Report-Based allocation is constant and, therefore, not illustrated here.

Audit-Based Contracts

The auditing scenario remains consistent with Section 3.5 with the updated funder objective function of Equation (3.12) and constraints found in Equations (3.8), (3.10), (3.11), and (3.13). In exploring audit contracts under a budget constraint, the discussion runs parallel to Section 3.5. As such, an enforcing penalty analogous with

Lemma 1 is outlined in Lemma 3:

Lemma 3. *Under a constrained budget, there exists a penalty, P_i^{C*}, that enforces incentive compatibility for all possible efficiency types of nonprofit i under a constrained budget using first-best allocations such that $P_i^{C*} \leq \tilde{P}_i$ where $\tilde{P}_i = 1 + \frac{3\left(\sum_{j=1}^{N} c_j^3\right)^{1/3}}{2c_i B^{1/3}}$.*

The optimal contract displayed in Theorem 2 itself does not change apart from its components as detailed in Corollary 4 and Lemma 3. Thus, the interpretation and conclusions in Section 3.5 still continue to hold. However, budget certainly has a profound effect on funding scenarios and decisions. The sheer number of nonprofits applying for grants, let alone monetary awards, can constrain a funder's budget. Following from Lemma 3, we can make the following observations with respect to nonprofit characteristics and the funder's budget.

Corollary 5. *The following are true for the incentive compatibility enforcing penalty, P_i^{C*}:*

i. $P_i^{C*} > 1$.

ii. As budget, B, decreases, the penalty, P_i^{C*}, increases.

iii. As the number of nonprofits, N, goes to infinity, so does the constrained penalty, P_i^{C*}.

Just as in Corollary 2(i), Corollary 5(i) indicates that all nonprofits must be over-penalized in order to enforce incentive compatibility for all types, implying that each nonprofit will need to repay *more than* what was originally granted to them in the event that they misreport. The penalty intuitively decreases in B (Corollary 5(ii)). When the funder has limited resources and her budget is tight, she needs to manage her money more effectively, which dictates a higher penalty. Such a scenario results, for example, when the number of nonprofits is large (Corollary 5(iii)).

Analogous to Lemma 2, Lemma 4 below gives the cut-off efficiency type, $\theta_i^{C*}(P_i)$, for the budget-constrained case:

Lemma 4. *Given a penalty* $\mathbf{0} < \mathbf{P} \leq \mathbf{1}$*, the cut-off efficiency type,* $\mathbf{\Theta^{C*}(P)}$*, under a constrained budget is as follows:*

$$\mathbf{\Theta^{C*}(P)} = \left\{ \theta_1, ..., \theta_N \left| \frac{Bc_i^3 {\theta_i}^2}{\Lambda} + \frac{3B^{2/3}c_i^2 {\theta_i}^2}{2\Lambda^{2/3}} = \frac{Bc_i^3 (1 - P_i)}{c_i^3 + Y_i} + \frac{3c_i^2 B^{2/3} {\theta_i}^{2/3}}{2 \left(c_i^3 + Y_i\right)^{2/3}} \right. \right\}$$

where $\Lambda = \sum_{i=1}^{N} c_i^3 \max\left\{\theta_i, \theta_i^*(P_i)\right\}^2$ *and* $Y_i = \sum_{j \neq i} c_j^3 \max\left\{\theta_j, \theta_j^*(P_j)\right\}^2$.

The Audit-Based Contracts displayed in Theorems 2 and 3 can be extended to the budget-constrained case by replacing their components with $A_i^{FBC}\left(\max\left\{\mathbf{\Theta}, \mathbf{\Theta^{C*}(P)}\right\}\right)$ from Corollary 4 and Lemmas 3 and 4, respectively, where max is taken component-wise. Similar to its counterpart in the unconstrained case, the cut-off type in Lemma 4 is still decreasing in penalty, P_i. As with both the first-best and optimal Audit-Based Contract allocations, the other nonprofits' types introduce an externality to nonprofit i brought to bear in $\theta_i^*(P_i)$. This externality is illustrated in Figure 3.4.

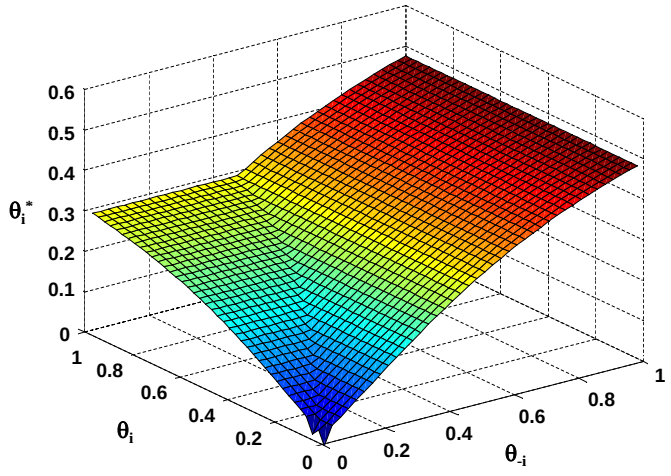


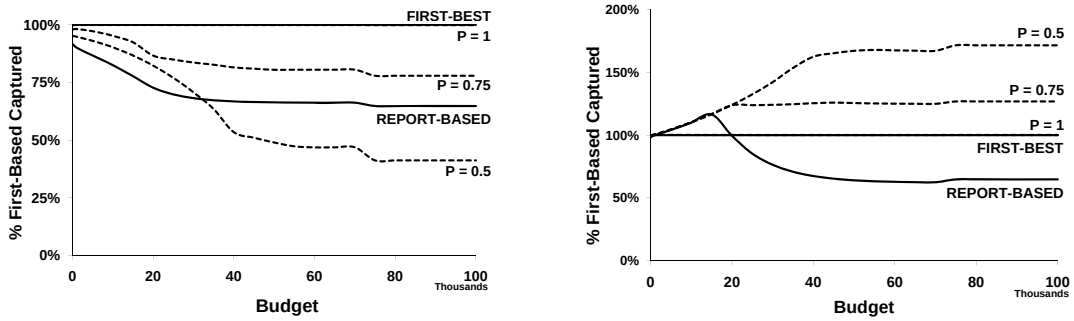
Figure 3.4: Budget-Constrained Cut-off, $\theta_i^{C*}(P_i)$: An externality is imposed within $\theta_i^{C*}(P_i)$ by the other nonprofits' efficiency types. This is illustrated here for two nonprofits $(i, -i)$ with types $\theta_i \sim U[0, 1]$, $c_i = 5$, $\alpha = 1$, $P_i = 0.75$, and $B = 100$.

Effect of Contract Types on Performance

Analogous to Section 3.6, we use numerical examples to illustrate the effect of each contract on the funder, the nonprofits and the nonprofit sector overall. We make

the same restrictions for numerical examples: we look at a symmetric population of nonprofits with efficiency types the funder believes are uniformly distributed, $\theta_i \sim U[0,1]$, $c_i = c$, and $P_i = P$ for all i.[6] All results are in expectation, and thus, the results labeled as "nonprofit" are indeed the results for the *population* of nonprofits. We focus on the Audit-Based Contract, since the optimal contract always achieves first-best. Figure 3.5 below includes both the budget-constrained and unconstrained cases, while Figure 3.1 of Section 3.6 was restricted to only unconstrained cases.

Figure 3.5 shows that all our observations for the funder and the nonprofits from Section 3.6 continue to hold when the budget is constrained. We further observe that a tight budget improves the performance of both the Report-Based and the Audit-Based Contracts. Even the first-best does not have much room to distribute a tight budget effectively; hence, all contracts perform similarly. As the budget increases, we observe that the performances of the contracts start to diverge. In particular, the performance of the Report-Based Contract significantly deteriorates. Hence, the value of the Audit-Based Contract increases as the budget increases.



(a) Funder (b) Nonprofits

Figure 3.5: Percentage of Expected First-Best Captured under *Constrained Budget*: Shows the percentage of first-best (benchmark) utility captured by each contract when the budget is constrained with $c = 25$ and $\alpha = 1$. The Audit-Based Contract is indicated by dashed lines while the solid lines show the Report-Based Contract and the first-best contract.

[6] Analogous to the unconstrained case, the results remain unchanged for heterogeneous nonprofits, i.e., $c_i \neq c_{-i}$, $P_i \neq P_{-i}$, and varying type spaces. For interested readers, such analysis is available from the authors.

All in all, incorporating a budget constraint into the basic model is relatively straightforward, though more computationally demanding. Though we find that the Audit-Based Contract is most beneficial in the unconstrained budget cases, the intuitions gained in this analysis can help even smaller funders to best understand their contractual options.

3.7.2 Uncertainty in Production

The assumption that nonprofit production, that is, nonprofit output or outcome, can be measured unambiguously may be unrealistic in some situations, especially given the discussion in Sections 4.3 and 3.3 concerning the challenges of outcome measurement and evaluation in the nonprofit sector. This assumption is now relaxed through the following updated production function:

$$y_i = 2\xi_i\sqrt{e_i\theta_i A_i} \qquad \text{(Uncertain Nonprofit Output Production)} \quad (3.14)$$

where ξ_i is a random variable with support $(0,\infty)$. This random variable ξ_i can be interpreted as an unmeasurable portion of the production, more specifically random variation in the production process, random variation or error in the accuracy of output measurement, or a combination of these. Under this new model, the updated model equations are as follows:

$$\begin{aligned} u_i^* &= A_i - \frac{1}{2}(A_i\theta_i)^{2/3}E_{\xi_i}[\xi_i]^{1/3}\left(E_{\xi_i}[\xi_i] - 4\xi_i\right), && \text{(Nonprofit Utility)} \\ y_i^* &= 2(A_i\theta_i)^{2/3}E_{\xi_i}\left[\xi_i\right]^{1/3}\xi_i, && \text{(Nonprofit Output)} \\ U_f &= \sum_{i=1}^{N} E_{\theta_i,\xi_i}\left[2c_i\xi_i(A_i\theta_i)^{2/3}E_{\xi_i}\left[\xi_i\right]^{1/3} - \alpha A_i\right] && \text{(Funder Utility)} \end{aligned}$$

where each nonprofit i has maximized his *expected* utility. The following propositions result from analysis similar to that which led to the theorems and corollaries of Sections 3.4 and 3.5:

Proposition 4. *Under uncertain production, the* Report-Based Contract *takes the form* $\widetilde{A_i^R}(\theta_i) = \widetilde{A_i^R} = \frac{64}{27}{\phi_i}^3 E_{\xi_i}[\xi_i]E_{\theta_i,\xi_i}[\xi_i{\theta_i}^{2/3}]^3$ *where the uncertainty in production is*

defined by Equation (3.14), $\phi_i = c_i/\alpha$, *and* $i = 1, ..., N$.

It is straightforward to show that when production is uncertain for N nonprofits each with an observable efficiency type, the first-best contract takes the form $\widetilde{A_i^{FB}}(\theta_i) = E_{\xi_i}[\xi_i]^4 A_i^{FB}(\theta_i)$ for nonprofit i where the uncertainty in production is again defined by Equation (3.14) and $i = 1, ..., N$. Thus, in key components of the Report-Based Contract from Section 3.4, the uncertainty of production is inconsequential. The same holds for the Audit-Based Contract of Section 3.5. Specifically, the optimal penalty, P_i^*, and cut-off type, $\theta_i^*(P_i)$ for a given P_i, are unchanged; only the allocations change according to the first-best allocations detailed above. Ergo, these components follow from previous analysis as detailed in Proposition 5 below.

Proposition 5. *For nonprofit* i *under uncertain production, the minimum penalty that enforces incentive compatibility for all possible efficiency types,* P_i^*, *and the cut-off efficiency type,* $\theta_i^*(P_i)$, *for a given penalty* $0 < P_i \leq 1$ *are unchanged from their definitions in Lemmas 1 and 2.*

In summary, extending the basic model from Section 3.3 to incorporate uncertainty in production does not significantly change our results. Overall, the conclusions drawn from the analysis of the basic model and its resulting contracts are robust to this extension.

3.7.3 Auditing Costs

As briefly mentioned in Section 3.3, an auditing cost is not included in the funder's objective function formulation because there are several situations where this would not be appropriate. For example, nonprofits may choose to self-audit using a credible third-party auditor. Also, funders may not have specific auditing costs or may have auditing costs and budgets separate from the contracts themselves. In this extension section, however, we explore the impact of including the cost of auditing in the funder's objective function.

It can first be noted that such an inclusion does not affect the Report-Based or first-best contracts from Section 3.4 because these assume no auditing. For the

Audit-Based Contracts from Section 3.5, the funder's utility function can be updated to include auditing costs as follows:

$$U_f = \sum_{i=1}^{N} E_{\theta_i}\left[c_i y_i - \alpha A_i - \gamma I_i^A\right] = \sum_{i=1}^{N} E_{\theta_i}\left[2c_i(A_i\theta_i)^{2/3} - \alpha A_i - \gamma I_i^A\right] \tag{3.15}$$

In this formulation, the cost of auditing an individual nonprofit is γ. Since the funder may not choose or need to audit all nonprofits, I_i^A is the indicator function of auditing nonprofit i. While this formulation does not affect the form of the first-best allocations, it does affect the funder's choices of which nonprofits to fund and which nonprofits to audit.

Note that the optimal Audit-Based Contract detailed in Theorem 2 is no longer optimal when there is an auditing cost, as discussed later in this section. However, if the funder is committed to auditing *all* nonprofits that she funds, a similar contract can be characterized as follows:

Proposition 6. *With auditing costs of* $\gamma > 0$*, the* Audit-Based Contract

$$(P_i^*, A_i(\theta_i)) = \begin{cases} \left(\overline{P_i^*}, A_i^{FB}(\theta_i)\right) & \text{for } \theta_i \geq \overline{\theta_i} \\ \left(\overline{P_i^*}, 0\right) & \text{otherwise} \end{cases}$$

achieves complete transparency where $\overline{P_i^*} = 1 + \frac{9}{8\phi_i}$, $\overline{\theta_i} = \sqrt{\frac{27}{32}\frac{\alpha^2}{c_i^3}\gamma}$, $\phi_i = c_i/\alpha$, *and* $A_i^{FB}(\theta_i)$ *is defined by Corollary 1.*

Thus, the funder will only offer the optimal contract to certain efficiency types, namely high efficiency types that satisfy $\theta_i \geq \overline{\theta_i}$, so that types below this receive no allocation. However, the higher penalty, $\overline{P_i^*} > P_i^*$, ensures that *all* types will still remain incentive compatible, even those with zero allocation. As such, this contract enables complete transparency, but potentially at a high cost since all nonprofits are audited. Alternatively, the funder may choose not to audit some of the nonprofits that she funds and use a contract corresponding to the Audit-Based Contract detailed in Theorem 3 where only the high efficiency type nonprofits must be audited. Consequently, this revised Audit-Based Contract is as follows:

Proposition 7. *With auditing costs of $\gamma > 0$, there exists a $\tilde{\theta}_i$ such that the* Audit-Based Contract *with a funder specified penalty, $0 < P_i \leq 1$, takes the form*

$$\left(\overline{P_i^A}, \overline{A_i^A}(\theta_i)\right) = \begin{cases} \left(P_i, A_i^{FB}(\tilde{\theta}_i)\right) & \text{for } \theta_i < \max\left\{\theta_i^*(P_i), \overline{\theta}_i\right\} \\ \left(P_i, A_i^{FB}(\theta_i)\right) & \text{otherwise} \end{cases}$$

where $\tilde{\theta}_i \in \left[\theta_i^*(P_i), \overline{\theta}_i\right]$ if $\theta_i^*(P_i) < \overline{\theta}_i$ and $\tilde{\theta}_i = \theta_i^*(P_i)$ otherwise, $\theta_i^*(P_i)$ is defined by Lemma 2, $\overline{\theta}_i$ by Proposition 6, and $A_i^{FB}(\theta_i)$ by Corollary 1.

It still remains that the funder is dedicated to funding low efficiency type nonprofits in this contract. They do not present any additional costs of auditing, but instead only the cost of their inefficiency manifest as reduced output. The main differences between the settings with and without audit costs are due to the constant payment and the cut-off type. If the audit cost is low, then $\theta_i^*(P_i)$ would most likely be higher than $\overline{\theta}_i$, and the two settings are equivalent. However, if the audit cost is high, i.e., $\theta_i^*(P_i) < \overline{\theta}_i$, then the funder needs to increase the cut-off type to $\overline{\theta}_i$ and consequently the constant allocation to guarantee incentive compatibility for moderate efficiency types, i.e., the types she prefers to award first-best allocation but cannot due to the audit cost. Once again, if the audit cost is high, there may be unfavorable situations where the funder gives a high constant allocation under this contract, which would decrease the performance and transparency of the contract.

In the presence of auditing costs, identifying the optimal penalty is not as straightforward as in the case of Section 3.5 where there are no such costs. However, one can use Propositions 6 and 7 to search over possible penalty values for the value that yields the highest funder utility. For example, when $c_i = 2$, $\alpha = 1$, and $\gamma = 1$, the funder would prefer a penalty of 0.9750. Notice that this penalty is strictly less than one, indicating that granting allocations to all types and only auditing some (Proposition 7) is better than granting allocations to some types and auditing all (Proposition 6). Many different reasons may motivate a funder to select specific penalty values as discussed in Section 3.5, including such consideration of auditing costs.

As evident in Propositions 6 and 7, for both the optimal and audit contracts, the funder's decision of whether to fund (offer the contract to) each nonprofit hinges on

the cost of auditing, γ, relative to the value presented to the funder by the nonprofit's output, c_i. The more highly valued the nonprofit output, the more likely the nonprofit is to be funded. As expected, the performance of the Audit-Based Contract deteriorates as the audit cost increases relative to the value that the funder can generate. When the audit cost is too high, simply relying on reports of nonprofit efficiency, i.e., the Report-Based Contract, may be a better approach for the funder.

3.8. Discussion and Conclusion

To conclude, our analysis has revealed that common report-based funding methods do not facilitate efficient allocation of funds as they do not result in operational transparency in nonprofits nor resolve the asymmetric information. Audit-based contracts with sensibly chosen parameters, on the other hand, can achieve both performance and transparency comparable to the first-best. Furthermore, both the nonprofit population and the sector overall benefit from auditing. Therefore, it may not be surprising to see auditing on the rise within the sector, especially in the wake of the Sarbanes-Oxley Act. The California Nonprofit Integrity Act of 2004 requires independent audits for large nonprofits (California Government Code 2007). In their "Principles for Good Governance and Ethical Practice: A Guide for Charities and Foundations," The Panel on the Nonprofit Sector (2007) recommends nonprofits to have independent audits. Furthermore, organizations like Independent Sector and Board Source are recommending nonprofits to self-audit, self-regulate, and take proactive actions to sustain trust and confidence (BoardSource and Independent Sector 2006).

Indeed, our conclusions regarding both funder and nonprofit preference for auditing not only uncover funders' potential position as change agents in the nonprofit sector, but also indicate a potential for collaboration to change nonprofit culture from merely heavy reporting to efficient monitoring. Such a culture change will increase the use of auditing, transparency, and, thus, efficiency for the sector overall. Carman's (2009) recent empirical findings support what we find theoretically, suggesting that "funders might [...] be able to change the way they make funding decisions [...] by explicitly using evaluation and performance information to make funding decisions."

We do not make any restrictions regarding the funders or nonprofits that we target in this work; however, our models and results would be most applicable and beneficial to large funding organizations. Such funders have both the power and means to initiate change both in the nonprofits they fund and the sector overall. Furthermore, as our results show, these types of funders have the most to gain by moving from their current funding methods to emerging strategies, such as auditing. Where funders engage with a potentially growing and changing pool of nonprofits, requiring them to constantly learn more about the organizations they fund, our model should prove most effective. Regarding the nonprofits funded, our model does not discriminate; it is suitable for both nascent and more established nonprofits. Our paper is thus very complementary with current research in operations management on the subjects of emergency relief and humanitarian logistics, where recent work focuses on efficiency and performance measurement (Beamon and Balcik 2008; Van der Laan, De Brito, and Vergunst 2009). For funding decisions in this area, auditing would be an additional step of monitoring with compelling benefits.

Our analysis has several limitations. First, it is limited to theoretical and numerical analysis. The nature of contracting makes it difficult to obtain data, especially on nonprofit true efficiencies in the midst of their reports. This underscores the incentives necessary in the contracts to obtain truthful data. As such, empirically establishing the impact of these contracts would be very difficult. However, data could still be useful in providing insights and enhancing numerical analysis. Also, while we used the most common definition and measure of efficiency in the nonprofit sector, this is a recognized limitation. A different measure of operational efficiency, such as outcome per unit of funds, could be insightful. While such outcome measures might be more difficult to quantify in some contexts, when properly implemented, they are indeed true operational measures. Auditing by no means is limited to the efficiency definition used in this paper as other operational efficiencies can also be monitored through auditing.

Both our basic model and contracting approach can be extended for further understanding of the funder-nonprofit relationship and the nonprofit sector overall. Extensions to the basic model can generate insight into the impact of different operations

strategies on our results. One example is the inclusion of multiple funders. This inclusion will result in a common agency problem where multiple principals (funders) share a common pool of agents (nonprofits). Such a model will further understanding of the dynamics between nonprofits and how they can collectively benefit from auditing as an industry practice. A simplified version of this idea would be to include additional funding sources into the nonprofit's utility and production functions, that is, A_i would consist of both the modeled funder's allocation to nonprofit i *and* other funding allocations from unmodeled funders. Even this simplified version can help in understanding the externalities that funders pose to one another as well as nonprofits' reactions.

Another line of potential investigation also follows from the assumptions of the basic model. Here the basic model assumes that inefficiency (i.e., the percentage of funds not going directly to mission as defined by $1-\theta$) is disadvantageous and useless. Perhaps at least part of this "inefficiency" goes toward capacity planning or other measures to enhance the effectiveness of nonprofit efforts, ultimately resulting in more fruitful effort. Consider a humanitarian disaster relief organization where production may be measured in human lives saved. While some portion of funding goes directly toward relief efforts ($\theta_i A_i$), the remaining portion of funds ($(1-\theta_i)A_i$) are not necessarily squandered. Such remaining funds could be invested in building preparedness through IT systems, pre-positioned stockpiles, contract arrangements, or training. As a consequence, the humanitarian organization could enhance its effectiveness, that is, enhance the yield of its efforts when a disaster actually hits. This could be modeled by modifying the production function from Equation (3.2) to be a function of allocation, efficiency, and some function of effort and "inefficiency" $(1-\theta_i)$. The ensuing updated results will shed light on the value of "inefficiency" in nonprofit production, especially as compared with the results presented here. As a simple demonstration, consider the production function modified with a multiplicative, decreasing "inefficiency" function, $h(\theta_i)$: $y = 2\sqrt{h(\theta_i)e_i\theta_i A_i}$ where $h(\theta_i) \geq 0$ and $h'(\theta_i) \leq 0$. So, in the case of the humanitarian organization, the more money set aside for infrastructure or preparedness, the higher the yield on effort. The main results of this research hold when $h(\theta_i) + \theta_i h'(\theta_i) \geq 0$, which ensures that the production function

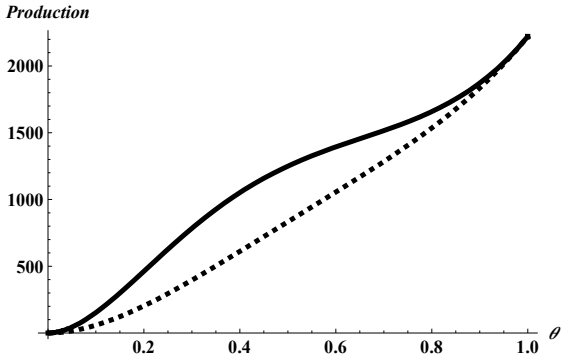


Figure 3.6: Production Functions: Original and Modified with Inefficiency: The original (Equation (3.2)) and modified production function are displayed as dashed and solid lines, respectively. In the modified function, inefficiency increases the contribution of effort to production. The first-best is illustrated here with $h(\theta) = 1 + 2(1-\theta)^2$, $\alpha = 1$, and $c = 25$.

is increasing in efficiency, θ_i. Figure 3.6 displays both the original production function from Equation (3.2) and the modified production function $y = 2\sqrt{h(\theta_i)e_i\theta_i A_i}$ with $h(\theta) = 1 + 2(1-\theta)^2$. It can be observed that the nonprofit's "inefficiency" gives it a visible bump by increasing the yield of effort. Both of these directions can provide insight into fundraising marketplace dynamics, the implications of funding heterogeneity, and associated costs for nonprofits.

Extensions from the contracting perspective can provide other solutions to the reliability issues explored here. One such extension is the use of long-term or multi-year contracts. Although not commonplace in nonprofit funding, the use of a long-term contract may enable the funder to more precisely develop beliefs about the nonprofits' efficiency types as well as incentivize the nonprofits through future allocations. Issues such as commitment, renegotiation, and breach of contract will need to be considered when analyzing these contracts. The current economic downturn provides new opportunities to evaluate inefficiency in the nonprofit sector. However, proper consideration should be given to the additional stresses these contracts may impose on already financially burdened nonprofits. Another potential extension is the use of signaling. Perhaps the nonprofit proposal can be a signal of the nonprofit's type,

enabling the funder to have more precise beliefs about the efficiency type of the nonprofit. A signaling game is a bit of a diversion from the line of contractual analysis studied here, but it may prove productive. Yet a third potential extension is the evaluation of reputation impacts and efficiency announcements with a dynamic model. Along with long-term contracts, this extension would be fruitful in shedding light on sector dynamics.

The metaphor of a nonprofit as a "seller" of services to a funder (Brest and Harvey 2008) captures much about their relationship and lends naturally to viewing grant agreements as contracts: funders have goals and contract with nonprofits to perform the activities necessary to, in part, achieve these goals. As such, our nonprofit problem and a more traditional operations management problem are not so distant. Corporations manufacture products and services, and nonprofits produce outputs and outcomes; operations management has a crucial role in both settings. A proper appreciation for the difficulty that nonprofits face in providing socially important services combined with sound understanding of operations management techniques provides excellent opportunities for cross-sector learnings. Possibilities abound for research in areas involving and benefiting nonprofit organizations. This study of efficient funding is just one of these many prospects.

Acknowledgements

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Chapter 4

Operations Management in Public Health: An Introduction

4.1. Introduction

The United States public health system is comprised of 3,000 local health departments (LHDs), which are the governmental, local public health presence. Over the course of history, public health has been the critical force in major health achievements in the United States, such as vaccinations against childhood diseases, decreased automobile fatalities, and fluoridated drinking water (Perez and Larkin 2009). The United States also depends on its public health departments for delivery of critical services at the local level everyday. In fact, it is the LHDs that assume primary responsibility for most localized public health activities rather than the state or federal public health presence (DeFriese *et al.* 1981; Mays and Smith 2009). Consequently, federal and state resources for public health are passed onto LHDs. Each LHD is responsible for coordinating all public health activities using a mix of federal, state, and local revenue sources. The National Association of City & County Health Officials (NACCHO) outlines ten essential public health services for local health departments, detailed in Table 4.1, as an effort to set standard expectations (NACCHO 2009). These ten essential services breakdown into myriad separate activities and services that can be grouped into the following categories (NACCHO 2009): immunization services,

1.	Monitor health status to identify and solve community health problems.
2.	Diagnose and investigate health problems and health hazards in the community.
3.	Inform, educate, and empower people about health issues.
4.	Mobilize community partnerships and action to identify and solve health problems.
5.	Develop policies and plans that support individual and community health efforts.
6.	Enforce laws and regulations that protect health and ensure safety.
7.	Link people to needed personal health services and assure the provision of health care when otherwise unavailable.
8.	Assure competent public and personal health care workforce.
9.	Evaluate effectiveness, accessibility, and quality of personal and population-based health services.
10.	Research for new insights and innovative solutions to health problems.

Table 4.1: Local Health Department 10 Essential Services
(Source: NACCHO 2009)

screening for diseases and conditions, treatment for communicable diseases, maternal and child health services, population-based primary prevention services, surveillance and epidemiology, environmental health, regulation, inspection, and licensing, and other activities.

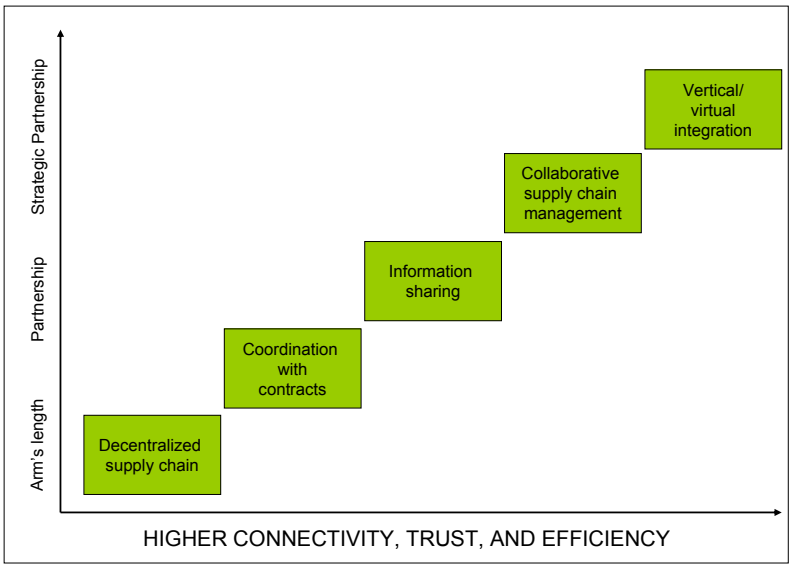
Ominous new health threats have been a mainstay of headlines in this decade, from Hurricane Katrina to the H1N1 pandemic to childhood obesity. In fact, the Organization for Economic Cooperation and Development (2007) suggests that the next generation of Americans may be the first in history with health worse than their parents. Stirring the pot of such health woes, the United States spends twice as much money compared to every other nation (Perez and Larkin 2009). All of this has brought renewed concern to issues surrounding the United States' public health system, particularly gaps in the availability and quality of public health services (Scutchfield, Mays, and Lurie 2009).

Fortunately, such concerns have met response and financial support. The federal government has continued to invest new funds to support public health activities since 2001, particularly emergency preparation and response (Trust for America's Health 2006; Scutchfield, Mays, and Lurie 2009). Furthermore, public health programs were allocated $1 billion in President Obama's stimulus package (Perez and Larkin 2009).

Given such somber and legitimate concern over the future and equity of our country's health and support from government funds to inspire solutions through research, it is certainly time for academics to contribute their expertise to this worthy cause. Public health systems research offers a unique place for contribution from operations research and management science. Public health systems research has most recently been defined as "a field of study that examines the organization, financing, and delivery of public health services within communities, and the impact of these services on public health" as well as "a multidisciplinary field of study that recognizes and investigates system-level properties and outcomes that result from the dynamic interactions among various components of the public health system and how those interactions affect organizations, communities, environments, and population health status" (Scutchfield 2009). Perez and Larkin (2009) implore that the central concern of public health systems research is investigating efficient and effective ways of organizing and managing programs and systems to promote positive changes, whether that be health outcomes or system improvements. Given such a definition, it is clear that the systems-minded research of our field is invaluable to the cause and area of public health systems research.

As Perez and Larkin (2009) of the Robert Wood Johnson Foundation note in their recent call to research, the area of public health systems research is one with abundant opportunity for good scholarship. Especially as political interest mounts, the public health system asks – and researchers must answer – "How do we move toward a system that supports health where we live, where we learn, where we work, and where we play, and that makes it easier for everyone to make healthier choices?" (Perez and Larkin 2009). Operations research and management science have a place in finding such answers.

Collaboration is an essential part of this public health system. "You can't do public health without collaboration," one public health worker commented, "Everything we do is a collaboration" (Schultz 2010). As illustrated in Figure 4.1 from Erhun and Keskinocak (2007), collaboration can take on many forms and embodies the level of centralization within a system. Centralization itself represents the most extreme form of collaboration where different entities are totally vertically integrated.



Source: Erhun and Keskinocak (2007)

Figure 4.1: Supply Chain Collaboration Spectrum

Related to the idea of centralization of the public health system, there are two institutional characteristics on which previous research has focused. First is a local board of health, which has local authority over local public health decision making. Such local boards of health are frequently composed of community members with "political access, professional credibility, and/or technical expertise that can be used to attract and maintain resources (Mays *et al.* 2004a, 2004b, 2006)," and as such are able to garner public and political support for the local health departments (Mays and Smith 2009). Second is the degree of decision making centralization at the state level, which is the degree of control the state level government (as opposed to the local government) exerts in local health contexts across the state. Centralized state decision making facilitates the traditional benefits of system centralization, such as economies of scale and resource coordination across agencies. However, decentralized decision making is hypothesized to facilitate informed and responsive resource decisions that more closely meet local needs. Such a decentralized system is congruent with the existence of a local board of health to make such local resource decisions. Mays and Smith (2009) find such decentralized structures to be associated with higher

expenditures, larger expenditure increases over time, and more resilience to expenditure reductions – findings consistent with those associated with local boards of health. The authors conclude that "policies to develop and support local governing and administrative bodies may be effective in expanding public health capacity" (Mays and Smith 2009). In fact, operations researchers have begun to explore such settings that may exhibit a preference for *de*centralization, such as Harrington and Chang (2000) who find value for *de*centralization in the presence of sufficient market diversity. This may well be the case for local health departments serving such a variety of community population-based health needs.

Our research, however, takes the local communities to be the system of interest, where local health departments exist and serve. Collaborative relationships form links where information, expertise, resources, and risk can flow within a community. This connectivity ultimately helps local health departments serve their communities, and, as Figure 4.1 implies, such collaborations have the potential to increase the efficiency of local public health delivery and revenues, which is the goal of this research.

4.2. Research Agenda and Conceptual Framework

Local public health departments do not exist in isolation, but are imbedded in communities of potential partners. Chapter 2 of this dissertation speaks to collaboration across such communities, where entities such as local health departments "must see themselves embedded within communities of potential collaborators, creating a network of resources, information and beneficiaries where collaboration decisions become strategic production and operations decisions." At a high-level, the agenda for this research consists of three parts as detailed in Figure 4.2. Each part employs data from the National Association for City and County Health Officials (NACCHO) 2005 and 2008 National Profile of Local Health Departments Surveys for analysis.

Chapter 5 summarizes the "Description" phase of this research, which draws an empirical portrait of local health department revenues (expenditure as proxy) and collaboration, critically surveying how these factors changed between 2005 and 2008

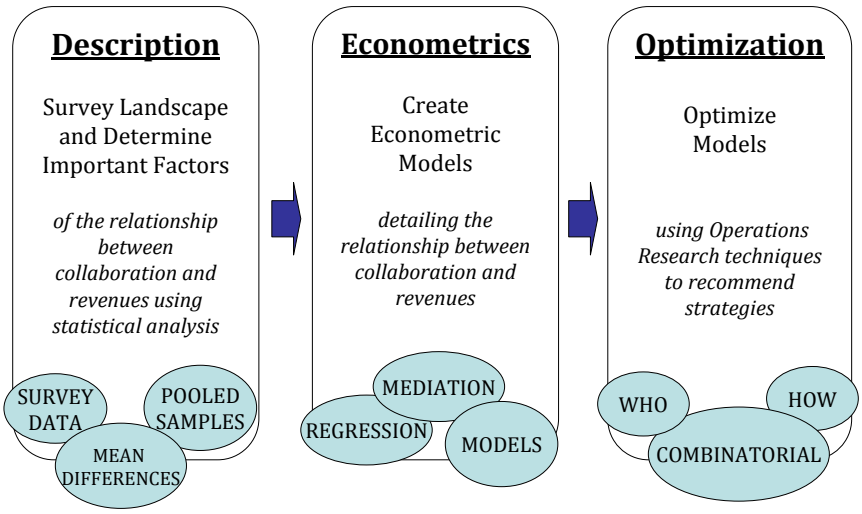


Figure 4.2: Methodology and Road-Map:
A Cross-Disciplinary Approach to Describe, Model, and Optimize

and motivating additional research to investigate potential relationships. The results of this chapter are based on summary statistics and mean difference testing. In this chapter we find that while expenditure per capita rose between 2005 and 2008, changes in the collaboration landscape were only captured through analysis by partners, activities, and partner-activity combinations. Similarly, analysis by combinations revealed heterogeneous associations with expenditure per capita, which serves as a proxy for revenue. Thus, we conclude that just as scholars must expand their concept of collaboration to incorporate setting, partners, activities, and combinations of these, practitioners must also ask "Who," "With whom," and "How?" when approaching their own collaboration portfolios. Ultimately, such research and practice focused on strategic collaboration may well help local health departments to leverage additional resources and better meet the needs of their communities.

The second phase is "Econometrics," Chapter 6, where the conclusions from the "Description" phase are used to inform the development of a variety of econometric models that explore the relationship between collaboration and revenues. The goal of this study is to offer guidance on how local health departments should collaborate strategically, specifically how many partners, which partners, and which activities,

based upon quantitative evaluation of the relationship between revenues and collaboration. Robust multiple linear regressions are performed on multiple models where each incorporates collaboration in different ways. We find the relationship between revenue (expenditure per capita) and collaboration to be significant and varies by urbanization. Just as collaboration is multifaceted so is this relationship across different models of collaboration, including the total number of partnerships, number of partners by activity, and specific partners. Thus, such diverse relationships between revenue and collaboration models suggest that strategic management of local health department collaboration portfolios is not straightforward but of the upmost importance. We conclude that such strategic collaboration is possible, particularly for the goal of revenue generation.

The final, future phase is "Optimization" where the econometric models are optimized to generate collaboration recommendations for local health departments. This is further discussed in Chapter 7, which concludes this section of research focused on public health and looks ahead to future directions.

4.3. Literature Review

Several bodies of literature are related with this research, most broadly collaboration and public health research. This section provides a review of relevant literature in each of these areas, including public health, operations management, and nonprofit organizations research. Our research contributes in these areas individually, apart from its contribution inherent in spanning and connecting these relatively disparate research bodies. A more detailed discussion of our contribution then concludes this chapter.

4.3.1 Public Health

Public health systems and services research (PHSSR) is a developing research field recently experiencing an infusion of funding and early research as concerns about health care continue to increase. (See www.publichealthsystems.org or www.rwjf.org/

publichealth.) Scutchfield, Mays, and Lurie (2009) provide a comprehensive review of the history, achievements, and current state of the field. Perez and Larkin of the Robert Wood Johnson Foundation provide a commentary on the development of research as well as the involvement and support of the Robert Wood Johnson Foundation. In reminding readers that America is comparatively spending twice as much on health care, they state that the future is leaning on the public health system. They urge researchers that "good scholarship can be brought to bear on how best to organize, manage, finance, and administer public health systems and services. ... Finding out how to organize and manage programs that promote those changes, in an efficient and effective manner, is a central concern of PHSSR" (Perez and Larkin 2009).

Our research fits in the field of public health systems research in understanding how to organize and manage collaboration in an effective manner, mainly for revenue generation. Thus, public health literature relating to collaboration and finance are relevant.

Operations Management. Research at the intersection of health and operations management began very early. In 1968, Packer explored ideas for implementing operations management in community health systems. Tingley and Liebman (1984) use linear goal programming to allocate funds within the USDA's Supplemental Food Program for Women, Infants and Children (WIC). More recent examples include Zaric and Brandeau (2001, 2007), who use an optimization framework to analyze resource allocation in HIV prevention with the goal of shaping policy to provide the greatest health benefit.

Finance. Public health finance lies at the intersection of several fields: health economics, finance, health services research, and prevention effectiveness (Honoré and Amy 2007). Research in this specialized field, though, is still relatively nascent.

Using the NACCHO 1992/1993 survey, Gordon, Gerzoff, and Richards (1997) examine the relationship between local health department expenditures and department characteristics. They find that local health departments studied spend on average

$26 per capita annually, or less than a dime a day. Furthermore, 70% of expenditure variability is explained by a nonlinear relationship with population size within the jurisdiction. However, they also find a broad range of spending levels even among similarly sized jurisdictions. Mays *et al.* (2004) examine the relationship between public heath spending at the local, state, and federal levels and essential public health service performance. They find that the strategy of improving of performance through increased expenditure shows to be ineffective as significant increases in spending are necessary to even modestly improve performance. The authors caution, however, that their data and results may not be representative of the national system as data were from 315 self-selected local public health departments; instead it is recommended to take their results as exploratory. Smith *et al.* (2007) look at a case study in Georgia public health and that the practice of public health is primarily driven by finance rather than need or strategy. There was agreement among all participants in their case study that need, effectiveness, and strategy were ideal drivers, but this was in stark contrast to the data suggesting finance as the driver.

Bernet (2007) uses cross-sectional data from Missouri local public health agencies finding that more federal and state funds lead to more funds raised at the local level. This is contrary to the wide-held belief that increases in one source of funding will decrease others. These federal funds are allocated among state and local health departments using a mix of both formulaic and competitive methods. Buehler and Holtgrave (2007) look at four programs to highlight formula-based allocation methods within public health. These formulaic strategies attempt to balance "potentially competing interests," but often do not appropriately consider regional resource differences and changes in needs, growth rates, or health trends. Levi, Juliano, and Richardson (2007) look at variation and instability in federal and state financing of public health. At the federal level the authors find that "core" public health functions have experienced funding decreases, while the state level is characterized by variation. The consequence appears to be a large variation in public health capacities and capabilities across the country, which the authors argue is creating vulnerability and national threat. Mays and Smith (2009) study local public health department spending variation across communities and over time with the goal of identifying correlates.

The variation they find is significant; the top quintile spends more than 13 times that of the lowest quintile. This variation was found to be associated with local boards of health and decentralized administration structures but inversely associated with local medical spending. However, two-thirds of the variation remained unaccounted for in their study.

Overall, more research efforts are needed to understand the public health system. In fact, a 2007 editorial by Honoré and Amy (2007) urges an agenda of leadership, education, practice and research to advance public health and public health finance. They specifically cite innovative revenue generation strategies as key in future research efforts.

4.3.2 Collaboration

Literature regarding collaboration is rich and multi-disciplinary. This section does not attempt to provide a comprehensive review here. It does, however, look at collaboration literature from a variety of perspectives relevant to this research, namely operations management and nonprofit organizations literature.

Operations Management. Erhun and Keskinocak (2007) and Erhun (2009) both provide general reviews of for-profit collaboration from an operations management perspective. They delineate both inter- and intra-firm collaboration and coordination. One example of operations management research into for-profit collaboration includes the study of internet-based buyer alliances by Granot and Sosic (2005), who quantify and compare the discounts between the different alliance situations and look at stability criteria for initial and long-term participation. Collaborative procurement is another application of collaboration in the for-profit sector, and is examined by Keskinocak and Savasaneril (2005) who give quantitative factors needed for collaboration to be beneficial for each party. From a more organizations perspective, Cowan *et al.* (2007) look at the formation of partnerships between corporations motivated only by a desire to increase knowledge, for example, outside of the firm's core competency. They examine and model how firms choose and value different potential

partners under incomplete information.

Public Health. With regard to collaboration, NACCHO's *Operational Definition of a Functional Local Health Department* states that a functional local health department, among other things collaborates in emergencies, engages the community, develops partnerships with various external entities, and coordinates public health system's efforts. Thus, public health entities collaborate with a wide range partners for an even wider range of purposes from service delivery to education. Lasker (1997) provides a review of such collaboration, first looking at the imperative for collaboration including the historical relationships, previous attempts and the current situation then moving to models and case studies focusing on improvement and strategy.

As an example of public health collaboration with governmental entities, using an NIJ/CDC survey, Hammett (1998) finds that nearly all correctional systems collaborate with public health departments who are often providing funds, staff, or direct service. Halverson, Mays, and Kaluzny (2000) specifically examine collaboration with community medical care providers in public health departments looking at organizational and market influences. They conclude that where organizational and market incentives are lacking, collaboration may need more focused and intentional effort.

Partnering can also be viewed strategically as an important component of improving public health and public health systems. Roussos and Fawcett (2000) provide a review of public health collaboration with an eye to community/systems change, behavioral change, and population-level health outcomes. The authors find that current research, which are mostly case studies, are insufficient to make conclusions about partnership effects on population-level outcomes, but this research does suggest that "at least under some conditions, implementation of collaborative partnerships is associated with improvements in population-level outcomes." Varda *et al.* (2008) use connectivity to enable more strategic identification of partners and improve understanding of collaborative relationships over time. They emphasize the necessity of strategy for effectiveness, costs, and quality of collaborations. The authors mention the need to understand how resource expenditures are linked to collaboration to provide increased accountability and improvement.

In setting collaboration strategies, understanding the effects of collaboration is critical. Bazzoli *et al.* (1997) look to collaboration in health and human service delivery, specifically to identify the range, influencing factors, and extent of collaborative activities. Based on their research, they emphasize the importance of investigation into the *types* of activities instead of a binary view of collaboration. Harris, Beatty, and Barnes (2009) find that resources, partnerships, and services vary between rural, metropolitan, and urban local health departments. Furthermore, working partnerships partially mediated the relationship between resources (e.g., funding and staff) and services while the effects of information and financial partnerships were less clear. Through this partial mediation, the authors argue that partnerships reduce service provision disparities between rural, metropolitan, and urban local health departments. The authors conclude that partnerships may be important, especially under scarce resources.

Nonprofit Organizations. Chapter 1 of this dissertation provides a comprehensive review of operations research applications in community-based nonprofit organizations. This review includes discussion of nonprofit collaboration with other community institutions and organizations, which is especially relevant to this research. McGuire (2006) gives a review of current nonprofit collaboration literature and the gaps left to fill. Overall, he finds many questions left to be answered. In a time where company philanthropy budgets are getting tighter, Andreasen (1996) encourages nonprofits to pursue corporate partners and cause-related marketing in order to pull funding through their marketing budgets. He encourages nonprofits to "approach cause-related marketing alliances with the same bottom-line mentality" as their corporate partners, but also sites several unique risks these partnerships pose to nonprofits. Austin (2000) looks at case studies to set up a framework guiding nonprofits in collaborating with businesses. Foster and Meinhard (2002) construct a regression model to explain predisposition to collaborate, including organizational factors, environmental pressures, and organizational attitudes. The authors find that organizational and attitudinal factors are the most explanatory, however, environmental factors amplify or reduce the strength of these factors.

Nonprofits also collaborate with one another. O'Flanagan and Taliento (2004) investigate the nonprofit organizational structure of the federation, perhaps as a very formal collaborative structure through providing nonprofits with an equivalent to mergers and acquisitions. Ritchie and Weinberg (2003) discuss nonprofit collaboration, competition, and combinations. They cite two critical differences between nonprofit and for-profit models: nonmonetary goals that dominate financial considerations and cross-sector diversity of such goals implying that rival nonprofits may have very different objectives. They describe the broad factors of values and pragmatics that will determine if combative, collegial, alternative, or directional competition will emerge in a given market.

In studying why and how nonprofits collaborate, authors have mainly used the tools of econometric and network analyses. As an example of the former, Guo and Acar (2005) use logistic regression analysis to identify factors that influence the likelihood of nonprofit organizations developing more formal types of collaboration. In the area of network analysis, a brief explanation is provided by Provan *et al.* (2005) as well as the development of key questions that nonprofits themselves can use to get the most out of such research. These questions center around the concepts of network extent, centrality, planning, growth, ties, relationship strength, trust, growth, benefits, and drawbacks of partnerships.

4.4. Contribution

As mentioned previously, Honoré and Amy (2007) cite innovative revenue generation strategies as key in future public health research efforts, and such strategies are precisely where this research fits, building upon a quantitative base of understanding revenues (expenditure per capita serving as proxy), collaboration patterns, and their relationships. Supplementing current public health *finance* research, we seek to develop collaboration strategies based on quantitative data. In reaching this ultimate goal, this research makes many other meaningful contributions. For example this research adds to public health finance literature investigating expenditure differences across local health departments by examining the relationship between expenditures

and collaboration. Supplementing current public health *collaboration* research, we seek to link expenditures and collaboration patterns adding to the understanding of the effects of local health department collaboration. While collaboration literature has drawn conclusions regarding factors critical in collaboration, strategies taking advantage of such conclusions are lacking. A further unique contribution to public health literature is the development of such collaboration strategies with the goal of revenue generation. In fact, the methods we propose for optimization and strategy generation will be able to be used with a large variety of data resulting in the development of local health department collaboration strategies for a variety of corresponding goals, such as emergency preparedness and specific health outcomes.

Local health departments partner with many nonprofit organizations, which is a prominent consideration of this research. This study examines nonprofit collaboration from the partner perspective, which is both a unique and important contribution. Understanding the relationship between collaborating with nonprofits and local health department expenditures also sheds light on how nonprofits shape their communities and the delivery of local health services.

This research contributes to current operations management literature at the intersection of operations management and health literature, expressly at the intersection of collaboration, health care, and operations management research streams, as one of the first to focus on the local public health setting. Such a localized setting presents interesting challenges and opportunities. Furthermore, this research combines empirical and theoretical operations methods. It fits within an area of great potential impact, specifically research that combines operations research methods and optimization with real-world data. Such a combination is potently applicable, yet, as we demonstrate, can remain true to the academic rigor of our field.

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Chapter 5

An Empirical Portrait of Local Health Department Revenues and Collaboration: A Descriptive Analysis

Community-based collaboration is an essential part of the public health system. The 2002 report from Institute of Medicine (IOM), "The Future of the Public's Health in the 21st Century," promotes partnerships as critical to meeting public health goals and challenges, underlining the increasing emphasis on collaboration in public health policy, practice, and research. In fact, a functional local health department is defined to, among other things, collaborate in emergencies, engage the community, develop partnerships with various external entities, and coordinate public health system efforts. Local public health departments are embedded in communities of such potential partners, "creating a network of resources, information and beneficiaries (Chapter 2)." Collaborative relationships form the links of this network, and, consequently, mobilize resources. While resources, information, and beneficiaries can flow into a local health

department, they can also flow out. As such, community-based collaboration decisions become tactical operations decisions implying that local health departments can approach collaboration with specific strategies in mind, including revenue generation. It is this aspect of collaboration that we will study in this paper.

As such, it is critical to understand the local health department landscape of collaboration and revenues. We draw an empirical portrait of local health department revenue (using expenditure as proxy) and collaboration from 2005 to 2008, critically surveying the who, how, and with whom of local health department collaboration (i.e., urbanization, activities, and partners) while suggesting revenue differences as a potential answer to why. That is, this research asks

1. Do local health departments that engage with particular partners or/and in particular activities have significantly different revenues than those that do not?

In answering this question, we also ask

2. Have local health department revenues changed between 2005 and 2008 (overall, urban, suburban, rural)? If so, how?

3. Have local health department collaboration patterns changed between 2005 and 2008 (overall, urban, suburban, rural)? If so, how?

Thus, this research considers collaboration as a strategic lever for mobilizing resources and generating revenue for local health departments. With a complementary approach, Beatty, Harris, and Barnes (2010) find that partnerships partially mediate resources and services; that is, local health departments with limited resources can utilize these resources more effectively when they establish partnerships.

5.1. Methods

This study uses data from the 2005 and 2008 National Profile of Local Health Departments Surveys conducted by the National Association of City and County Health Officials (NACCHO). These surveys are in-depth questionnaires distributed through

e-mail to the top agency executive of every local health department in the nation. The e-mail contained a link to an individualized, web-based questionnaire, although paper questionnaires were available upon request. In both years, the purpose of these studies was to "advance and support the development of a database for local health departments to describe and understand their structure, function, and capacities" with the hope of strengthening research, practice, advocacy, capacity, funding, and population-based health outcomes (NACCHO 2009, 2006).

In both years, the "Profile" questionnaire included a set of questions sent to all local health departments in the United States. One of three supplemental "module" surveys was included in the questionnaire for a random sample. Stratified random sampling (without replacement) by population size served was used to select local health departments to receive the modules. In 2008, 83% (2,332) of a total 2,794 local health departments responded to the study. In 2005, 80% (2,300) of a total of 2,864 local health departments responded.

While this report includes information on many topics, expenditure and collaboration are of particular interest to this research. Expenditures were used to proxy for revenues. Data on expenditure was collected in the profile questionnaire, while questions regarding collaboration were found in the module surveys. The collaboration module sample size was 547 and 517 with response rates of 83% (454) and 84% (433) in 2008 and 2005, respectively. After cleaning data to remove samples that were incomplete, the sample sizes for this analysis were 411 and 375 for 2008 and 2005, respectively. The 2008 expenditure data was adjusted for inflation using the Consumer Price Index. Consequently, all expenditures are displayed in 2005 dollars. The expenditure per capita measure was created by dividing expenditure by jurisdiction population, both of which are provided in the NACCHO survey.

We approach collaboration from a multidimensional perspective. We measure collaboration several ways based on binary responses to partner and activity combinations: total number of partnerships, activities, partners, and partner-activity combinations. Across 2005 and 2008, there are 21 common partners. Thus, the total number of partnerships is measured as the number of partners that a local health department collaborated with in any way - between zero and 21. In each year, there are

four different possible collaboration activities. In 2005, the activities include exchanging information, working together on programs or projects, the local health department providing financial resources, the local health department providing a leadership role; in 2008, the activities include exchanging information, sharing resources, using written agreements, and meeting regularly. Only exchanging information is common between 2005 and 2008. Thus activities are measured by two variables, the total number of partners with whom a local health department exchanged information and with whom it engaged beyond exchanging information. Each partner and partner-activity combination is modeled as dummy (binary) variables.

This study also incorporates local health department urbanization as an important characteristic that may influence both expenditure and collaboration. The measure of urbanization used in this study is the NACCHO categorization of local health departments as rural, suburban, or urban by the Rural-Urban Commuting Area (RUCA) codes (rural 1-3.99, suburban 4-6.99, and urban 7-10). These codes are based on census-tract level demographic, population, and work commuting data (Hart, Larson, and Lishner 2005).

In regard to statistical procedures used, t-tests were used to assess whether means were statistically different from one another. Expenditure per capita was found not to be normally distributed; therefore, t-tests were performed on its logarithm.

5.2. Results

The goals of this research are to further understand revenues (expenditure as proxy) and collaboration, both individually and in conjunction. Individually, revenues and collaboration are explored from the perspectives of time and local health department urbanization. In conjunction, this research seeks to determine if local health department revenues vary by collaboration patterns.

5.2.1 Expenditure per Capita

Between 2005 and 2008, the landscape for local health departments did indeed change. Mean expenditure per capita increased during this time both overall and for suburban and rural departments (see Table 1). Expenditure per capita was found to be significantly lower for urban local health departments (as compared to all others) and higher for rural, a finding consistent with Beatty, Harris, and Barnes (2010).

5.2.2 Collaboration

In both 2005 and 2008, all local health departments collaborated with at least one partner in some way, that is, 100% collaboration across local health departments. As evidence by this number, such a binary measure obscures much about collaboration. Therefore, this research examines collaboration as measured by the number of partnerships, activities, partners, and partner-activity combinations.

Number of Partnerships. While the mean number of partners per local health department did not significantly change between 2005 and 2008, variation begins to emerge when the mean number of partners is parsed out by urbanization. Urban local health departments were found to have significantly more partners, while rural significantly less. Suburban departments were not statistically different from either urban or rural.

Activities. Further variation emerges when collaboration is divided out by activities. Mean difference testing reveals that the number of partners with whom local health departments exchanged information significantly increased by 1.4 partners between 2005 and 2008 (Table 1). However, the number of partners engaged beyond exchanging information decreased, though we caution that this may be due to the different options of activities available in each year.

Urban local health departments were found to have significantly more exchanging information partners, while rural significantly less. The 2005-2008 increase in exchanging information partners persists across urbanization with rural departments

		Overall	Urban	Suburban	Rural
Expenditure per Capita	**2005**	$ 38.02 **	$ 36.45	$ 38.31 **	$ 41.24 **
		($34.03)	*($32.30)*	*($41.13)*	*($31.43)*
	2008	$ 45.40 **	$ 41.80 †††	$ 40.45 **	$ 55.08 **†††
		($54.55)	*($61.72)*	*($28.04)*	*($55.52)*
	Overall	$ 41.88 **	$ 39.09 †††	$ 39.45 **	$ 49.12 **†††
		($46.05)	*($49.10)*	*($34.67)*	*($47.11)*
Number of Partners	**2005**	15.3	16.0 †††	15.1	14.0 †††
		(3.8)	*(3.8)*	*(3.5)*	*(3.8)*
	2008	15.1	15.7 †††	15.4	14.1 †††
		(3.8)	*(3.7)*	*(3.5)*	*(4.0)*
	Overall	15.2	15.8 †††	15.2	14.0 †††
		(3.8)	*(3.8)*	*(3.5)*	*(3.9)*
Number of Exchanging Information Partners	**2005**	12.8 ***	13.6 ***†††	12.9 **	11.0 ***†††
		(5.5)	*(5.6)*	*(5.0)*	*(5.4)*
	2008	14.2 ***	14.9 ***†††	14.4 **	13.0 ***†††
		(4.3)	*(4.2)*	*(4.2)*	*(4.4)*
	Overall	13.5 ***	14.2 ***†††	13.7 **	12.1 ***†††
		(5.0)	*(5.0)*	*(4.7)*	*(4.9)*
Number of Beyond Exchanging Information Partners	**2005**	10.7 ***	11.6 ***†††	9.8 ***††	9.6 ***†††
		(4.7)	*(4.9)*	*(4.4)*	*(4.3)*
	2008	7.5 ***	8.3 ***†††	7.5 ***	6.1 ***†††
		(4.5)	*(4.8)*	*(4.0)*	*(4.1)*
	Overall	9.0 ***	10.0 ***†††	8.6 ***†	7.6 ***†††
		(4.9)	*(5.1)*	*(4.3)*	*(4.5)*

Note. Means are displayed with standard deviation below in parentheses. 2005 inflation-adjusted dollars are displayed. Statistical Significance of Mean Difference between Years: ** ***p<0.01; Statistical Significance of Mean Difference by Urbanization Category: †p<0.05, ††p<0.05, †††p<0.01

Table 5.1: Expenditure per Capita, Number of Partnerships, and Number of Partnerships by Activity

experiencing the largest increase. Suburban departments were not statistically different from either urban or rural.

Partners. Here collaboration is measured by binary partner variables describing whether or not a local health department was engaged with a particular partner in any way. Differences in the collaboration landscapes of 2005 and 2008 become more apparent when parsing out collaboration by partners as seen in Table 2. It is

observed that the increase in the percentage of local health departments collaborating with universities is the only change that holds across urbanization categories. Instead, we find that increases and decreases in the percentage of local health departments engaged with each partner vary by urbanization.

Partner-Activity Combinations. Dissection by both partners and activities allows the most detailed view of the local health department collaboration landscape. Accordingly, supplemental Table 1S details the percentage of local health departments engaged with each partner in each activity. Exchanging information with universities has the highest variance across urbanizations with significantly fewer rural departments collaborating in this way. The least variance occurs when no local health departments engage, such as providing financial resources to tribal governments. Such patterns illustrate that refinement of collaboration by both partners and activities offers a wealth of additional information.

5.2.3 Expenditure per Capita and Collaboration

We have now examined the who (urbanization), how (partnerships and activities), and with whom (partners) of local health department collaboration. We now examine revenues and collaboration in conjunction, developing the idea of collaboration as a strategic lever by putting revenue generation as a potential answer to why. Figure 1 graphically illustrates the significant differences in mean expenditure per capita of local health departments who collaborate with specific partners in specific activities as compared to those who do not. Most partner-activity combinations are associated with increased mean expenditure per capita, though not all.

Partners. The Over All Activities column of Figure 1 displays significant differences in mean expenditure per capita for those health departments in collaboration with specific partners versus those not. Although collaboration with most partners is associated with significantly higher mean expenditures per capita, there are partners which show lower mean expenditure per capita for those departments in collaboration (e.g., utilities and parks and recreation).

	Percentage		Change in Percentage			
				Urbanization		
	2005	2008	Overall	Rural	Suburban	Urban
Hospitals	92%	93%			▲*	
Medical Groups	93%	90%		▼*		
Community Health Ctrs	64%	66%			▲*	
Other Providers	89%	86%				
Health Insurers	47%	50%		▲*		
Emergency Responders	96%	97%			▼*	▲*
Development Agencies	66%	68%				
Housing Agencies	66%	62%				▼*
Utilities	51%	46%	▼*			
Environmental Orgs	73%	66%	▼*	▼*		
Coop Extensions	80%	74%	▼*	▼*		▼*
Schools	99%	98%	▼*	▼*		▼*
Parks & Recreation	70%	69%				
Transportation	51%	48%				
Faith Communities	84%	82%				
Libraries	60%	58%				
Universities	67%	76%	▲*	▲*	▲*	▲*
Business	80%	84%	▲*	▲*		
Media	93%	95%			▲*	
Tribal Government	14%	17%		▲*		
Community-Based Orgs	94%	87%	▼*	▼*		▼*

Note. ▲ (▼) indicates an increase (decrease) between 2005 and 2008 in the percentage of LHDs who partner; Statistical Significance: *p<0.1, **p<0.05, ***p<0.01

Table 5.2: Percentage of Local Health Departments Collaborating with Specific Partners

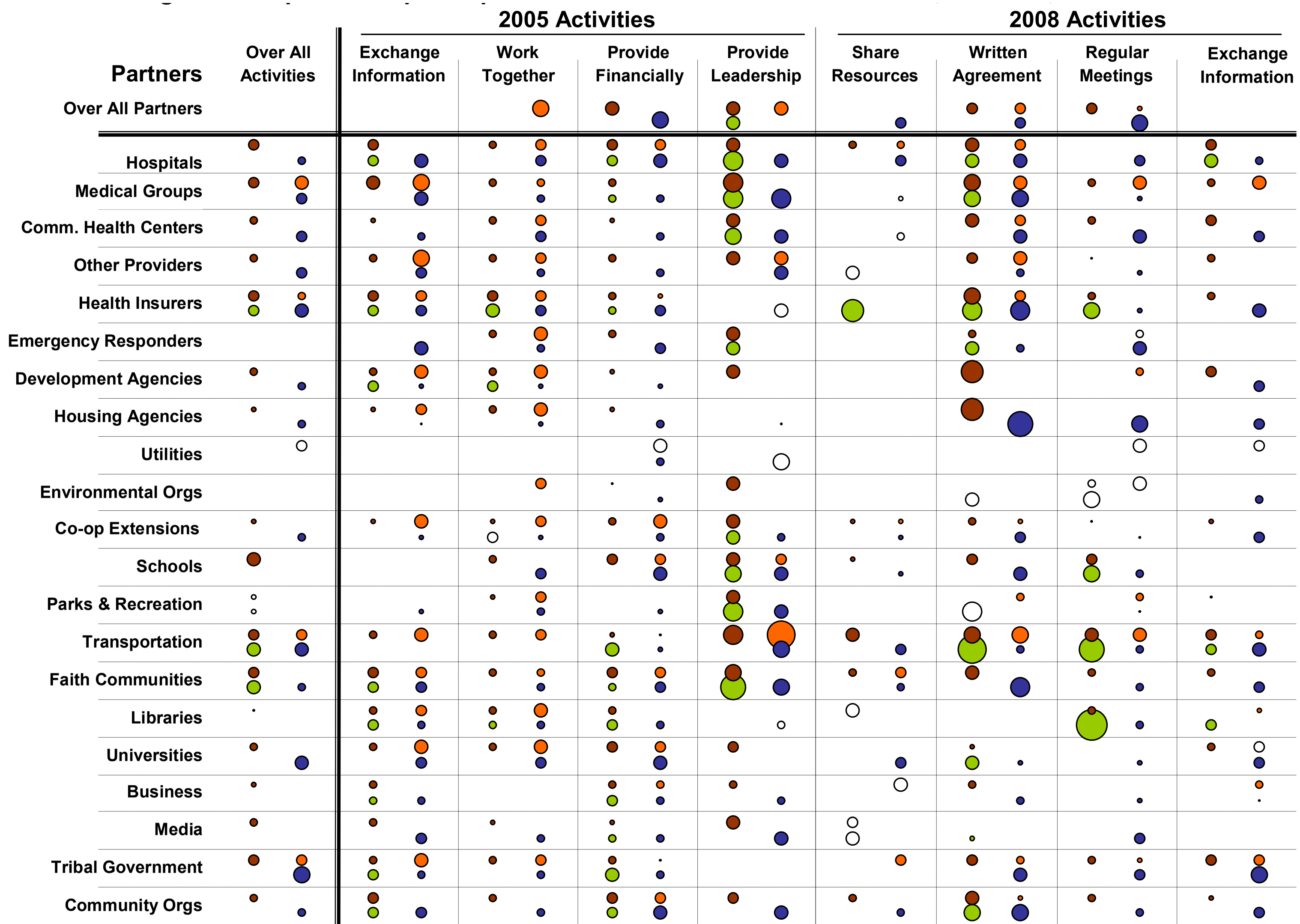
Parsing this out by urbanization, however, reveals heterogeneity both in number of partners and by specific partners. Compared to rural and suburban departments, urban local health departments by far have the most partners associated with significantly higher mean expenditure per capita at 13. Furthermore, only collaboration with health insurers and transportation has significant expenditure per capita mean difference across all urbanizations.

Activities. The Over All Partners row of Figure 1 displays significant differences in mean expenditure per capita for those health departments engaged in certain collaborative activities versus those not. Engagement in providing financially, providing leadership, written agreements, and regular meetings are each associated with significantly higher mean expenditure per capita for health departments in general.

Considering urbanization, however, reveals that rural local health departments show significantly higher means only for engagement in providing financial resources and leadership. Suburban departments show such increased expenditure per capita associated with more activities and urban for even more.

Partners and Activities. Allowing for combinations of partner and activity allows the most diversity in collaboration patterns. As noted above, collaboration can be associated with lower revenues. It is at this partner-activity level of distinction that this fact becomes more evident, as can be seen in Figure 1. For example, consider sharing personnel/resources with libraries and media. In fact, sharing personnel/resources (2008) is associated with a lower mean expenditure per capita for more partners and local health departments.

Urban local health departments have the most significant collaboration combinations associated with higher mean expenditure per capita (70 in 2005 and 53 in 2008) followed by suburban (34 and 24) and rural (26 and 16) departments. Contrastingly, suburban departments have the most combinations associated with lower means (3 in 2005 and 6 in 2008) followed by rural (1 and 5) and urban (3 and 2).



Note. The size of bubble indicates the magnitude of the difference between the mean expenditure per capita of those local health departments collaborating in the indicated activity with the indicated partner as compared to the mean expenditure per capita of those who do not. Only mean differences of significance less than 0.10 are displayed. The following colors and positions indicate urbanization category: ● overall (upper left), ● rural (lower left), ● suburban (upper right), ● urban (lower right). Negative mean differences are displayed as white bubbles. A table displaying this information in a numerical format can be found in the additional information online.

Figure 5.1: Expenditure per Capita Mean Difference over Urbanization, Partners, and Activities

5.3. Discussion

While expenditures and collaboration have both been subjects of investigation, they have most often been studied separately. This research critically surveys these factors between 2005 and 2008, both separately and together, motivating additional research to investigate potential relationships.

5.3.1 Expenditures per Capita

Expenditure per capita did increase between 2005 and 2008, a finding consistent with news and policy. The federal government has continued to invest new funds to support public health activities since 2001, particularly emergency preparation and response funds (Trust for America's Health 2006; Scutchfield, Mays, and Lurie 2009), which are often directed toward urban areas (e.g., The Federal Emergency Management Agency's Urban Areas Security Initiative). Not only do such funds constitute part of the observed urban increase in expenditure per capita, but this may also explain the significant increase in urban local health departments partnering with emergency responders. In fact, the majority of local health departments collaborate with emergency responders.

The disparity found in expenditure per capita for urban and rural health departments is consistent with current research (e.g., Gordon, Gerzoff, and Richards 1997; Levi, Juliano, and Richardson 2007; Mays and Smith 2009). Scholars caution such significant variation has ominous consequences, particularly large variation in public health capacities and capabilities that create health inequality, vulnerability, and national threat (Levi, Juliano, and Richardson 2007). While scholars have identified relationships between expenditures and population size (Gordon, Gerzoff, and Richards 1997), essential public health service performance (Mays *et al.* 2004), federal and state funding (Levi, Juliano, and Richardson 2007), governing structures, and administration (Mays and Smith 2009), much of the variation in expenditure per capita remains unexplained (Mays and Smith 2009).

5.3.2 Collaboration

In 2000, less than 40% of collaborations with hospitals were formalized by contract (Halverson, Mays, and Kaluzny 2000). While in 2008 results indicate a similar percentage of local health departments in written agreements with hospitals (41%), such agreements are significantly related with higher revenues (expenditure per capita), both overall and across all urbanizations. Similarly, a stable two thirds collaborated with community health centers in 2000 (Halverson, Mays, and Kaluzny 2000), 2005, and 2008. Again, we find such relationships are typically characterized by higher revenues. While Halverson, Mays, and Kaluzny (2000) suggest that collaboration may increase with managed care market share, our findings add that revenue is a part of this interaction and written agreements may allow local health departments to leverage these market trends to gain revenue.

Our results also confirm interview findings by Varda *et al.* (2008): Local health departments often play the coordinating role within collaborations (52% overall). Such leadership is associated with higher revenue (expenditure per capita), offering both reason and incentive for such roles. Furthermore, community-based organizations, faith communities, medical groups, other providers, and universities are common collaborators. These interviews also noted a want of business partners, though our results indicate a strong and increasing business presence in local health department collaboration landscapes.

In studying why and how entities collaborate, authors have used the tools of case studies (Roussos and Fawceett 2000), econometric models (Halverson, Mays, and Kaluzny 2000), and network analyses (Provan *et al.* 2005; Varda *et al.* 2008). Quantitative threads of such research have evolved from a binary view of collaboration (i.e., collaborate or not) to a perspective that incorporates the number of partners (Beatty, Harris, and Barnes 2010) or activities (Bazzoli *et al.* 1997). While number of partnerships and activities are steps toward further understanding collaboration, it is crucial to consider patterns of collaboration - activity and partner. For instance, a binary view of our results indicates that 100% of local health departments collaborated - a number that did not change between 2005 and 2008 or between local health

department characteristics. However, dissection of this result by partner reveals distinctions. Similarly, changes and differences are exposed through examination by collaboration activity. Ultimate refinement, though, was obtained by decomposing collaboration into activity and partner combinations. It is crucial to regard such patterns of collaboration - with whom and how do local health departments collaborate.

5.3.3 Expenditures and Collaboration

Congruent with the discussion above, we conclude that a one-dimensional (binary) view indeed conceals much about collaboration, its associations, and surely its effects as well. Our findings here indicate that, in addition to local health department characteristics, collaboration patterns are critical in understanding and explaining expenditure differences across local health departments. Thus, "Who?," "With whom?," and "How?" are all necessary questions to answer, both for researchers investigating collaboration and local health department managers approaching collaboration strategically.

5.3.4 Limitations

Collaboration data is obtained from specific modules of the National Profile of Local Health Departments Surveys, which are distributed to different subsets of the local health department population in each year. Thus, the data sets are limited in size and, as such, may limit the significance of the results presented here. Furthermore, these samples cannot be used to directly compare local health departments between 2005 and 2008 or to create a panel data set, although such a panel would be useful for causal inference and greater statistical significance. Though 2005 and 2008 survey modules on collaboration contain some similar activities, such as exchanging information, due to the distinct nature of these questionnaires, inferences comparing the two cannot be readily made. Also, while most collaboration in the public health system happens at the local level, collaboration that takes place at the state or federal levels is not captured in this data. Therefore, this study cannot consider such collaboration.

Another limitation is noted by several public health scholars, which is the absence of data regarding the spending of other health-related organizations, such as hospitals and community organizations (Mays, Halverson, and Kaluzny 1998; Mays and Smith 2009). These organizations are certainly important in understanding the community and collaboration landscape around public health resources within a community.

5.4. Conclusions

This study encourages further investigation into relationships between expenditure per capita and collaboration, particularly to quantify potential causal relationships and explain the mechanisms by which such relationships function. The role of local health department characteristics, especially urbanization, is essential to incorporate and should also be further explored. Such research to further understand the relationship between expenditures and collaboration patterns may prove key in mitigating the repercussions of expenditure variation across local health departments. Consequently, collaboration may be important in alleviating health inequalities and vulnerabilities, especially as a lever that local health departments can directly engage within their community settings. As such, strategies must be developed that enable local health department actors to be intentional in organizing and managing their collaborative relationships. Our results suggest that local health departments can indeed approach collaboration strategically, even with revenue goals. In fact, such innovative revenue generation strategies have been cited as key in future research efforts (Amy and Honoré 2007). Just as scholars must expand their concept of collaboration, practitioners must also ask "Who?," "With whom?," and "How?" when approaching their collaboration portfolio. Ultimately, such research and practice focused on strategic collaboration may well help local health departments to leverage additional resources and better meet the needs of their communities.

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Chapter 6

Strategic Collaboration for Revenue Generation: A Study of the Relationship between Collaboration and Revenues

Collaboration is an essential part of the public health system. Practitioners, policy shapers, and researchers tend to be in agreement on this. "You can't do public health without collaboration," as one public health worker commented. "Everything we do is a collaboration" (Schulz 2010). This is because local public health departments do not exist in isolation, but are imbedded in rich communities of potential partners.

Current research supports this purported value of collaboration, suggesting that connectivity enabled by collaboration ultimately helps local health departments serve their communities. Consequently, current research also promotes approaching collaboration strategically (e.g., Varda *et al.* 2008); however, questions remain regarding if and what strategy can be achieved. Particularly, our research develops the idea of strategic collaboration with the goal of revenue generation. There are expectations that through collaboration, local health departments may leverage additional

financial resources for public health programs. In fact, Chapter 6 give evidence that there are significant revenue differences between local health departments engaged in certain collaboration patterns and those not. However, partnerships require significant time and resources to maintain; a local health department has only limited time, resources, and energy for such investments (Varda *et al.* 2008). Thus strategy is of the upmost importance when local health departments approach collaboration.

Here, we build upon the idea of strategic collaboration by utilizing robust multiple regression models. Such a controlled statistical analysis enables us to make relational conclusions and corresponding recommendations. Thus, we answer the main research question,

1. How should local health departments collaborate strategically? That is, how many partners should a local health department engage? Who should local health departments partner with and how?

In answering this main question, we also explore the following additional research questions:

2. Are local health department revenues and collaboration significantly related? If so, how?

3. Is this relationship significantly different between rural, suburban, and urban local health departments?

4. Are more partners always better or is there a "sweet spot"? These questions enable us to provide insights into lingering academic questions regarding the tradeoffs of collaboration benefits and costs and practitioner dilemmas regarding strategy in collaboration.

6.1. Background

This research lies at the intersection of several fields, namely public health collaboration and finance, which we overview below.

6.1.1 Public Health Collaboration

With regard to collaboration, the *Operational Definition of a Functional Local Health Department* by the National Association of City and County Health Officials (NACCHO) states that a functional local health department, among other things collaborates in emergencies, engages the community, develops partnerships with various external entities, and coordinates public health system efforts. Thus, public health entities collaborate with a wide range partners for an even wider range of purposes from service delivery to education. Lasker (1997) provides a review of such collaboration, first looking at the imperative for collaboration including the historical relationships, previous attempts, and the current situation then moving to models and case studies focusing on improvement and strategy.

Partnering can also be viewed strategically as an important component of improving public health and public health systems. Roussos and Fawcett (2000) provide a review of public health collaboration with an eye to community/systems change, behavioral change, and population-level health outcomes. The authors find that current research, which are mostly case studies, are insufficient to make conclusions about partnership effects on population-level outcomes, but their research does suggest that "at least under some conditions, implementation of collaborative partnerships is associated with improvements in population-level outcomes." Varda *et al.* (2008) use connectivity to enable more strategic identification of partners and improve understanding of collaborative relationships over time. They emphasize the necessity of strategy for effectiveness, cost, and quality of collaborations. The authors conclude by noting the idea of "relationship budgeting," that is "strategically managing the cost of collaboration (Varda *et al.* 2008)." The authors mention the need to understand how resource expenditures are linked to collaboration to provide increased accountability and improvement.

In setting collaboration strategies, understanding the effects of collaboration is critical. Bazzoli *et al.* (1997) look to collaboration in health and human service delivery, specifically to identify the range, influencing factors, and extent of collaborative activities. They cite several purposes of collaboration, including rationalization of local resources, and conclude that distinct patterns are based on types of activities.

Based on their research, they emphasize the importance of investigation into the types of activities instead of a binary view of collaboration. Harris, Beatty, and Barnes (2010) find that resources, partnerships, and services vary between rural, metropolitan, and urban local health departments. Furthermore, working partnerships mediated the relationship between resources (e.g., funding and staff) and services while the effects of information and financial partnerships were less clear. Through this mediation, the authors argue that partnerships reduce service provision disparities between rural, metropolitan, and urban local health departments. The authors conclude that partnerships may be important, especially under scarce resources.

6.1.2 Public Health Finance

Variations in health resources imply inefficient and inequitable use of resources and, consequently, have been a nearly constant topic of policy concerns. Using the NACCHO 1992/1993 survey, Gordon, Gerzoff, and Richards (1997) examine the relationship between local health department expenditures and department characteristics. They find that 70% of expenditure variability is explained by a nonlinear relationship with population size within the jurisdiction. However, they also find a broad range of spending levels even among similarly sized jurisdictions. Levi, Juliano, and Richardson (2007) look at variation and instability in federal and state financing of public health. At the federal level the authors find that "core" public health functions have experienced funding decreases, while the state level is characterized by variation. The consequence appears to be a large variation in public health capacities and capabilities across the country, which the authors argue is creating vulnerability and national threat. Mays and Smith (2009) study local public health department spending variation across communities and over time with the goal of identifying correlates. The variation they find is significant; the top quintile spends more than 13 times that of the lowest quintile. While this variation was found to be associated with local boards of health, decentralized administration structures, and (inversely) local medical spending, two-thirds of the variation remained unaccounted for in their study.

Such variation remains to be completely explained even after accounting for price differences, socioeconomic status, illness burden, and geography (Mays and Smith 2009). Thus, our study of the association between resources and collaboration patterns can add to this body of literature as well as our understanding of resource differences between local health departments.

6.1.3 Contribution

Overall, more research efforts are needed to understand the public health system. In fact, Honoré and Amy (2007) urge an agenda to advance public health and public health finance. They specifically cite innovative revenue generation strategies as key in future research efforts and such strategies are precisely where this research fits, building upon a quantitative base of understanding the relationship between revenues (expenditures) and collaboration patterns. Supplementing current public health finance research of expenditure differences across local health departments, we seek to examine the relationship between expenditures and collaboration. Supplementing current public health collaboration research, we seek to link expenditures and collaboration patterns adding to the understanding of the effects of local health department collaboration. While collaboration literature has drawn conclusions regarding factors critical in collaboration, strategies taking advantage of such conclusions are lacking. A further unique contribution to public health literature is the development of such collaboration strategies with the goal of revenue generation.

6.2. Methodology

6.2.1 Study Population

Three samples were used in this study. Each was composed of a portion of the nation's nearly 3,000 local public health departments, which are defined by NACCHO as a local or state governmental administrative or service unit responsible for performing public health functions for a jurisdiction smaller than a state (NACCHO 2006). Both

2005 and 2008 sample sets were used along with a third, which pools the 2005 and 2008 sample sets for a combined 2005-2008 sample. This research leverages these sample sets for the most power in each situation whether pooled or separate by years. The data used for each piece of analysis is noted.

6.2.2 Data

This study uses data from the 2005 and 2008 National Profile of Local Health Departments Surveys conducted by NACCHO. These surveys are in-depth questionnaires distributed through e-mail to the top agency executive of every local health department in the nation. The e-mail contained a link to an individualized, web-based questionnaire, although paper questionnaires were available upon request. In both years, the purpose of these studies was to "advance and support the development of a database for local health departments to describe and understand their structure, function, and capacities" with the hope of strengthening research, practice, advocacy, capacity, funding, and population-based health outcomes (NACCHO 2009, 2006).

The "Profile" questionnaire included a set of questions sent to all local health departments in the United States. One of three supplemental "module" surveys was included in the questionnaire for a random sample. Stratified random sampling (without replacement) by population size served was used to select local health departments to receive the modules. In 2008, 83% (2,332) of a total 2,794 local health departments responded to the study. In 2005, 80% (2,300) of a total of 2,864 local health departments responded.

Expenditure and collaboration are of particular interest to this research. Expenditures were used to proxy for revenues. Data on this was collected in the profile questionnaire, while questions regarding collaboration were found in the module surveys. The collaboration module sample sizes were 547 and 517 with response rates of 83% (454) and 84% (433) in 2008 and 2005, respectively. After cleaning data to remove samples that were incomplete, the sample sizes for this analysis were 411 and 375 for 2008 and 2005, respectively.

6.2.3 Measures

Dependent Variable: Revenue (Expenditure per Capita as Proxy)

The data does not contain information on local health department revenues; however, expenditures serve as a reasonable proxy. The 2008 expenditure data was adjusted for inflation using the Consumer Price Index, thus expenditures are displayed in 2005 dollars. The expenditure per capita measure was created by dividing expenditure by jurisdiction population, both of which are provided in the NACCHO survey. The distribution of expenditure per capita is not normal. For this reason, expenditure per capita is transformed monotonically by taking its logarithm for a resulting normally distributed dependent variable. All analysis done regarding expenditure per capita is performed on this transformed data. Because the transformation is monotonic, all results hold true for expenditure per capita.

Independent Variables of Interest: Collaboration Measures

Collaboration measures are based on binary responses to partner and activity combinations. The total number of partnerships is measured as the number of partners that a local health department collaborated with in any way. Likewise, we model collaboration activity as the total number of partners a local health department engages with in a particular activity. A local health department can engage with all partners in each activity, therefore each activity variable can range between 0 and 21. In regression analysis, all number of partnerships variables and their squares are mean-centered to avoid multicollinearity. Partner binary variables measure if a local health department collaborated with each particular partner in any way.

Interaction Terms: Collaboration and Urbanization

These collaboration measures are interacted with urbanization categorical variables (rural, suburban, and urban) to model the relationship between collaboration and revenue as moderated by urbanization. Recent research indeed confirms resource and partnership variation based on urbanization (Beatty, Harris, and Barnes 2010). The

measure of urbanization used in our study is the NACCHO categorization of local health departments as rural, suburban, or urban by the Rural-Urban Commuting Area (RUCA) codes (rural 1-3.99, suburban 4-6.99, and urban 7-10). These codes are based on census-tract level demographic, population, and work commuting data (Hart, Larson, and Lishner 2005).

Control Variables

Each of our models uses a common set of control variables. Fulltime employees, total number of services provided in a jurisdiction, and year were each included. The number of fulltime employees was normalized by tens of population.

6.2.4 Methods

Robust multiple linear regression is used as the estimation procedure for each of the models outlined in Figures 1-4. This procedure uses robust estimates for standard errors of the estimated coefficients. That is, these estimated standard errors are corrected using the White robust standard errors and are thus robust to heteroscedasticity that may be present (White 1980).

6.3. Results

6.3.1 Total Number of Partners

For analysis of the relationship between total number of partners and expenditure per capita, the merged 2005-2008 data set is used for a total of 727 observations. A quadratic form is employed to model total number of partners, as seen in Figure 6.1. This form captures the idea of diminishing returns in the number of partners, i.e., that there is a "sweet spot" in terms of the optimal number of partners a local health department should be engaging. Such a form has been supported by literature regarding collaboration, such as Chan, Feldman, and Manning (1999) who find quadratic relationships between financial indicators and number of hospitals collaborating in

consortia. Figure 6.1 contains our results for this quadratic model that is moderated by urbanization.

These results first reveal that the total number of partnerships is significantly associated with expenditure per capita, which is true for all urbanizations of health departments ($p < 0.01$). This relationship is found to indeed be moderated by urbanization. In particular, this relationship is found to be significantly different for urban and rural local health departments ($p < 0.05$) when comparing coefficients across urbanizations but not for suburban.

While there is evidence that this relationship is indeed quadratic (urban $p < 0.1$, suburban $p < 0.15$, rural $p < 0.05$), this quadratic relationship must be concave to validate a diminishing returns or "sweet spot" philosophy regarding the number of partnerships in which a local health department is engaged (Varda *et al.* 2008). However, in each case both β_1 and β_2 are positive, indicating a strictly increasing shape. These initial results contradict such diminishing returns ideas and instead indicate that local health departments should collaborate with as many partners as possible; i.e., when it comes to number of partners, more is better. This relationship, however, can be further understood by considering additional collaboration measures.

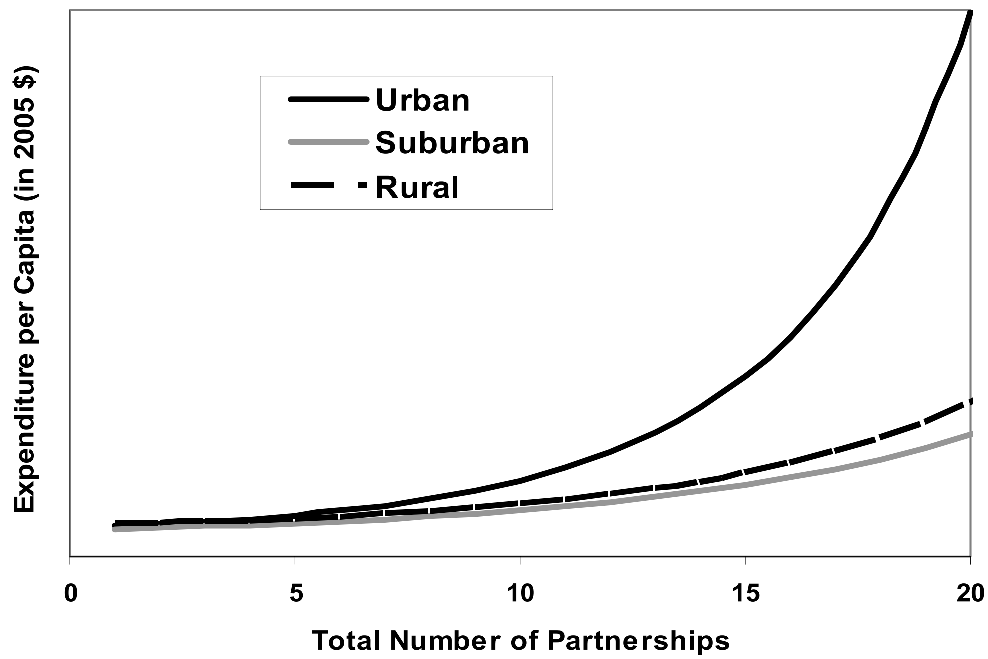
6.3.2 Total Number of Partners by Activity

While the total number of partnerships in which a local health department is engaged communicates some information about collaboration, the types of collaborative activities are also especially important to consider. Here collaboration is modeled as a vector of activity variables, that is, a vector of the number of partners with whom a local health department engages with in each activity. Again a quadratic model is employed where each coefficient will give us information about the value (in terms of association with expenditure per capita) of engaging (or not) with an additional partner in each activity. Since the collaboration activities vary by year, we run separate regressions for 2005 and 2008. Results are contained in Figures 6.2 and 6.3.

Models indicate that the number of partners in select activities is significantly related to expenditure per capita. These relationships are found to be moderated

$$\ln(expcap_i) = \beta_0\ \mathbf{urb_i} + \beta_1\ \mathbf{urb_i}\ totpart_i + \beta_2\ \mathbf{urb_i}\ totpart_i^2 + \delta\ \mathbf{X_i} + e_i$$

	β_0 Urban	β_0 Suburban	β_0 Rural	β_1 Urban	β_1 Suburban	β_1 Rural	β_2 Urban	β_2 Suburban	β_2 Rural
Coefficient	1.845 ***	1.762 ***	1.937 ***	0.047 ***	0.036 ***	0.019 ***	0.005 *	0.002	0.003 **
p-value	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.060)	(0.145)	(0.028)



Note. Subscript *i* indicates local health department *i*. **Bold** denotes vectors. *ln(expcap)* is the logarithm of Expenditure per Capita, the dependent variable in all models. **urb**: Urbanization (dummies: urban, suburban, rural); **act**: Total Number of Partnerships Engaged by Activity (In 2005, Exchanging Information, Working Together, Providing Finanically, and Leading. In 2008, Exchanging Information, Sharing Personnel/Resources, Written Agreement, and Regular Meetings.); **part**: Partner Vector; **X**: Vector of Control Variables; **e**: Error Term.

Figure 6.1: Total Number of Partnerships: Model and Results

by urbanization and exhibit diverse directions and magnitudes. Positive linear associations are found for leading (2005: urban, suburban) and exchanging information (2008: suburban). However, regular meetings have a negative association (2008: suburban).

Where the previous total number of partnerships model reinforced a "more is better" approach to partnering, here the "sweet spot" shape now becomes apparent for certain activities. Working together (2005) and providing financially (2005) are both significantly quadratic across rural, suburban, and urban health departments. Providing financially is unimodal, giving evidence that engaging with more partners in this way is not always better. In fact, we find that in some extreme cases, engaging with fewer partners is better. For example, while written agreement (2008) is significantly (linearly) related to expenditure per capita, this linear relationship is decreasing for rural departments.

6.3.3 Partners

While the total number of partners communicates some information about collaboration, the specific partners that a local health department chooses to engage are also important to consider and model. In fact, it is expected that the association between expenditure per capita and collaboration would vary among local health department partners (Chapter 6). In this section, we model collaboration as a vector of dummy (binary) partner variables in a linear relationship. Thus, each coefficient will give us information about the value of engaging (or not) with a specific partner. The merged 2005-2008 data set is used for a total of 727 observations and results are displayed in Figure 6.4.

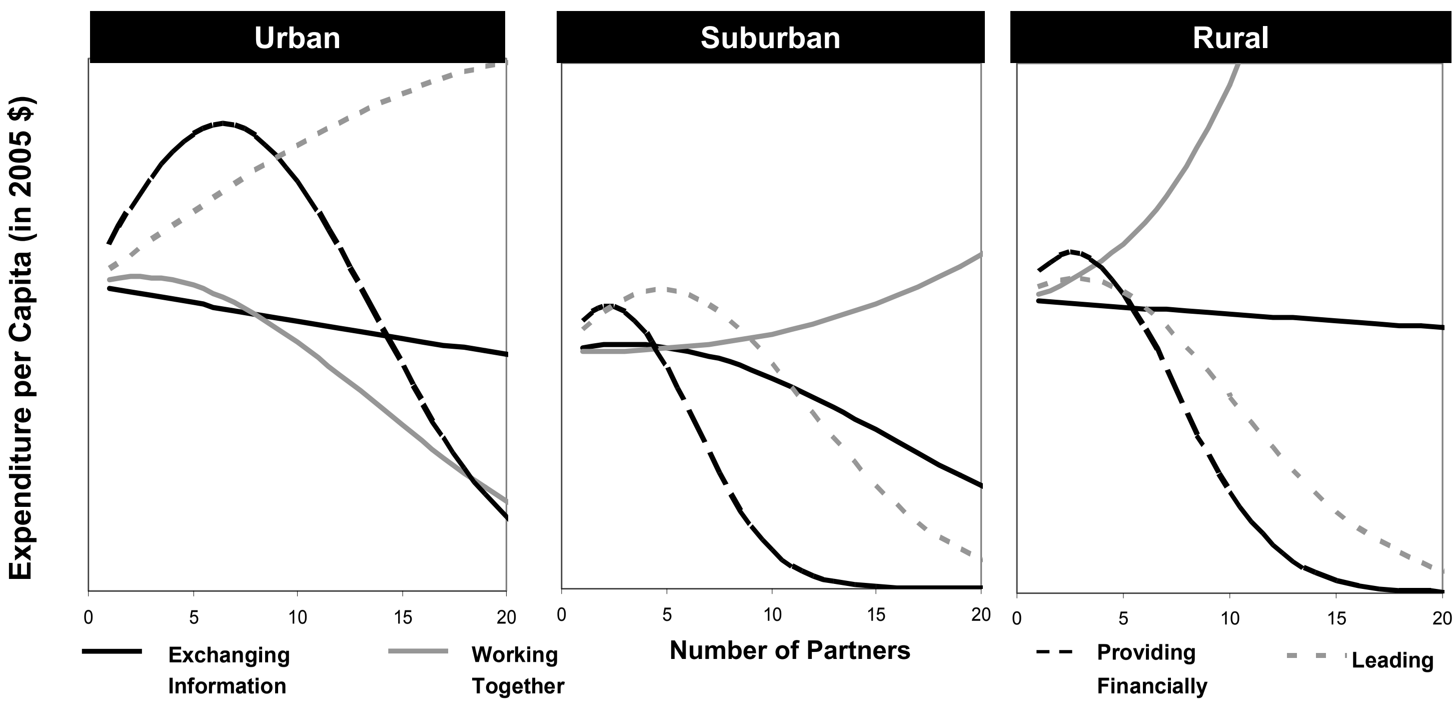
We find variation among partners in their associations with expenditure per capita not only in strength but also in direction as seen in Figure 6.4. That is, some partners are positively associated with expenditure per capita, while others are negatively associated. In fact, health insurers, media, and tribal government agencies are significant across all urbanization categories, though only health insurers and tribal government are uniformly positively associated with expenditures per capita ($p < 0.01$ and

$\ln(expcap_i) = \beta_0\, \mathbf{urb}_i + \beta_1\, \mathbf{urb}_i\, \mathbf{act}_i + \beta_2\, \mathbf{urb}_i\, \mathbf{act}_i^2 + \delta\, \mathbf{X}_i + e_i$

	Urban	Suburb	Rural
β_0	2.015 *** (0.000)	1.772 *** (0.000)	1.974 *** (0.000)

β_1	Urban	Suburb	Rural
Exchanging Information	-0.013 (0.142)	0.018 (0.247)	-0.005 (0.305)
Working Together	0.019 * (0.086)	-0.003 (0.226)	0.015 (0.146)
Providing Financially	0.129 *** (0.000)	0.150 *** (0.000)	0.114 *** (0.000)
Leading	0.047 * (0.058)	0.095 * (0.091)	0.050 (0.166)

β_2	Urban	Suburb	Rural
Exchanging Information²	0.000 (0.762)	-0.003 (0.662)	0.000 (0.945)
Working Together²	-0.004 ** (0.024)	0.001 * (0.075)	0.004 ** (0.015)
Providing Financially²	-0.010 *** (0.007)	-0.033 ** (0.013)	-0.022 *** (0.010)
Leading²	-0.001 (0.805)	-0.010 (0.664)	-0.009 (0.691)



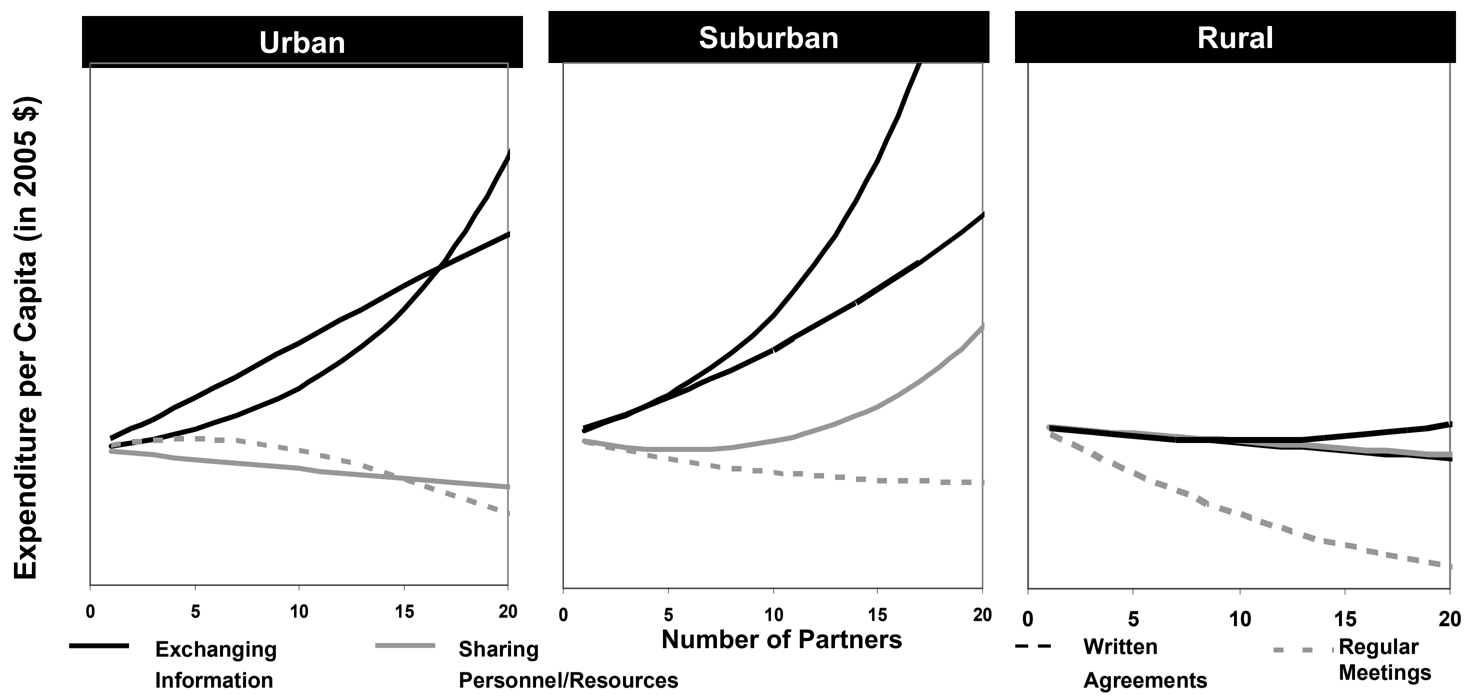
Note. Subscript *i* indicates local health department *i*. **Bold** denotes vectors. *ln(expcap)* is the logarithm of Expenditure per Capita, the dependent variable in all models. **urb**: Urbanization (dummies: urban, suburban, rural); **act**: Total Number of Partnerships Engaged by Activity (In 2005, Exchanging Information, Working Together, Providing Financially, and Leading); **X**: Vector of Control Variables; **e**: Error Term.

Figure 6.2: 2005 Total Number of Partners by Activity: Model and Results

$\ln(expcap_i) = \beta_0\ \mathbf{urb}_i + \beta_1\ \mathbf{urb}_i\ \mathbf{act}_i + \beta_2\ \mathbf{urb}_i\ \mathbf{act}_i^2 + \delta\ \mathbf{X}_i + e_i$

β_0 Urban	β_0 Suburban	β_0 Rural
2.752 *** (0.000)	2.852 *** (0.000)	2.916 *** (0.000)

	β_1 Urban	β_1 Suburban	β_1 Rural		β_2 Urban	β_2 Suburban	β_2 Rural	
	0.017 (0.265)	0.039 * (0.058)	-0.011 (0.395)	Exchanging Information	0.002 (0.576)	0.002 (0.545)	0.000 (0.820)	Exchanging Information^2
	-0.016 (0.415)	-0.033 (0.301)	-0.01 (0.620)	Sharing Resources	0.000 (0.890)	0.003 (0.652)	0.000 (0.985)	Sharing Resources^2
	0.067 *** (0.005)	0.045 *** (0.001)	-0.020 ** (0.019)	Written Agreements	-0.001 (0.778)	0.000 (0.961)	0.001 (0.924)	Written Agreements^2
	0.028 (0.143)	-0.038 * (0.067)	-0.060 (0.325)	Regular Meetings	-0.003 (0.236)	0.001 (0.396)	-0.002 (0.430)	Regular Meetings^2



Note. Subscript *i* indicates local health department *i*. **Bold** denotes vectors. *ln(expcap)* is the logarithm of Expenditure per Capita, the dependent variable in all models. **urb**: Urbanization (dummies: urban, suburban, rural); **act**: Total Number of Partnerships Engaged by Activity (In 2008, Exchanging Information, Sharing Personnel/ Resources, Written Agreement, and Regular Meetings.); **X**: Vector of Control Variables; **e**: Error Term.

Figure 6.3: 2008 Total Number of Partners by Activity: Model and Results

$p < 0.05$). Instead, media has a positive association for only rural health departments, while negative for the others ($p < 0.1$).

6.4. Discussion

Robust multiple regression models have enabled resolution of our originally posed research questions building upon previous evidence of significant revenue differences by collaboration patterns (Chapter 6). We now revisit these research questions to facilitate discussion of our results.

Are local health department revenues and collaboration significantly related? If so, how?

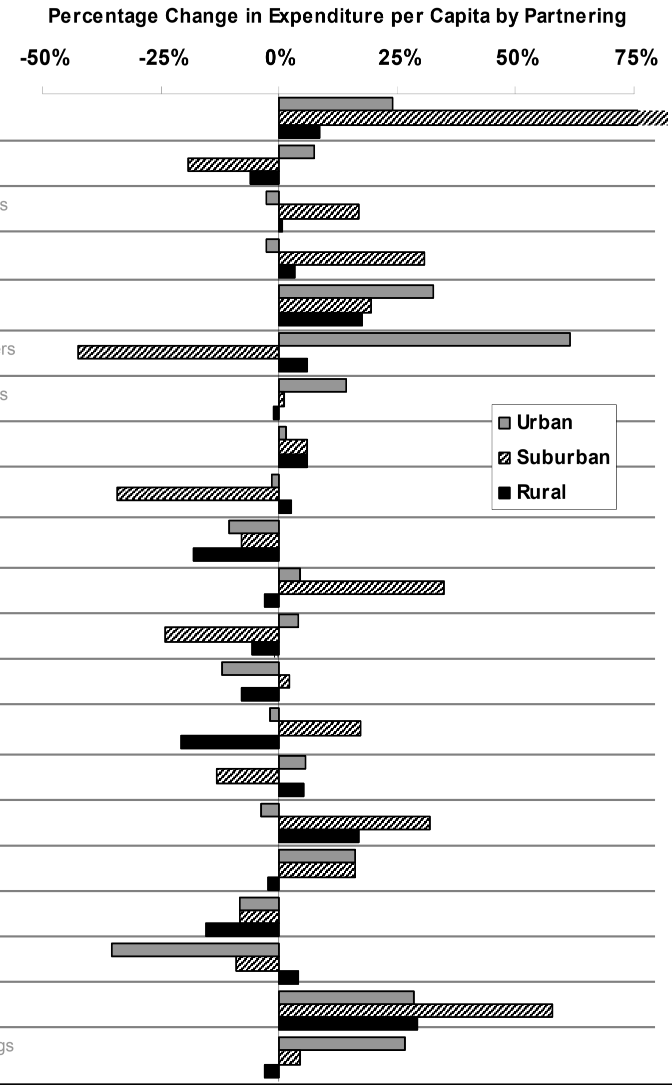
Yes, we find that collaboration is indeed significantly related to revenues with expenditure per capita serving as proxy. Varda *et al.* (2008) remark on the current disconnect between "the cost of collaboration and evidence of its benefit," noting the resulting opportunities for "measurement, innovation, and improvement." Inherent in our research linking revenue and expenditure per capita is not merely quantitative evaluation of the financial benefits of collaboration but also its financial costs. More specifically, we find that the total number of partnerships, number of partners engaged by activity, and specific partners each have varying but significant relationships with revenues (expenditure per capita), which further vary by local health department urbanization. Where previous quantitative public health collaboration research emphasizes the importance of the number of partners and types of activities instead of a binary view of collaboration (e.g., Beatty, Harris, and Barnes 2010; Bazzoli *et al.* 1997), our findings expand their conclusions.

Research has found expenditure to be associated with population size (Gordon, Gerzoff, and Richards 1997) and essential public health service performance (Mays *et al.* 2004), and expenditure variation to be related with federal and state funding (Levi, Juliano, and Richardson 2007), governing structures, and administration (Mays and Smith 2009), though much remains unexplained. Our findings add to the current

$$\ln(expcap_i) = \beta_0\ \mathbf{urb}_i + \beta_1\ \mathbf{urb}_i\ \mathbf{part}_i + \delta\ \mathbf{X}_i + e_i$$

Urban	Suburban	Rural
1.551*** (0.000)	0.792*** (0.000)	2.394*** (0.000)

Partner	Urban	Suburban	Rural
Hospitals	0.215 (0.284)	1.706*** (0.000)	0.081 (0.356)
Medical Groups	0.073 (0.519)	-0.212 (0.425)	-0.062 (0.750)
Community Health Ctrs	-0.029 (0.717)	0.154 (0.316)	0.006 (0.934)
Other Providers	-0.027 (0.786)	0.268 (0.656)	0.034 (0.901)
Health Insurers	0.283*** (0.000)	0.179*** (0.000)	0.161*** (0.000)
Emergency Responders	0.479* (0.056)	-0.553** (0.043)	0.058 (0.148)
Development Agencies	0.132 (0.121)	0.011 (0.300)	-0.011 (0.298)
Housing Agencies	0.014 (0.888)	0.059 (0.908)	0.057 (0.786)
Utilities	-0.014 (0.847)	-0.418*** (0.007)	0.024 (0.942)
Environmental Orgs	-0.11 (0.230)	-0.081 (0.367)	-0.201** (0.039)
Coop Extensions	0.044 (0.588)	0.3 (0.492)	-0.031 (0.832)
Schools	0.041 (0.889)	-0.278 (0.640)	-0.06 (0.960)
Parks & Recreation	-0.128 (0.226)	0.021 (0.470)	-0.081 (0.312)
Transportation	-0.021 (0.792)	0.16 (0.368)	-0.233** (0.022)
Faith Communities	0.054 (0.670)	-0.14 (0.605)	0.049 (0.819)
Libraries	-0.039 (0.609)	0.275* (0.094)	0.155 (0.186)
Universities	0.149 (0.125)	0.15 (0.198)	-0.023 (0.294)
Business	-0.088 (0.429)	-0.088 (0.581)	-0.166* (0.088)
Media	-0.435 (0.027)	-0.095 (0.082)	0.040 (0.083)
Tribal Government	0.250 (0.016)	0.455 (0.001)	0.255 (0.001)
Community-Based Orgs	0.236 (0.139)	0.045 (0.331)	-0.031 (0.318)



Note. Subscript *i* indicates local health department *i*. **Bold** denotes vectors. *ln(expcap)* is the logarithm of Expenditure per Capita, the dependent variable in all models. **urb**: Urbanization (dummies: urban, suburban, rural); **part**: Partner Vector; **X**: Vector of Control Variables; **e**: Error Term.

Figure 6.4: Partners: Model and Results

body of public health finance literature by exploring and confirming this association between revenues (expenditure per capita) and collaboration patterns. Furthermore, in helping to explain revenue (expenditure per capita), collaboration may be a mechanism for evening out disparities and variation in revenues and resources across local health departments. Doing so may also impact and even out variation in public health capacities and capabilities throughout the country.

Is this relationship significantly different between rural, suburban, and urban local health departments?

Yes, results indicate that local health department urbanization plays an important role in the relationship between collaboration and revenue (expenditure per capita). In fact, urbanization is found to play a moderating role, that is, the relationship between expenditure per capita and collaboration is found to be different and varied depending upon whether the local health department is urban, suburban, or rural.

Beyond the empirical differences in expenditure per capita and collaboration patterns cited in recent literature (Chapter 6; Beatty, Harris, and Barnes 2010), urbanization may signify important differences that are critical in understanding how collaboration is related to revenue. For instance, consider rural local health departments. We find that rural departments have more activities and partners significantly associated with decreased revenue (expenditure per capita). These findings indicate that it may be especially important for such rural departments to be strategic when engaging collaboratively. For these departments, scarcity of human resources, greater employee shortages, lower levels of insurance coverage, less economies of scale, weaker technical infrastructure, insubstantial transportation infrastructure, and more geographic and social isolation (Wholey, Gregg, and Moscovice 2009) are all characteristics that may cause collaborative activities to be more costly. Therefore, in rural areas collaboration may require significant care and strategy.

Moreover, Wholey, Gregg, and Moscovice (2009) note that community size may influence the role of local health departments, specifically that rural (i.e., smaller) communities "tend to have fewer organizations available to address local health needs

and may be more reliant on their [local health department] to take on that role" and that in urban (i.e., larger) communities "public health systems may fragment into specialized collaborations" for specific purposes (e.g., child health). These authors speculate that as community size increases, local health departments play a less central a role in collaborations. Our findings do indicate leading as a significant activity. However, the magnitude of the association between leading and revenue (expenditure per capita) does not follow their assertion, but rather suburban departments exhibit the strongest positive association with revenue (expenditure per capita) and urban the weakest.

Are more partners always better or is there a "sweet spot"?

No, engaging with more partners is not always better and there is not always a "sweet spot." Although modeling collaboration as the total number of partners engaged in any activity did give evidence of a nonlinear relationship with expenditure per capita, there is no evidence that this relationship is concave. Instead, the optimal number of partners depends on the activities of engagement. Thus, discriminating by activities reveals that how a local health department engages in these partnerships is crucial. When discriminating by types of activities, this concave "sweet spot" shape emerges for some activities, while others show to be strictly increasing or decreasing in the number of partnerships.

For instance, consider the activity of financial provision (2005) where results indicate that urban departments should optimally provide financially to six partners, suburban two, and rural three. Research shows that partnerships involving financial provision may experience challenges and conflicts with partners (Roussos and Fawcett 2000). Thus, partnerships where the local health department is providing financially may be more taxing in terms of time and energy, which may explain our finding of diminishing returns in the number of partnerships involving financial provision. Therefore, the number of partnerships by activity is an important measure to account for collaboration and considerations should be given to the difficulty and effort required of different collaborative activities.

How should local health departments collaborate strategically? That is, how many partners should a local health department engage? Who should local health departments partner with and how?

In response to Chapter 5 that asserts the necessity of asking "Who?," "With whom?," and "How?" when investigating collaboration, we provide differentiated and quantitatively grounded collaboration portfolio recommendations to rural, suburban, and urban local health departments. Thus, based upon our quantitative models and results, this research can offer guidance to local health departments on how to collaborate strategically. Specifically, this research makes suggestions regarding number of partnerships, particularly by activity, and which partners. These suggestions are based upon mean coefficient estimates from our models and all suggestions are considering the goal of revenue generation. The number of partners per activity is recommended based on optimizing over the quadratic forms of Models 2 and 3 for each activity. Similarly, partner recommendations are based on Model 4. The recommended partners are based on significant positive associations with revenue (expenditure per capita), and, likewise not recommended partners are based on negative associations.

We emphasize that these recommendations exclusively consider collaboration for the goal of revenue generation. Of course, there are many reasons for local health departments to engage in collaboration and revenue generation only presents one. We emphasize that the methods and concepts we utilize to generate recommendations are applicable to a wide variety of local health department goals, specifically our use of quantitative data to ensure relevance and significance, consideration of urbanization as a significant moderating local health department characteristic, and multifaceted and broad incorporation of collaboration including the number of partnerships, collaborative activities, and specific partners (congruent with Chapter 5).

6.5. Limitations

The data used imposes several limitations. One limitation has already been mentioned, namely the lack of direct revenue data, which we proxy with expenditure

data, as is standard. Furthermore, we obtain collaboration data from specific NACCHO profile modules, and, therefore, only consider samples that contain data in this module. These survey modules are not distributed to the same local health departments in each year. Therefore, these samples cannot be used to create a panel data set, although such a panel would be useful for causal inference and greater statistical significance. The 2005 and 2008 collaboration questionnaires do contain some similar activities, such as "exchanging information" and "providing financial resources" in 2005 and "sharing personnel/resources" in 2008. However, due to the distinct nature of the survey questionnaires in 2005 and 2008, inferences comparing the two cannot be readily made. Changes between the years, including maturing of partnerships, may also have influences that we are unable to capture and for which we cannot draw any conclusions. Another limitation is noted by several public health scholars, which is the absence of data regarding the spending of other health-related organizations, such as hospitals and community organizations (Mays, Halverson, and Kaluzny 1998; Mays and Smith 2009). These organizations are certainly important in understanding the community and collaboration landscape around public health resources within a community.

6.6. Conclusion

This research provides insights into lingering academic questions regarding the tradeoffs of collaboration benefits and costs and persistent practitioner dilemmas regarding strategy in collaboration. Furthermore, this research gives evidence that collaboration and revenues (expenditure per capita) are related, and that collaboration portfolios can be managed strategically to help local health departments gain revenue for public health. Consequently, we conclude that approaching collaboration strategically is extremely valuable and, as this study shows, potentially lucrative. Furthermore, both local health department urbanization and collaboration patterns - number of partnerships, number of partners per collaborative activity, and specific partners - are all important in further understanding this relationship and collaborating strategically.

Overall, more research efforts are needed to understand the public health system.

In fact, Honoré and Amy (2007) urge an agenda to advance public health and public health finance. They specifically cite innovative revenue generation strategies as key in future research efforts and such strategies are precisely where this research fits, building upon a quantitative base to understand the relationship between revenues (expenditures per capita) and collaboration patterns. Connecting collaboration and revenue in this way not only presents local health departments with an innovative revenue generation idea but also offers a viable objective for collaboration: strategic collaboration for revenue generation. That is, local health departments can manage the partners and activities in which they chose to engage with the goal of generating additional resources for public health programs and services

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Chapter 7

Operations Management in Public Health: Conclusions and Future Directions

Honoré and Amy (2007) cite innovative revenue generation strategies as key in future public health research efforts, and such strategies are precisely where this research fits, building upon a quantitative base of understanding the relationship between revenues (expenditures) and collaboration patterns. Supplementing current public health *finance* research of expenditure differences across local health departments, we examined the relationship between expenditures and collaboration. Supplementing current public health *collaboration* research, we linked expenditures and collaboration patterns adding to the understanding of the effects of local health department collaboration. Furthermore, local health departments partner with many nonprofit organizations, which was a prominent consideration of this research. This study examined nonprofit collaboration from the partner perspective, which is both a unique and important contribution. Understanding the relationship between collaborating with nonprofits and local health department expenditures also sheds light on how nonprofits shape their communities and the delivery of local health services.

7.1. Looking Back: Descriptive and Econometric Analyses

In the foundational statistical analysis in Chapter 5, we find that significant increases in mean expenditure per capita (a proxy for revenue) occurred between 2005 and 2008. Furthermore, differences in mean expenditure per capita were found among local health departments based upon urbanization, mainly if the department is rural or urban. Looking to collaboration, it was found that mean expenditure per capita varied by both activities and partners, together and separately. Thus, we conclude that just as scholars must expand their concept of collaboration to incorporate setting, partners, activities, and combinations of these, practitioners must also ask "Who," "With whom," and "How?" when approaching their own collaboration portfolios. Ultimately, such research and practice focused on strategic collaboration may well help local health departments to leverage additional resources and better meet the needs of their communities.

Given this discussion, local health department urbanization and collaboration patterns (specifically with whom *and* how a local health department collaborates) are both important in recognizing and interpreting variation in expenditure per capita across local health departments as is time. Furthermore, these are both important in understanding the relationship between expenditures per capita and collaboration We add to the literature by showing that *patterns* of collaboration are important - beyond a binary view of collaboration and beyond just types of collaboration.

Extending the analysis to econometric models in Chapter 6, we found that collaboration is indeed significantly related to expenditure per capita, our proxy for local health department revenues. Results here also indicated that local health department urbanization plays an important role in the relationship between collaboration and expenditure per capita, reinforcing the conclusions from Chapter 5. In fact, local health department urbanization was found to play a moderating role in this relationship, that is, the relationship between expenditure per capita and collaboration was found to be different and varied depending upon local health department urbanization. Just as

collaboration is multifaceted so is this relationship across different models of collaboration, including the total number of partnerships, number of partners by activity, and specific partners. Such diverse relationships between revenue and collaboration models suggest that strategic management of local health department collaboration portfolios is not straightforward but of the upmost importance. We conclude that such strategic collaboration is possible, particularly for the goal of revenue generation and in this chapter offered guidance on how local health departments should collaborate strategically, specifically how many partners, which partners, and which activities, based upon quantitative evaluation of the relationship between revenues and collaboration.

7.2. Looking Ahead: Optimization

Collaboration certainly has the potential to help local health departments gain revenue for public health. Analysis of the relationship between local health department collaboration patterns and expenditure per capita has yielded many conclusions. Yet the important question remains: "How does a local health department make sense of their community network and collaborate strategically to improve their revenues?" "Optimization," as outlined in Chapter 4, has the goal of answering this question for local health departments through the development of an optimization framework and tool that will recommend collaboration strategies with the goal of revenue generation.

While literature has drawn conclusions regarding factors critical in collaboration, strategies taking advantage of such conclusions are still lacking, thus the development of collaboration strategies with the goal of revenue generation based upon the analysis presented here in Chapters 4 through 6 will be yet a further unique contribution to existing literature. One simple example of such collaboration strategies and optimization concepts is found in *Example: Optimizing Across Partners* located within this chapter. The methods devised for optimization and strategy generation will be able to be used with a large variety of data resulting in the development of local health department collaboration strategies for a variety of corresponding goals, such as emergency preparedness and specific health outcomes.

Example: Optimizing Across Partners

A simplified example solution to this problem is the reduced optimization problem of merely optimizing over partners, that is, maximizing $\ln(expcap_i) = \beta_0 + \beta_1 \overrightarrow{part}_i + \overrightarrow{\delta}_i \overrightarrow{X}_i + e_i$. This yields a simple bipartite graph matching problem where one half of the graph is the local health department and the other its potential partners. Using the coefficient estimates from this basic partners model and ranking the resulting recommended partners in order of their associations with expenditure per capita yields the recommended partners displayed in Figure 7.1. Worst-case and best-case models leverage the p-values and confidence intervals on our coefficient estimates. The worst-case (best-case) scenario employs the lower (upper) bounds of the confidence interval estimates of the coefficients. These worst-case and best-case scenarios capture additional important recommendations. Specifically, local health departments should most certainly collaborate with tribal governments and health insurers, who are each listed as recommended partners even in the worst-case scenario. However, they should NOT collaborate with utilities and media, as they are not listed as partners even in the best-case scenario.

Worst-Case	Average	Best-Case
Tribal Government	Tribal Government	Schools
Health Insurers	Health Insurers	Tribal Government
	Hospitals	Health Insurers
	Medical Groups	Hospitals
	Coop Extensions	Medical Groups
	Libraries	Emergency Responders
	Housing Agencies	Coop Extensions
	Universities	Community-Based Orgs
	Development Agencies	Libraries
	Faith Communities	Faith Communities
	Community Health Ctrs	Housing Agencies
	Emergency Responders	Development Agencies
	Community-Based Orgs	Universities
	Other Providers	Other Providers
		Community Health Ctrs
		Transportation
		Business
		Parks & Recreation
		Environmental Orgs

Figure 7.1: Recommended Partners

7.3. Future Considerations

The optimization framework should be tailored and reflect consideration for specific local health department characteristics. Thus, our previous research in Chapters 5 and 6 provides a strong empirical foundation for this optimization framework to build upon. Moreover, the framework should be easy to use and implement for local health department leaders and those advising them, such as the Centers for Disease Control.

In developing more advanced solutions, this research concludes that it is crucial for any optimization framework to reflect local health department characteristics and collaboration patterns. Furthermore, if possible it should also incorporate potential synergies among partners, activities, and combinations of these; the optimization framework should consider the association with expenditure per capita of a given collaboration pattern as a whole. For instance, it might be the case that partnering with both of two particular partners is *additionally* associated with expenditure per capita in comparison to partnering with either alone. Future research to incorporate collaboration patterns and synergies would be insightful, and the development of a corresponding tool has great potential to affect local health department decision making regarding collaboration. Such a problem builds upon the basic bipartite graph setting of the optimization framework here. However, incorporating such patterns and synergies would yield a hypergraph.

The platform restrictions and using only local computers may pose a significant limitation on such research lines. Such optimization over a hypergraph computationally taxing. Consequently, efficient optimization algorithms would need to be developed to bound memory usage. Each edge of such a hypergraph must be weighted for optimization, but the limitations of the supporting data and statistical analysis are considerably restrictive. Since our data prevents econometric analysis of such complexity and quantity of explanatory variables, development of alternatives for leveraging the data to draw inferences regarding associations between collaboration patterns and synergies and expenditures per capita is necessary. One such alternative is to use correlation coefficients to weight the edges where nonparametric correlation measures may be particularly insightful, such as Spearman's correlation coefficient that only assumes a monotonic relationship between the two variables.

Such a network hypergraph optimization is not only complicated, but it may indeed produce a problem that is quite literally too hard. Thus, while the simple example found in this chapter (*Example: Optimizing Across Partners*) oversimplifies our problem, optimizing a hypergraph for synergies may overcomplicate it. A middle ground must be found that incorporates an appropriate level of complexity to

be applicable while remaining simple enough to implement. For example, one middle ground solution may be to incorporate uncertainty into the optimization. That is, Basing collaboration strategies and optimized solutions on econometric models presents the challenge of incorporating uncertainty into the optimization and subsequent recommendations. Econometric models themselves communicate the level of estimate uncertainty through information such as p-values and confidence intervals. Thus, while stochastic, the econometric estimates have known distributions. Stochastic programming or multi-bandit formulations may prove helpful in incorporating such uncertainty.

7.4. Conclusions

In addition to contributions in the public health and nonprofit bodies of research, this research contributes to current operations management literature at the intersection of operations management and health literature, expressly at the intersection of collaboration, health care, and operations management research streams, as one of the first to focus on the local public health setting. Such a localized setting presents interesting challenges and opportunities. Furthermore, this research combines empirical and theoretical operations methods. It fits within an area of great potential impact, specifically research that combines operations research methods and optimization with real-world data. Such a combination is potently applicable, yet, as we demonstrate, can remain true to the academic rigor of our field. Ultimately, such research and practice focused on strategic collaboration may well help local health departments to leverage additional resources and better meet the needs of their communities.

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Chapter 8

Concluding Remarks and Future Work

As mentioned in the Introduction, this dissertation lies at the intersection of operations management and nonprofit and philanthropic studies. There exist both similarities and differences between the traditional for-profit settings of operations management and those in the nonprofit sector. These similarities yield a potential for relevance and value of operations research techniques applied in the nonprofit sector, while the differences expose a fertile frontier for future research where our traditional solutions are no longer directly applicable. The research contained in this dissertation open up a host of very exciting future research potential.

Chapter 2 contains an abundance of future research directions. For example, foundation funding portfolio optimization offers opportunities to increase the power of philanthropic dollars in doing good by appropriately incorporating and maximizing over risk, reward, and a portfolio of grantees. Even this exciting research is intermingled with other research potential, such as performance measurement and evaluation of social goals and nonprofit means.

In looking at funder-nonprofit relationships and funding structures (Chapter 3), I am interested to work with funders to better understand the grant-making process to see if the contracts we propose Chapter 3 would be applicable and to explore other

possibilities of improving this contractual relationship. One example is the use of long-term or multi-year contracts. The use of a long-term contract may enable the funder to more precisely develop beliefs about the nonprofits as well as incentivize the nonprofits through future allocations. Issues such as commitment, renegotiation and breach of contract will need to be considered when analyzing these contracts. Thus, it is important to collaborate with funding organizations and to better understand mechanisms currently employed and challenges.

There are several very natural extensions to the work in public health systems research (Chapters 4-7). Using the same data, it would be interesting to find measures or proxies for performance of local health departments to see the effects of collaboration and partnership patterns on performance and whether performance is different from simple revenue. This will provide more insight into the true effects of collaboration in the system of local health departments and lead to collaboration strategies that will improve performance and consequently overall care.

The nonprofit sector is a significant and growing part of today's economic fabric and it is ripe with opportunity for research and application that can result in a more efficient nonprofit sector, leading to a better economy and increased social welfare. Operations management has not traditionally been applied to the nonprofit sector, especially outside of the humanitarian/disaster relief area. While traditional operations management models and solutions cannot simply be cut and paste, there does exist a wealth of potential cross-sectoral learning with significant societal impact. The nonprofit sector is ripe with opportunity for operations management research and application; This dissertation represents some of the first fruits. Such research can result in more efficient supply chains and improved decision making for all nonprofit organizations with the most important effect of changed lives.

Appendix A

Chapter 3 Proofs

Proof of Theorems 1 and 4: We use backward induction to solve each stage of the sequence of events outlined in Section 3.3. The nonprofit i maximizes his utility based on the given allocation:

$$\max_{e_i \geq 0} \; u_i = \max_{e_i \geq 0} \left\{ A_i - \frac{e_i^2}{2} + y_i \right\} \qquad \text{subject to} \quad y_i \;=\; 2\sqrt{e_i \theta_i A_i}.$$

Substituting the production function into nonprofit i's utility function, we obtain $u_i = A_i - \frac{e_i^2}{2} + 2\sqrt{e_i \theta_i A_i}$. Using the first-order condition to determine the effort, e_i^*, that maximizes nonprofit i's utility, we get

$$\frac{du_i}{de_i} = -e_i + \frac{A_i \theta_i}{\sqrt{e_i \theta_i A_i}} = 0 \quad \Rightarrow \quad e_i^* = (A_i \theta_i)^{1/3}.$$

The second-order condition shows that the e_i^* found above is a unique maximizer as the utility function is strictly concave: $\frac{d^2 u_i}{de_i^2} = -1 - \frac{A_i \theta_i}{2e_i \sqrt{e_i \theta_i A_i}} < 0$ since $\theta_i \geq 0$, $A_i \geq 0$, and $e_i \geq 0$. Then substitution gives output, $y_i^* = 2(A_i \theta_i)^{2/3}$, and utility, $u_i^* = A_i + \frac{3}{2}(A_i \theta_i)^{2/3}$.

Next, we solve for the funder's allocation of her resources in order to maximize

her utility:

$$\max_{A_i(\theta_i)\geq 0} U_f = \max_{A_i(\theta_i)\geq 0} \left\{ \sum_{i=1}^{N} E_{\theta_i}[c_i y_i] + \alpha \left(B - \sum_{i=1}^{N} E_{\theta_i}\left[A_i(\theta_i)\right] \right) \right\}.$$

Using the output best-response y_i^* found above, we can reformulate the funder's problem:

$$\max_{A_i(\theta_i)\geq 0} \left\{ \sum_{i=1}^{N} E_{\theta_i}\left[(2c_i(A_i(\theta_i)\ \theta_i)^{2/3} - \alpha A_i(\theta_i)\ ) \right] + \alpha B \right\}.$$

The funder's constraints can be similarly formulated resulting in Equations (3.8) - (3.10).

First, we look to the individual rationality constraint, Equation (3.8), which we find to be redundant as $A_i(\theta_i) \geq 0$. The incentive compatibility constraint ensures nonprofits report truthfully. A nonprofit will report truthfully when his utility is maximized at his true type. Therefore, we can examine the first-order conditions of the nonprofits' utility function:

$$\frac{du_i}{d\hat{\theta}_i} = \frac{d}{d\hat{\theta}_i}\left(A_i(\hat{\theta}_i) + \frac{3}{2}\left(A_i(\hat{\theta}_i)\theta_i \right)^{2/3} \right) = \frac{dA_i(\hat{\theta}_i)}{d\hat{\theta}_i} + \frac{\theta^{2/3}}{A_i(\hat{\theta}_i)^{1/3}} \frac{dA_i(\hat{\theta}_i)}{d\hat{\theta}_i} = 0.$$

The solution to this differential equation under the constraint that $A_i(\theta_i) \geq 0$ for all θ_i is $A_i(\theta_i) = A_i$ where A_i is some constant. Therefore, the funder cannot differentiate the types based on this simple contract because the incentive compatibility constraint only holds with equality and that at a constant allocation, $A_i(\theta_i) = A_i$. Accordingly, A_i is used throughout the remainder of this proof.

Next, we use the Karush-Kuhn-Tucker (KKT) conditions to accommodate the

budget constraint. The KKT conditions are

$$\begin{aligned}
\frac{4}{3}c_i A_i^{-1/3} E[{\theta_i}^{2/3}] - \alpha - \lambda &\leq 0 \qquad \forall i \quad \text{[C1]} \\
A_i \left(\frac{4}{3}c_i A_i^{-1/3} E[{\theta_i}^{2/3}] - \alpha - \lambda \right) &= 0 \qquad \forall i \quad \text{[C2]} \\
\sum_{i=1}^{N} A_i - B &\leq 0 \qquad \text{[C3]} \\
\lambda(B - \sum_{i=1}^{N} A_i) &= 0 \qquad \text{[C4]} \\
\lambda, A_i &\geq 0 \qquad \forall i \quad \text{[C5, C6]}
\end{aligned}$$

where λ is the Lagrange multiplier from the budget constraint. The objective function is strictly concave. To show this, we can take the negative of the objective function and show convexity by the Hessian matrix being positive semi-definite, which follows directly as:

$$\frac{d^2(-U_f)}{dA_i^2} = \frac{4}{9}c_i E[{\theta_i}^{2/3}] A_i^{-4/3} \geq 0 \qquad \forall i \quad \text{and} \quad \frac{d^2(-U_f)}{dA_i dA_j} = 0 \geq 0 \qquad \forall i \neq j.$$

This along with the budget constraint being linear provide that the KKT conditions are both necessary and sufficient.

It can first be noted that we must have $A_i > 0$ by these conditions. Thus, condition [C1] will hold with equality. Solving for A_i as a function of λ from condition [C1] above (holding with equality), we obtain $A_i(\lambda) = \frac{64 c_i^3 E[{\theta_i}^{2/3}]^3}{27(\alpha+\lambda)^3}$. Now there are two possibilities to consider: $\lambda = 0$ and $\lambda > 0$, which correspond to the cases of a solution unconstrained and constrained by the budget respectively.

We will first explore the unconstrained case. For this case when $\lambda = 0$, we have that the unconstrained solution to the Report-Based Contract is as follows:

$$A_i^R(\theta_i) = A_i^R = \frac{64}{27}\phi_i^3 E[{\theta_i}^{2/3}]^3$$

where $\phi_i = c_i/\alpha$.

For the case when $\lambda > 0$, i.e., the constrained case where $B - \sum_{i=1}^{N} A_i = 0$, we obtain $(\alpha+\lambda)^3 = \frac{64}{27B}\sum_{i=1}^{N} c_i^3 E[{\theta_i}^{2/3}]^3$, resulting in the following constrained solution for the Report-Based Contract:

$$A_i^{RC}(\boldsymbol{\Theta}) = A_i^{RC} = \frac{B}{\Omega} c_i^3 E[{\theta_i}^{2/3}]^3$$

where $\Omega = \sum_{i=1}^{N} c_i^3 E[{\theta_i}^{2/3}]^3$. This concludes the proof of Theorems 1 and 4. ■

Proof of Lemma 1: Since our goal is to achieve first-best under truthful revelation of efficiency types (i.e., incentive compatibility), we use first-best allocations from the outset. We suppress the subscript i for expositional simplicity.

To identify a penalty which enforces incentive compatibility, we first consider the Audit IC constraint from Equation (3.11) with unconstrained first-best allocations from Corollary 1:

$$\begin{aligned} \frac{64c^3}{27\alpha^3}\theta^2 + \frac{3}{2}\left(\frac{64c^3}{27\alpha^3}\theta^2\theta\right)^{2/3} &\geq \frac{64c^3}{27\alpha^3}\hat{\theta}^2 + \frac{3}{2}\left(\frac{64c^3}{27\alpha^3}\hat{\theta}^2\theta\right)^{2/3} - P\,\frac{64c^3}{27\alpha^3}\hat{\theta}^2 \\ \Rightarrow\; P &\geq \frac{1}{8c\hat{\theta}^2}\left(-8c\left(\theta^2 - \hat{\theta}^2\right) - 9\theta^2\alpha + 9\theta^{2/3}\hat{\theta}^{4/3}\alpha\right) \equiv \Psi_U. \end{aligned}$$

We seek to maximize this expression, Ψ_U, with respect to both θ and $\hat{\theta}$ to find a P^* that enforces the Audit IC constraint above regardless of θ and $\hat{\theta}$, that is, regardless of a nonprofit's true and reported type. We can reformulate the expression Ψ_U in terms of the ratio $T \equiv \frac{\theta}{\hat{\theta}}$:

$$\Psi_U = 1 - \left(\frac{\theta}{\hat{\theta}}\right)^2 - \frac{9\alpha}{8c}\left(\frac{\theta}{\hat{\theta}}\right)^2 + \frac{9\alpha}{8c}\left(\frac{\theta}{\hat{\theta}}\right)^{2/3} = 1 - T^2 - \frac{9\alpha}{8c}T^2 + \frac{9\alpha}{8c}T^{2/3}.$$

Now we can maximize the reformulated expression with respect to one variable, the ratio T. The first-order condition and resulting solution are $-2T - \frac{9\alpha T}{4c} + \frac{3\alpha}{4cT^{1/3}} = 0 \Rightarrow T = \left(\frac{3\alpha}{8c+9\alpha}\right)^{3/4}$. The second-order condition testing concavity is $-2 - \frac{9\alpha}{4c} - \frac{9\alpha}{4cT^{4/3}} < 0$, which holds true. This indicates the function is indeed concave and thus the solution of the first-order condition is a global maximum. Substitution of

the first-order condition solution into the Ψ_U equation gives the solution: the penalty $P^* = 1 + \frac{3}{4\phi\sqrt{\frac{8\phi}{3}+3}}$ will enforce the incentive compatibility and the first-best allocations and performance. We note that this penalty is not unique; any penalty greater than P_i^* will also achieve incentive compatibility, truthful efficiency reports, and thus first-best allocations. This completes the proof of Lemma 1. ■

Proof of Theorem 2: The proof of Theorem 2 directly follows from the definition of Audit-Based Contracts and Lemma 1 and Corollary 1. ■

Proof of Corollary 2: Corollary 2(i) follows clearly from $\phi_i > 0$. Corollary 2(ii) follows from the negative first derivative of P_i^* with respect to ϕ_i. This completes the proof of Corollary 2. ■

Proof of Lemma 2: Since our goal is to achieve first-best under truthful revelation of efficiency types (i.e., incentive compatibility), we use first-best allocations from the outset. We supress the subscript i for expositional simplicity and note that $\phi = c/\alpha$. We first consider the case of an unconstrained budget followed by the constrained case.

We first consider the Audit IC constraint (Equation (3.11)) using first-best allocations to identify the type θ that satisfies this constraint with equality.

$$\begin{aligned} LHS(\theta) &= \frac{64c^3}{27\alpha^3}\theta^2 + \frac{3}{2}\left(\frac{64c^3}{27\alpha^3}\theta^2\theta\right)^{2/3} \\ &= \frac{64c^3}{27\alpha^3}\hat{\theta}^2(1-P) + \frac{3}{2}\left(\frac{64c^3}{27\alpha^3}\hat{\theta}^2\theta\right)^{2/3} = RHS(\theta,\hat{\theta}) \end{aligned} \tag{A.1}$$

where $LHS(\theta)$ and $RHS(\theta,\hat{\theta})$ are the left- and right-hand sides of the Audit IC constraint (Equation (3.11)), respectively. The simplified Audit IC constraint holding with equality is $8c\left(\hat{\theta}^2(P-1)+\theta^2\right) + 9\theta^2\alpha = 9\hat{\theta}^{4/3}\theta^{2/3}\alpha$.

Using the utility maximizing report of the nonprofit for $\hat{\theta}$, which is equal to 1,

and solving for θ yields

$$\begin{aligned}\theta^*(P) &= \left\{\theta | 8\phi\left(P-1+\theta^2\right)+9\theta^2 = 9\theta^{2/3}\right\} \\ &= \frac{1}{\eta^{9/2}}\left(9\eta^6\xi^{1/3}+8\eta^8\phi-8P\eta^8\phi+4\eta^5\xi^{2/3}\right. \\ &\qquad \left.\phi-4P\eta^5\xi^{2/3}\phi-\xi^{2/3}\sqrt{\eta^9\left(-27+16(-1+P)^2\eta\phi^2\right)}\right)^{1/2}\end{aligned}$$

where $\phi = c/\alpha$, $\eta = 9+8c$, and $\xi = -4(-1+P)\eta^5\phi + \sqrt{\eta^9\left(-27+16(-1+P)^2\eta\phi^2\right)}$.

The following results describe the behavior of the $LHS(\theta)$ and $RHS(\theta,\hat{\theta})$ from Equation (A.1):

(i) $LHS(\theta)$ is strictly increasing in θ: $\frac{dLHS(\theta)}{d\theta} = \frac{16}{27}\theta\phi^2(9+8\phi) > 0 \qquad \forall\theta \in [0,1]$.

(ii) $LHS(\theta)$ is convex in θ: $\frac{d^2LHS(\theta)}{d\theta^2} = \frac{16}{27}\phi^2(9+8\phi) > 0 \qquad \forall\theta \in [0,1]$.

(iii) $RHS(\theta,\hat{\theta})$ is strictly increasing in θ: $\frac{dRHS(\theta,\hat{\theta})}{d\theta} = \frac{16\hat{\theta}^{4/3}\phi^2}{9\theta^{1/3}} > 0 \qquad \forall\theta \in [0,1]$.

(iv) $RHS(\theta,\hat{\theta})$ is concave in θ: $\frac{d^2RHS(\theta,\hat{\theta})}{d\theta^2} = -\frac{16\hat{\theta}^{4/3}\phi^2}{27\theta^{4/3}} < 0 \qquad \forall\theta \in [0,1]$.

Thus, there can be at most two possible intersections of the $LHS(\theta)$ and $RHS(\theta,\hat{\theta})$ given the constraints on our parameters discussed in Section 3.3. It can be noted

$$\begin{aligned}LHS(0) = 0 &\leq \frac{64}{27}(1-P)\phi^3 = RHS(0,1) \qquad \text{and} \\ LHS(1) = \frac{8}{27}\phi^2(9+8\phi) &> \frac{8}{27}\phi^2(9+8(1-P)\phi) = RHS(1,1)\end{aligned}$$

imply that for $0 < P < 1$ there exists only one positive intersection in $(0,1)$. For $P = 1$ there are two intersections, one positive and the other zero. We take $\theta^*(P)$ to be the positive intersection in both of these cases. This concludes the proof of Lemma 2. ■

Proof of Theorem 3: All subscripts i have been omitted for expositional simplicity.

(i) For $\theta < \theta^*(P)$: According to Lemma 2, the incentive compatibility constraint holds with equality at $\theta^*(P)$ and does not hold for $\theta < \theta^*(P)$. However, by

giving all efficiency types $\theta < \theta^*(P)$ the first-best allocation for type $\theta^*(P)$, incentive compatibility holds for these types.

(ii) For $\theta \geq \theta^*(P)$: In this region, we allocate using the first-best allocations. According to Lemma 2, incentive compatibility holds for $\theta \geq \theta^*(P)$.

This concludes the proof of Theorem 3. ■

Proof of Corollary 3: We suppress the subscript i for expositional simplicity. Following from the proof of Lemma 2, $RHS(\theta, \hat{\theta})$ and $LHS(\theta)$ are both strictly increasing in θ. Furthermore, $RHS(\theta, \hat{\theta})$ is strictly decreasing in penalty P. From these points, we note that as the penalty P increases, $RHS(\theta, \hat{\theta})$ will decrease while $LHS(\theta)$ remains constant. Thus, the intersection of $RHS(\theta, \hat{\theta})$ and $LHS(\theta)$ will decrease and, consequently, the value of θ^* will decrease as well. This leads to Corollary 3(i). Corollary 3(ii) follows directly from the negative first derivative of θ^* with respect to ϕ under the unconstrained budget case. This concludes the proof of Corollary 3. ■

Proof of Proposition 1: Dividing the funder's utility from Equation (3.6) by α we obtain $\hat{U}_f = \sum_{i=1}^{N} E_{\theta_i}\left[2\phi_i(A_i\theta_i)^{2/3} - A_i\right] + B$, which gives the following for each respective contract:

$$\begin{aligned}
\hat{U}_f^{FB} &= \sum_{i=1}^{N}\left(\frac{32}{27}\phi_i^3 E_{\theta_i}\left[\theta_i^2\right]\right) + B, \\
\hat{U}_f^{R} &= \sum_{i=1}^{N}\left(\frac{32}{27}\phi_i^3 E_{\theta_i}\left[\theta_i^{2/3}\right]^3\right) + B, \\
\hat{U}_f^{A} &= \sum_{i=1}^{N}\left(\frac{32}{27}\phi_i^3 E_{\theta_i>\theta_i^*}\left[\theta_i^2\right] + \frac{32}{9}\phi_i^3 E_{\theta_i<\theta_i^*}\left[(\theta_i^*)^{4/3}\,\theta_i^{2/3}\right] - \frac{64}{27}\phi_i^3 E_{\theta_i<\theta_i^*}\left[(\theta_i^*)^2\right]\right) + B.
\end{aligned}$$

It can be easily observed that $\hat{U}_f^{FB} \geq \hat{U}_f^{R}$ by Jensen's inequality.

We establish the result that the funder's expected utility, U_f^A, is decreasing in the cut-off type, $\theta_i^*(P_i^F)$, and consequently increasing in the penalty, P_i^F, by showing that $\hat{U}_F^A$ is decreasing in the cut-off type, $\theta_i^*(P_i^F)$, which is implied by the negative derivative of $\hat{U}_F^A$ with respect to $\theta_i^*(P_i^F)$. Since $\theta_i^*(P)$ is decreasing in the penalty, P,

$\hat{U}_f^A$ is consequently increasing in the specified penalty, P_i^F, which leads to Proposition $1(iii)$.

From this, we find that the upper bound of $\hat{U}_f^A$ (at $\theta_i^* = 0$) is equal to $\hat{U}_f^{FB}$, and, consequently, greater than $\hat{U}_f^R$, completing the proof of Proposition $1(i)$. The lower bound of $\hat{U}_f^A$ (at $\theta_i^* = 1$) is $\sum_{i=1}^N \left(\frac{32}{27}\phi_i^3 \left(3E_{\theta_i}\left[\theta_i^{2/3}\right]^3 - 2 \right) \right)$, which is less than $\hat{U}_f^R$. Thus, $\hat{U}_f^A$ is increasing in θ_i^* from its lower bound to upper bound where $\hat{U}_f^R$ lies in between these bounds such that there must exist a $\tilde{\theta}_i$ such that $U_f^A \geq U_f^R$ for $\theta_i^*(P_i^F) \in [0, \tilde{\theta}_i]$ and $U_f^R \geq U_f^A$ for $\theta_i^*(P_i^F) \in (\tilde{\theta}_i, 1]$, proving Proposition $1(ii)$. This concludes the proof of Proposition 1. ■

Proof of Proposition 2: The nonprofit population utility function, $u_N = \sum_{i=1}^N E_{\theta_i}\left[A_i + \frac{3}{2}(A_i\theta_i)^{2/3}\right]$ gives the following utilities for each respective contract:

$$\begin{aligned}
u_N^{FB} &= \sum_{i=1}^N \left(\frac{8}{3}\phi_i^2 E_{\theta_i}\left[\theta_i^2\right] + \frac{64}{27}\phi_i^3 E_{\theta_i}\left[\theta_i^2\right] \right), \\
u_N^R &= \sum_{i=1}^N \left(\frac{8}{3}\phi_i^2 E_{\theta_i}\left[\theta_i^{2/3}\right]^3 + \frac{64}{27}\phi_i^3 E_{\theta_i}\left[\theta_i^{2/3}\right]^3 \right), \\
u_N^A &= \sum_{i=1}^N \left(\frac{8}{3}\phi_i^2 \left(E_{\theta_i \geq \theta_i^*}\left[\theta_i^2\right] + E_{\theta_i < \theta_i^*}\left[(\theta_i^*)^2\right] \right) + \right. \\
&\qquad \left. \frac{64}{27}\phi_i^3 \left(E_{\theta_i \geq \theta_i^*}\left[\theta_i^2\right] + E_{\theta_i < \theta_i^*}\left[\theta_i^{2/3}(\theta_i^*)^{4/3}\right] \right) \right).
\end{aligned}$$

It can be noted that $u_N^{FB} \geq u_N^R$ by Jensen's inequality and that

$$u_N^A \geq \sum_{i=1}^N \left(\frac{8}{3}\phi_i^2 \left(E_{\theta_i \geq \theta_i^*}\left[\theta_i^2\right] + E_{\theta_i < \theta_i^*}\left[(\theta_i^*)^2\right] \right) + \frac{64}{27}\phi_i^3 E_{\theta_i}\left[\theta_i^2\right] \right) \geq u_N^{FB}$$

where the first inequality comes from the fact that $E_{\theta_i < \theta_i^*}\left[\theta_i^{2/3}(\theta_i^*)^{4/3}\right] \geq E_{\theta_i < \theta_i^*}\left[\theta_i^2\right]$ and the second inequality comes from $E_{\theta_i < \theta_i^*}\left[(\theta_i^*)^2\right] \geq E_{\theta_i < \theta_i^*}\left[\theta_i^2\right]$. It can now be easily shown that $u_N^A \geq u_N^{FB} \geq u_N^R$, which leads to Proposition $2(i)$.

Following from the nonprofit population utility function, we establish the result

that u_N^A is increasing in the cut-off type, $\theta_i^*(P_i^F)$, and consequently decreasing in the penalty, P_i^F, by proving that the derivative of u_N^A with respect to $\theta_i^*(P)$ is positive. Since $\theta_i^*(P)$ is decreasing in the penalty, P, u_N^A is consequently decreasing in the specified penalty, P_i^F, which leads to Proposition 2(ii). This concludes the proof of Proposition 2. ■

Proof of Proposition 3: The expected sector efficiency is defined as $\Pi = E\left[\frac{\sum A_i\theta_i}{\sum A_i}\right]$ in Subsection 3.6.3, which leads to the following:

$$\begin{aligned}
\Pi^{FB} &= E\left[\frac{\sum_{i=1}^N \phi_i^3\theta_i^3}{\sum_{i=1}^N \phi_i^3\theta_i^2}\right], \\
\Pi^{R} &= E\left[\frac{\sum_{i=1}^N \phi_i^3 E\left[\theta_i^{2/3}\right]^3 \theta_i}{\sum_{i=1}^N \phi_i^3 E\left[\theta_i^{2/3}\right]^3}\right], \\
\Pi^{A} &= E_{\theta_i>\theta_i^*}\left[\frac{\sum_{i=1}^N \phi_i^3\theta_i^3}{\sum_{i=1}^N \phi_i^3\theta_i^2}\right] + E_{\theta_i<\theta_i^*}\left[\frac{\sum_{i=1}^N \phi_i^3 \left(\theta_i^*\right)^2\theta_i}{\sum_{i=1}^N \phi_i^3 \left(\theta_i^*\right)^2}\right].
\end{aligned}$$

Under the assumptions of independent and identical distribution across θ_i, we use an induction argument to establish that the term in the expectation of Π^{FB} is greater than that of Π^R. Considering the monotonicity of expectation, $\Pi^{FB} \geq \Pi^R$. Under such assumptions, we have the following simplifications of Π^R and Π^A:

$$\Pi^R = E\left[\theta_i\right], \qquad \Pi^A = E_{\theta_i>\theta_i^*}\left[\frac{\sum_{i=1}^N \phi_i^3\theta_i^3}{\sum_{i=1}^N \phi_i^3\theta_i^2}\right] + E_{\theta_i<\theta_i^*}\left[\theta_i\right].$$

These simplifications show clearly that Π^A will fall between Π^{FB} and Π^R depending on the value of $\theta_i^*(P_i^F)$, where $\theta_i^*(P_i^F) = 1$ leads to $\Pi^A = \Pi^R$ and $\theta_i^*(P_i^F) = 0$ leads to $\Pi^A = \Pi^{FB}$. Proposition 3(i) and (ii) clearly follow. Consequently, as $\theta_i^*(P_i^F)$ increases, Π^A moves toward Π^R, which is a decrease. By Corollary 3, since Π^A is decreasing in $\theta_i^*(P_i^F)$, Π^A must be increasing in P_i^F leading to Proposition 3(iii). This concludes the proof of Proposition 3. ■

Proof of Lemma 3: Since our goal is to achieve first-best under truthful revelation

of efficiency types (i.e., incentive compatibility), we use first-best allocations from the outset. We suppress the subscript i for expositional simplicity.

As in the unconstrained budget case, in order to identify an incentive compatibility enforcing penalty, we first will consider the incentive compatibility constraint from Equation (3.11) with constrained first-best allocations from Corollary 4:

$$\left(\frac{B}{c^3\theta^2+Y}\right)c^3\theta^2+\frac{3}{2}\left(\frac{B}{c^3\theta^2+Y}c^3\theta^2\theta\right)^{2/3}\geq\frac{B}{c^3\hat{\theta}^2+Y}c^3\hat{\theta}^2+\frac{3}{2}\left(\frac{B}{c^3\hat{\theta}^2+Y}c^3\hat{\theta}^2\theta\right)^{2/3}$$
$$-P\,\frac{B}{c^3\hat{\theta}^2+Y}c^3\hat{\theta}^2$$
$$\Rightarrow\;\; P\geq 1+\frac{3\theta^{2/3}\left(c^3\hat{\theta}^2+Y\right)^{1/3}}{2cB^{1/3}\hat{\theta}^{2/3}}-\frac{\theta^2\left(c^3\hat{\theta}^2+Y\right)}{\hat{\theta}^2\left(c^3\theta^2+Y\right)}-\frac{3\theta^2\left(c^3\hat{\theta}^2+Y\right)}{2cB^{1/3}\hat{\theta}^2\left(c^3\theta^2+Y\right)^{2/3}}\equiv\Psi_C$$

where $Y=\sum_{j\neq i}c_j^3\theta_j^2$. A penalty which enforces incentive compatibility is one that satisfies this inequality ($P\geq\Psi_C$). One such penalty is achieved when $\theta=\hat{\theta}=1$ for all nonprofits:

$$\tilde{P}=1+\frac{3\left(\sum_{j=1}^{N}c_j^3\right)^{1/3}}{2c_iB^{1/3}}\geq 1+\frac{3\theta^{2/3}\left(c^3\hat{\theta}^2+Y\right)^{1/3}}{2cB^{1/3}\hat{\theta}^{2/3}}\geq\Psi_C.$$

Thus, the penalty $\tilde{P}$ enforces the incentive compatibility constraint, although it may not be the least of such enforcing penalties. This completes the proof of Lemma 3. ■

Proof of Corollary 5: To prove Corollary 5(i), we use contradiction: suppose $0<P_i^{C*}\leq 1$. From the proof of Lemma 4, it follows that there is at least one positive intersection of the constrained Audit IC constraint. This implies that the constrained Audit IC constraint and, consequently, incentive compatibility will not hold for all types θ_i, which contradicts the definition of P_i^{C*} from Lemma 3. Therefore, $P_i^{C*}>1$ must be true. From Ψ_C in the proof of Lemma 3, we can use first derivatives to observe that P_i^{C*} is decreasing in B (Corollary 5(ii)) and increasing in N (Corollary 5(iii)). This completes the proof of Corollary 5. ■

Proof of Lemma 4: Since our goal is to achieve truthful revelation of efficiency types

(i.e., incentive compatibility), we consider the Audit IC constraint of Equation (3.11) but now with the appropriate constrained audit allocations, $A_i^{FBC}\left(\max\left\{\boldsymbol{\Theta}, \boldsymbol{\Theta}^{\mathbf{C}*}(\mathbf{P})\right\}\right)$, where $A_i^{FBC}(\boldsymbol{\Theta})$ is defined in Corollary 4, in order to identify the type θ_i that satisfies the set of constraints with equality.

$$\begin{aligned} LHS(\boldsymbol{\Theta}) &= u_i^*\left(A^{FBC}\left(\max\left(\theta_i, \theta_i^*\right), \max\left(\boldsymbol{\Theta}_{-\mathbf{i}}, \boldsymbol{\Theta}_{-\mathbf{i}}^*\right)\right), \theta_i\right) \\ &= u_i^*\left(A^{FBC}\left(\max\left(\hat{\theta}_i, \theta_i^*\right), \max\left(\boldsymbol{\Theta}_{-\mathbf{i}}, \boldsymbol{\Theta}_{-\mathbf{i}}^*\right)\right), \theta_i\right) \qquad \text{(A.2)} \\ &\quad -PA^{FBC}\left(\max\left(\hat{\theta}_i, \theta_i^*\right), \max\left(\boldsymbol{\Theta}_{-\mathbf{i}}, \boldsymbol{\Theta}_{-\mathbf{i}}^*\right)\right) \\ &= RHS(\hat{\theta}_i, \boldsymbol{\Theta}) \qquad \text{(A.3)} \end{aligned}$$

where $LHS(\boldsymbol{\Theta})$ and $RHS(\hat{\theta}_i, \boldsymbol{\Theta})$ are the left- and right-hand sides of the Audit IC constraint. Note that using constrained audit allocations ensures that the budget constraint will be satisfied. However, in this situation it is much less straight-forward to solve for $\boldsymbol{\Theta}^{\mathbf{C}*}(\mathbf{P})$ mostly due to the externality influences of the other nonprofits' types. After replacing $\hat{\theta}_i$ with its optimal value, which is equal to 1, we can identify $\boldsymbol{\Theta}^*(\mathbf{P})$ as

$$\begin{aligned} \boldsymbol{\Theta}^{\mathbf{C}*}(\mathbf{P}) &= \{\theta_1, ..., \theta_N \,|\, LHS(\boldsymbol{\Theta}) \\ &= u_i^*\left(A^{FBC}\left(\theta_i, \max\left(\boldsymbol{\Theta}_{-\mathbf{i}}, \boldsymbol{\Theta}_{-\mathbf{i}}^*\right)\right), \theta_i\right) \\ &= u_i^*\left(A^{FBC}\left(1, \max\left(\boldsymbol{\Theta}_{-\mathbf{i}}, \boldsymbol{\Theta}_{-\mathbf{i}}^*\right)\right), \theta_i\right) \\ &\quad -PA^{FBC}\left(1, \max\left(\boldsymbol{\Theta}_{-\mathbf{i}}, \boldsymbol{\Theta}_{-\mathbf{i}}^*\right)\right) = RHS(1, \boldsymbol{\Theta})\} \qquad \text{(A.4)} \end{aligned}$$

where a "constrained budget" is defined as $\sum_{i=1}^{N} A^{FB}(\theta_i) = B$ with N as the total number of nonprofits. Equation (A.4) yields the formulation found in Lemma 4. To prove the existence of $\boldsymbol{\Theta}^{\mathbf{C}*}(\mathbf{P}) \in [\mathbf{0}, \mathbf{1}]$, we examine the end-points of Equation (A.4). When substituting $\theta_i = 0$ into Equation (A.4), simplification gives us $0 < \frac{Bc_i^3(1-P_i)}{c_i^3+Y_i}$ implying $LHS((0, \boldsymbol{\Theta}_{-\mathbf{i}})) < RHS(1, (0, \boldsymbol{\Theta}_{-\mathbf{i}}))$ where $Y_i = \sum_{j \neq i} c_j^3 \theta_j^2$. Similarly substituting $\theta_i = 1$ into Equation (A.4), simplification gives us $0 > -\frac{Bc_i^3 P_i}{c_i^3+Y_i}$ implying $LHS((1, \boldsymbol{\Theta}_{-\mathbf{i}})) > RHS(1, (1, \boldsymbol{\Theta}_{-\mathbf{i}}))$ Thus, there must exist at least one $\boldsymbol{\Theta}^{\mathbf{C}*}(\mathbf{P}) \in [\mathbf{0}, \mathbf{1}]$ such that $LHS(\boldsymbol{\Theta}^{\mathbf{C}*}(\mathbf{P})) = RHS(1, \boldsymbol{\Theta}^{\mathbf{C}*}(\mathbf{P}))$. In the case that there

is more than one such point, we take $\mathbf{\Theta}^*(\mathbf{P})$ to be the least of such points. Note that the introduction of externality makes the constrained $\mathbf{\Theta}^*(\mathbf{P})$ more difficult to identify, however it can be solved for numerically. This concludes the proof of Lemma 4. ■

Proof of Proposition 4: The proof of Proposition 4 is very similar to that of Theorem 1. We use backward induction to solve each stage of the sequence of events outlined in Section 3.3. The nonprofit i maximizes his expected utility based on the given allocation:

$$\max_{e_i \geq 0} \; E_{\xi_i}[u_i] = \max_{e_i \geq 0} \left\{ A_i - \frac{e_i^2}{2} + E_{\xi_i}[y_i] \right\} \qquad \text{subject to} \quad y_i \;=\; 2\xi_i \sqrt{e_i \theta_i A_i}.$$

Substituting the production function into nonprofit i's utility function, we obtain $E_{\xi_i}[u_i] = A_i - e_i^2/2 + E_{\xi_i}[2\xi_i\sqrt{e_i\theta_i A_i}]$. Using the first-order condition to determine the effort, e_i^*, that maximizes nonprofit i's utility, we get

$$\frac{dE_{\xi_i}[u_i]}{de_i} = -e_i + \frac{\sqrt{A_i\theta_i}E_{\xi_i}[\xi_i]}{\sqrt{e_i}} = 0 \quad \Rightarrow \quad e_i^* = (A_i\theta_i)^{1/3}(E_{\xi_i}[\xi_i])^{2/3}.$$

The second-order condition shows that the e_i^* found above is a unique maximizer as the utility function is strictly concave: $\frac{d^2E_{\xi_i}[u_i]}{de_i^2} = -1 - (\sqrt{A_i\theta_i}E_{\xi_i}[\xi_i])/(2e_i^{3/2}) < 0$ since $\theta_i \geq 0$, $A_i \geq 0$, $e_i \geq 0$ and $E_{\xi_i}[\xi_i] > 0$. Then substitution gives output, $y_i^* = 2\xi_i(A_i\theta_i)^{2/3}(E_{\xi_i}[\xi_i])^{1/3}$, and expected utility, $E_{\xi_i}[u_i^*] = A_i + 3/2(A_i\theta_i)^{2/3}(E_{\xi_i}[\xi_i])^{4/3}$.

Next, we solve for the funder's allocation of her resources in order to maximize her utility:

$$\max_{A_i(\theta_i)\geq 0} U_f = \max_{A_i(\theta_i)\geq 0} \left\{ \sum_{i=1}^{N} E_{\theta_i,\xi_i}[c_i y_i] - \alpha \left(\sum_{i=1}^{N} E_{\theta_i,\xi_i}\left[A_i(\theta_i)\right] \right) \right\}.$$

Using the output best-response y_i^* found above, we can reformulate the funder's problem:

$$\max_{A_i(\theta_i)\geq 0}\left\{\sum_{i=1}^{N} E_{\theta_i,\xi_i}\left[2c_i\xi_i(A_i\theta_i)^{2/3}(E_{\xi_i}[\xi_i])^{1/3}-\alpha A_i(\theta_i)\right]\right\}.$$

The funder's constraints can be similarly formulated as in Equations (3.8) - (3.10) using $E_{\xi_i}[u_i^*]$. We can show that the individual rationality constraints, $E_{\xi_i}[u_i^*]\geq 0$, are redundant as $A_i(\theta_i)\geq 0$, $\theta_i\geq 0$, and $E_{\xi_i}[\xi_i]>0$. Using similar arguments as in Theorem 1, we can also show that $A_i(\theta_i)=A_i$ for all θ_i where A_i is some constant. Therefore, the incentive compatibility constraints are trivially satisfied. Thus, from the first-order condition we obtain

$$\widetilde{A_i^R}(\theta_i)=\widetilde{A_i^R}=\frac{64}{27}\phi_i^3 E_{\xi_i}[\xi_i]\left(E_{\theta_i,\xi_i}[\xi_i{\theta_i}^{2/3}]\right)^3>0$$

where $\phi_i=c_i/\alpha$. This concludes the proof of Proposition 4. ■

Proof of Proposition 5: For expositional simplicity, we suppress the subscript i. It is straightforward to observe that P^* and $\theta^*(P)$ are unchanged under uncertain production as the Audit IC constraint under uncertain production,

$$E_\xi[u^*(\theta|\theta)]=A(\theta)+\frac{3}{2}(A(\theta)\theta)^{2/3}(E_\xi[\xi])^{4/3}\geq$$
$$(1-P)A(\hat{\theta})+\frac{3}{2}(A(\hat{\theta})\theta)^{2/3}(E_\xi[\xi])^{4/3}=E_\xi[u^*(\hat{\theta}|\theta)]-PA(\hat{\theta}),$$

with first-best allocations,

$$\widetilde{A^{FB}}(\theta)+\frac{3}{2}(\widetilde{A^{FB}}(\theta)\theta)^{2/3}(E_\xi[\xi])^{4/3}\quad\geq\quad(1-P)\widetilde{A^{FB}}(\hat{\theta})+\frac{3}{2}(\widetilde{A^{FB}}(\hat{\theta})\theta_i)^{2/3}(E_\xi[\xi])^{4/3},$$

remains the same as the original Audit IC constraint with first-best allocations:

$$A^{FB}(\theta)+\frac{3}{2}(A^{FB}(\theta)\theta)^{2/3}\geq(1-P)A^{FB}(\hat{\theta})+\frac{3}{2}(A^{FB}(\hat{\theta})\theta)^{2/3}$$

as $\widetilde{A^{FB}}(\theta) = (E_\xi[\xi])^4 A^{FB}(\theta)$ and $E_\xi[\xi] > 0$. This completes the proof of Proposition 5. ■

Proof of Proposition 6: In this audit contract, if the funder funds a nonprofit, she allocates according to the first-best allocation and audits the nonprofit. Therefore, the funder will fund a type θ_i of nonprofit i only if her expected utility from that type is positive:

$$2c_i(A_i^{FB}(\theta_i)\theta_i)^{2/3} - \alpha A_i - \gamma = \frac{32}{9}\frac{c_i^3\theta_i^2}{\alpha^2} - \frac{64c_i^3\theta_i^2}{27\alpha^2} - \gamma > 0 \quad \Rightarrow \quad \frac{32}{27}\frac{c_i^3\theta_i^2}{\alpha^2} - \gamma > 0.$$

That is, the funder will only fund those nonprofits where $\theta_i \geq \sqrt{(27\alpha^2\gamma)/(32c_i^3)}$. Enforcing the incentive compatibility on "low" types, i.e., types that receive zero allocation, will be more difficult as those types will have an higher incentive to lie. To enforce IC Audit on those types, we need:

$$u_i^*(\hat{\theta}_i|\theta_i) - PA_i^{FB}(\hat{\theta}_i) \leq 0,$$

which is equivalent to

$$(1-P_i)A_i^{FB}(\hat{\theta}_i) + \frac{3}{2}(A_i^{FB}(\hat{\theta}_i)\theta)^{2/3} \leq 0 \;\Rightarrow\; P_i \geq 1 + \frac{3}{2}\frac{\theta_i^{2/3}}{(A_i^{FB}(\hat{\theta}_i))^{1/3}}$$
$$\Rightarrow\; P_i \geq 1 + \frac{9}{8\phi_i}\frac{\theta_i^{2/3}}{\hat{\theta}_i^{\,2/3}}.$$

The penalty is increasing in $\theta_i/\hat{\theta}_i$ and is maximized when $\theta_i/\hat{\theta}_i = 1$. That is, to enforce incentive compatibility for all "low" types, we need $P_i = 1 + 9/(8\phi_i)$. Since this penalty is greater than the one in Lemma 1, it will enforce incentive compatibility for "high" types as well. This completes the proof of Proposition 6. ■

Proof of Proposition 7: The proof of Proposition 7 directly follows from the proof of Lemma 2, and the definitions of $\theta_i^*(P_i)$ and $\overline{\theta}_i$. In particular, when $\overline{\theta}_i \leq \theta_i^*(P_i)$, the cut-off type remains as $\theta_i^*(P_i)$ and the allocations are unaffected. When $\overline{\theta}_i > \theta_i^*(P_i)$, however, the funder does not want to audit the types in between $\theta_i^*(P_i)$ and $\overline{\theta}_i$ due to

the high auditing costs. Thus, the funder gives a constant allocation to these types as well; i.e., the cut-off type moves to $\overline{\theta}_i$. The constant allocation will be determined by the incentive compatibility constraints of the types in between $\theta_i^*(P_i)$ and $\overline{\theta}_i$, since the higher constant allocation will continue to satisfy the Audit IC constraints for types lower than $\theta_i^*(P_i)$ by the definition of $\theta_i^*(P_i)$, and first-best allocations will satisfy the Audit IC constraints for types higher than $\overline{\theta}_i$. Due to the characteristics of the Audit IC constraints we have identified in the proof of Lemma 2, it is straightforward to show the existence of $\tilde{\theta}_i$. This completes the proof of

Appendix B

Collaboration Excerpts from NACCHO Surveys

B.1. Collaboration Excerpt from 2005 NAACHO Survey

Partnership and Collaboration

We are interested in knowing about your LPHA's collaborations with a number of types of non-governmental organizations. For each organization, check each listed activity that your LPHA has done in conjunction with that organization in the past year. (Check all that apply)
Flag records that check "No Relationship" or "N/A" in addition to one of the other columns. All of those responses need to be changed to invalid. Interesting to see how many people appear to have treated as "check one only".

	Exchange Information	Work together on activities or projects	LPHA provides financial resources	LPHA has the leadership role within the partnership	No relationship	N/A: Organization does not exist in jurisdiction
Hospitals	q173a	q173b	q173c	q173d	q173e	q173f
Physician Practices /Medical Groups	q174a	q174b	q174c	q174d	q174e	q174f
Community Health Centers	q175a	q175b	q175c	q175d	q175e	q175f
Other health care providers	q176a	q176b	q176c	q176d	q176e	q176f
Health insurers	q177a	q177b	q177c	q177d	q177e	q177f
Emergency responders	q178a	q178b	q178c	q178d	q178e	q178f
Land use agencies	q179a	q179b	q179c	q179d	q179e	q179f
Economic and community development agencies	q180a	q180b	q180c	q180d	q180e	q180f
Housing agencies	q181a	q181b	q181c	q181d	q181e	q181f
Utility companies/agencies	q182a	q182b	q182c	q182d	q182e	q182f
Environmental and conservation orgs	q183a	q183b	q183c	q183d	q183e	q183f
Cooperative extensions	q184a	q184b	q184c	q184d	q184e	q184f
Schools	q185a	q185b	q185c	q185d	q185e	q185f
Parks and recreations	q186a	q186b	q186c	q186d	q186e	q186f
Transportation	q187a	q187b	q187c	q187d	q187e	q187f
Community-based Organizations	q188a	q188b	q188c	q188d	q188e	q188f
Faith Communities	q189a	q189b	q189c	q189d	q189e	q189f
Other voluntary or non-profit organizations	q190a	q190b	q190c	q190d	q190e	q190f
Libraries	q191a	q191b	q191c	q191d	q191e	q191f
Universities	q192a	q192b	q192c	q192d	q192e	q192f
Business	q193a	q193b	q193c	q193d	q193e	q193f
Media	q194a	q194b	q194c	q194d	q194e	q194f
Tribal government agencies	q195a	q195b	q195c	q195d	q195e	q195f

Source: National Association of County & City Health Officials

B.2. Collaboration Excerpt from 2008 NAACHO Survey

Partnership and Collaboration

We are interested in knowing about your LHD's collaborations with other organizations. Check each way that your LHD has worked with each organization in the past year. For each organization, check all that apply. If the organization does not exist within your community service area, check N/A. (select all that apply) (Variable values: unchecked= 0, checked= 1)

	Shared Personnel/ Resources	Written agreement	Regularly scheduled meetings	Exchange information	No relationship	N/A
Hospitals	**q263a**	**q263b**	**q236c**	**q263d**	**q263e**	**q263f**
Physician Practices /Medical Groups	**q264a**	**q264b**	**q264c**	**q264d**	**q264e**	**q264f**
Community Health Centers	**q265a**	**q265b**	**q265c**	**q265d**	**q265e**	**q265f**
Other health care providers	**q266a**	**q266b**	**q266c**	**q266d**	**q266e**	**q266f**
Health insurers	**q267a**	**q267b**	**q267c**	**q267d**	**q267e**	**q267f**
Emergency responders	**q268a**	**q268b**	**q268c**	**q268d**	**q268e**	**q268f**
Local planning agency	**q269a**	**q269b**	**q269c**	**q269d**	**q269e**	**q269f**
Economic and community development agencies	**q270a**	**q270b**	**q270c**	**q270d**	**q270e)**	**q270f**
Housing agencies	**q271a**	**q271b**	**q271c**	**q271d**	**q271e**	**q271f**
Utility companies/agencies	**q272a**	**q272b**	**q272c**	**q272d**	**q272e**	**q272f**
Environmental and conservation organizations	**q273a**	**q273b**	**q273c**	**q273d**	**q273e**	**q273f**
Cooperative extensions	**q274a**	**q274b**	**q274c**	**q274d**	**q274e**	**q274f**
Schools	**q275a**	**q275b**	**q275c**	**q275d**	**q275e**	**q275f**
Parks and recreations	**q276a**	**q276b**	**q276c**	**q276d**	**q276e**	**q276f**
Transportation	**q277a**	**q277b**	**q277c**	**q277d**	**q277e**	**q277f**
Faith communities	**q278a**	**q278b**	**q278c**	**q278d**	**q278e**	**q278f**
Libraries	**q279a**	**q279b**	**q279c**	**q279d**	**q279e**	**q279f**
Colleges or universities	**q280a**	**q280b**	**q280c**	**q280d**	**q280e**	**q280f**
Business	**q281a**	**q281b**	**q281c**	**q281d**	**q281e**	**q281f**
Media	**q282a**	**q282b**	**q282c**	**q282d**	**q282e**	**q282f**
Tribal gov't agencies	**q283a**	**q283b**	**q283c**	**q283d**	**q283e**	**q283f**
Criminal justice system	**q284a**	**q284b**	**q284c**	**q284d**	**q284e**	**q284f**
Health voluntaries	**q285a**	**q285b**	**q285c**	**q285d**	**285e**	**q285f**
Community-based Nonprofits	**q286a**	**q286b**	**q286c**	**q286d**	**q286e**	**q286f**

Source: National Association of County & City Health Officials

Appendix C

Chapter 5 Supplemental Materials

		2005					2008				
	Overall	Overall	Exchange Information	Work Together	Provide Financial Resources	Provide Leadership	Overall	Shared Personnel/ Resouces	Written Agreement	Regular Meetings	Exchange Information
Overall		100%	98%	98%	38%	52%	100%	79%	77%	90%	100%
		(R) 100%	(R) 97%	(R) 99%	(R) 29%	(R) 41%	(R) 100%	(R) 71%	(R) 71%	(R) 82%	(R) 99%
		(S) 100%	(S) 97%	(S) 99%	(S) 32%	(S) 54%	(S) 100%	(S) 79%	(S) 84%	(S) 98%	(S) 100%
		(U) 100%	(U) 98%	(U) 98%	(U) 45%	(U) 56%	(U) 100%	(U) 84%	(U) 78%	(U) 92%	(U) 100%
Hospitals	100%	92% ***	76%	79%	11%	25%	93% **	40%	41%	57%	88%
	(R) 100%	(R) 86% *	(R) 67%	(R) 70%	(R) 9%	(R) 15%	(R) 89%	(R) 37%	(R) 36%	(R) 44%	(R) 86%
	(S) 100%	(S) 96%	(S) 82%	(S) 83%	(S) 9%	(S) 28%	(S) 100%	(S) 44%	(S) 44%	(S) 61%	(S) 98%
	(U) 100%	(U) 94% ***	(U) 78%	(U) 83%	(U) 14%	(U) 28%	(U) 93% *	(U) 40%	(U) 42%	(U) 63%	(U) 85%
Medical Groups / Physician Practices	93%	93% ***	83%	53%	5%	15%	90% ***	22%	25%	24%	88%
	(R) 88%	(R) 97%	(R) 83%	(R) 60%	(R) 3%	(R) 10%	(R) 92%	(R) 21%	(R) 25%	(R) 19%	(R) 89%
	(S) 98%	(S) 93% **	(S) 86%	(S) 45%	(S) 1%	(S) 12%	(S) 91% ***	(S) 27%	(S) 24%	(S) 20%	(S) 89%
	(U) 93%	(U) 90% ***	(U) 82%	(U) 53%	(U) 6%	(U) 19%	(U) 89% **	(U) 20%	(U) 25%	(U) 28%	(U) 87%
Community Health Centers	91%	64% *	53%	49%	13%	14%	66%	24%	21%	25%	63%
	(R) 94%	(R) 47%	(R) 38%	(R) 39%	(R) 4%	(R) 8%	(R) 50%	(R) 14%	(R) 13%	(R) 13%	(R) 50%
	(S) 92%	(S) 57%	(S) 46%	(S) 34%	(S) 4%	(S) 9%	(S) 68%	(S) 23%	(S) 22%	(S) 20%	(S) 65%
	(U) 90%	(U) 75% **	(U) 63%	(U) 60%	(U) 20%	(U) 18%	(U) 76% **	(U) 30%	(U) 26%	(U) 34%	(U) 69%
Other Providers	65%	89% ***	76%	54%	5%	14%	86% *	20%	18%	23%	85%
	(R) 49%	(R) 83%	(R) 68%	(R) 54%	(R) 2%	(R) 11%	(R) 83%	(R) 17%	(R) 9%	(R) 14%	(R) 83%
	(S) 63%	(S) 95% ***	(S) 86%	(S) 45%	(S) 7%	(S) 12%	(S) 93%	(S) 21%	(S) 24%	(S) 24%	(S) 94%
	(U) 75%	(U) 89% ***	(U) 77%	(U) 58%	(U) 5%	(U) 16%	(U) 86% **	(U) 21%	(U) 21%	(U) 29%	(U) 82%
Health Insurers	88%	47% ***	40%	22%	1%	2%	50% ***	6%	21%	8%	46%
	(R) 83%	(R) 40% ***	(R) 35%	(R) 15%	(R) 0%	(R) 2%	(R) 49% *	(R) 3%	(R) 19%	(R) 5%	(R) 43%
	(S) 94%	(S) 45% ***	(S) 42%	(S) 8%	(S) 0%	(S) 0%	(S) 52% **	(S) 6%	(S) 24%	(S) 8%	(S) 48%
	(U) 87%	(U) 51% ***	(U) 42%	(U) 30%	(U) 1%	(U) 3%	(U) 50% ***	(U) 7%	(U) 21%	(U) 11%	(U) 46%
Emergency Responders	49%	96%	75%	87%	11%	21%	97%	47%	45%	72%	85%
	(R) 45%	(R) 91%	(R) 70%	(R) 84%	(R) 9%	(R) 17%	(R) 91%	(R) 37%	(R) 33%	(R) 57%	(R) 81%
	(S) 48%	(S) 100%	(S) 79%	(S) 87%	(S) 11%	(S) 16%	(S) 98%	(S) 47%	(S) 55%	(S) 84%	(S) 89%
	(U) 50%	(U) 97% **	(U) 77%	(U) 88%	(U) 12%	(U) 24%	(U) 100%	(U) 54%	(U) 47%	(U) 76%	(U) 86%
Development Agencies	96%	66% ***	57%	42%	2%	2%	68% *	8%	5%	17%	65%
	(R) 91%	(R) 58% **	(R) 49%	(R) 41%	(R) 1%	(R) 1%	(R) 62%	(R) 8%	(R) 3%	(R) 13%	(R) 58%
	(S) 99%	(S) 67% ***	(S) 61%	(S) 37%	(S) 0%	(S) 1%	(S) 67%	(S) 5%	(S) 2%	(S) 17%	(S) 63%
	(U) 98%	(U) 70% *	(U) 59%	(U) 45%	(U) 3%	(U) 3%	(U) 73% **	(U) 9%	(U) 7%	(U) 21%	(U) 70%
Housing Agencies	67%	66% **	57%	38%	2%	3%	62%	8%	7%	16%	60%
	(R) 60%	(R) 49%	(R) 45%	(R) 19%	(R) 0%	(R) 0%	(R) 50%	(R) 3%	(R) 2%	(R) 9%	(R) 48%
	(S) 67%	(S) 59% *	(S) 53%	(S) 21%	(S) 0%	(S) 3%	(S) 62%	(S) 3%	(S) 3%	(S) 9%	(S) 57%
	(U) 71%	(U) 77% *	(U) 65%	(U) 52%	(U) 3%	(U) 5%	(U) 70% **	(U) 12%	(U) 11%	(U) 22%	(U) 69%

Percentage of Local Health Departments Engaged in Collaboration by Urbanization, Partner, and Activity (1 of 3)

		2005					2008				
	Overall	Overall	Exchange Information	Work Together	Provide Financial Resources	Provide Leadership	Overall	Shared Personnel/ Resouces	Written Agreement	Regular Meetings	Exchange Information
Utilities	64%	51%	45%	23%	0%	1%	46%	4%	4%	7%	45%
	(R) 50%	(R) 45%	(R) 38%	(R) 14%	(R) 0%	(R) 1%	(R) 38%	(R) 2%	(R) 1%	(R) 4%	(R) 36%
	(S) 61%	(S) 46%	(S) 39%	(S) 21%	(S) 0%	(S) 0%	(S) 46% **	(S) 4%	(S) 6%	(S) 11%	(S) 43%
	(U) 73%	(U) 56%	(U) 50%	(U) 28%	(U) 0%	(U) 0%	(U) 51%	(U) 5%	(U) 4%	(U) 8%	(U) 52%
Environmental Organizations	49%	73%	62%	42%	2%	5%	66%	11%	4%	17%	65%
	(R) 41%	(R) 67%	(R) 53%	(R) 31%	(R) 1%	(R) 4%	(R) 56%	(R) 8%	(R) 4%	(R) 9%	(R) 53%
	(S) 46%	(S) 62%	(S) 55%	(S) 33%	(S) 1%	(S) 4%	(S) 62%	(S) 7%	(S) 1%	(S) 12%	(S) 65%
	(U) 54%	(U) 79%	(U) 68%	(U) 50%	(U) 2%	(U) 6%	(U) 74%	(U) 14%	(U) 4%	(U) 24%	(U) 71%
Coop Extensions	69%	80% ***	65%	60%	6%	9%	74% ***	21%	11%	20%	72%
	(R) 61%	(R) 90%	(R) 67%	(R) 74%	(R) 5%	(R) 12%	(R) 80%	(R) 25%	(R) 9%	(R) 21%	(R) 74%
	(S) 62%	(S) 86% ***	(S) 70%	(S) 66%	(S) 4%	(S) 7%	(S) 83%	(S) 25%	(S) 16%	(S) 22%	(S) 77%
	(U) 77%	(U) 74% **	(U) 63%	(U) 51%	(U) 6%	(U) 9%	(U) 67% ***	(U) 17%	(U) 9%	(U) 19%	(U) 68%
Schools	77%	99%	80%	89%	17%	27%	98% *	44%	47%	47%	90%
	(R) 85%	(R) 100%	(R) 72%	(R) 91%	(R) 15%	(R) 20%	(R) 98%	(R) 41%	(R) 37%	(R) 37%	(R) 84%
	(S) 84%	(S) 99%	(S) 83%	(S) 87%	(S) 14%	(S) 28%	(S) 99%	(S) 41%	(S) 53%	(S) 48%	(S) 91%
	(U) 70%	(U) 100%	(U) 83%	(U) 88%	(U) 19%	(U) 30%	(U) 98%	(U) 48%	(U) 50%	(U) 54%	(U) 93%
Parks & Recreation	99%	70%	58%	51%	3%	4%	69% ***	15%	4%	19%	67%
	(R) 99%	(R) 52%	(R) 40%	(R) 32%	(R) 3%	(R) 0%	(R) 50% **	(R) 5%	(R) 2%	(R) 8%	(R) 47%
	(S) 99%	(S) 64%	(S) 54%	(S) 38%	(S) 1%	(S) 0%	(S) 61%	(S) 11%	(S) 2%	(S) 16%	(S) 62%
	(U) 99%	(U) 81% *	(U) 67%	(U) 64%	(U) 4%	(U) 8%	(U) 84%	(U) 23%	(U) 5%	(U) 28%	(U) 81%
Transportation	70%	51% *	44%	28%	3%	3%	48% ***	5%	7%	11%	47%
	(R) 51%	(R) 49%	(R) 39%	(R) 23%	(R) 2%	(R) 1%	(R) 43% **	(R) 3%	(R) 5%	(R) 8%	(R) 40%
	(S) 63%	(S) 49% **	(S) 46%	(S) 26%	(S) 5%	(S) 5%	(S) 45% ***	(S) 2%	(S) 7%	(S) 13%	(S) 43%
	(U) 83%	(U) 53%	(U) 46%	(U) 32%	(U) 2%	(U) 3%	(U) 52% ***	(U) 8%	(U) 7%	(U) 12%	(U) 52%
Faith Communities	83%	90% ***	73%	73%	11%	17%	82% ***	15%	10%	23%	78%
	(R) 82%	(R) 84% **	(R) 63%	(R) 66%	(R) 8%	(R) 11%	(R) 81% *	(R) 12%	(R) 5%	(R) 17%	(R) 72%
	(S) 80%	(S) 91% **	(S) 76%	(S) 74%	(S) 8%	(S) 11%	(S) 78%	(S) 10%	(S) 9%	(S) 21%	(S) 74%
	(U) 85%	(U) 93% ***	(U) 76%	(U) 76%	(U) 14%	(U) 22%	(U) 84% ***	(U) 18%	(U) 13%	(U) 28%	(U) 82%
Libraries	59%	60% ***	53%	27%	1%	4%	58%	9%	3%	6%	58%
	(R) 51%	(R) 51% ***	(R) 43%	(R) 22%	(R) 1%	(R) 1%	(R) 52%	(R) 4%	(R) 2%	(R) 2%	(R) 50%
	(S) 55%	(S) 57% ***	(S) 51%	(S) 26%	(S) 1%	(S) 4%	(S) 54%	(S) 6%	(S) 2%	(S) 5%	(S) 54%
	(U) 65%	(U) 66% **	(U) 59%	(U) 30%	(U) 1%	(U) 6%	(U) 64%	(U) 13%	(U) 3%	(U) 9%	(U) 66%
Universities	72%	67% ***	55%	54%	6%	9%	76% **	27%	34%	23%	69%
	(R) 52%	(R) 42%	(R) 24%	(R) 37%	(R) 3%	(R) 4%	(R) 59%	(R) 18%	(R) 23%	(R) 8%	(R) 50%
	(S) 81%	(S) 74% ***	(S) 63%	(S) 54%	(S) 1%	(S) 7%	(S) 87%	(S) 26%	(S) 37%	(S) 24%	(S) 77%
	(U) 79%	(U) 76% ***	(U) 66%	(U) 62%	(U) 10%	(U) 12%	(U) 82% ***	(U) 34%	(U) 39%	(U) 32%	(U) 77%

Percentage of Local Health Departments Engaged in Collaboration by Urbanization, Partner, and Activity (2 of 3)

		2005					2008				
	Overall	Overall	Exchange Information	Work Together	Provide Financial Resources	Provide Leadership	Overall	Shared Personnel/ Resouces	Written Agreement	Regular Meetings	Exchange Information
Business	82%	80% **	67%	48%	2%	6%	84% *	12%	9%	18%	83%
	(R) 81%	(R) 75% *	(R) 62%	(R) 44%	(R) 0%	(R) 2%	(R) 85%	(R) 10%	(R) 5%	(R) 16%	(R) 79%
	(S) 79%	(S) 75%	(S) 62%	(S) 41%	(S) 3%	(S) 3%	(S) 83%	(S) 11%	(S) 6%	(S) 7%	(S) 82%
	(U) 84%	(U) 83% *	(U) 72%	(U) 53%	(U) 3%	(U) 9%	(U) 85%	(U) 14%	(U) 13%	(U) 23%	(U) 85%
Media	94%	93% **	80%	52%	3%	6%	95%	11%	3%	12%	93%
	(R) 92%	(R) 90%	(R) 75%	(R) 49%	(R) 2%	(R) 3%	(R) 93%	(R) 11%	(R) 3%	(R) 7%	(R) 90%
	(S) 97%	(S) 95%	(S) 84%	(S) 53%	(S) 3%	(S) 5%	(S) 99%	(S) 9%	(S) 2%	(S) 9%	(S) 97%
	(U) 94%	(U) 93% **	(U) 81%	(U) 53%	(U) 4%	(U) 8%	(U) 94%	(U) 11%	(U) 3%	(U) 16%	(U) 94%
Tribal Government	16%	14% ***	12%	11%	0%	1%	17% ***	3%	5%	5%	17%
	(R) 20%	(R) 14% *	(R) 12%	(R) 12%	(R) 0%	(R) 1%	(R) 25%	(R) 3%	(R) 4%	(R) 5%	(R) 25%
	(S) 15%	(S) 12% **	(S) 11%	(S) 9%	(S) 0%	(S) 1%	(S) 17% ***	(S) 4%	(S) 7%	(S) 8%	(S) 18%
	(U) 14%	(U) 15% **	(U) 13%	(U) 11%	(U) 0%	(U) 0%	(U) 12% ***	(U) 3%	(U) 4%	(U) 4%	(U) 12%
Community-Based Organizations	90%	94% **	76%	79%	16%	24%	87% **	27%	24%	44%	83%
	(R) 85%	(R) 89% **	(R) 66%	(R) 71%	(R) 9%	(R) 14%	(R) 81%	(R) 17%	(R) 14%	(R) 30%	(R) 78%
	(S) 94%	(S) 96%	(S) 79%	(S) 80%	(S) 11%	(S) 21%	(S) 93%	(S) 24%	(S) 30%	(S) 45%	(S) 84%
	(U) 92%	(U) 96% **	(U) 80%	(U) 82%	(U) 21%	(U) 30%	(U) 88% **	(U) 34%	(U) 28%	(U) 52%	(U) 87%

Note. 2005 inflation-adjusted dollars displayed. Statistical Significance: **p<0.05, ***p<0.01; Urbanization is indicated as (R) rural, (S) suburban, (U) urban.

Percentage of Local Health Departments Engaged in Collaboration by Urbanization, Partner, and Activity (3 of 3)

		2005				2008			
	Overall	Exchange Information	Work Together	Provide Financial Resources	Provide Leadership	Shared Personnel/ Resouces	Written Agreement	Regular Meetings	Exchange Information
Overall			$ 27.25 **	$ 22.39 ***	$ 16.02 ***		$ 14.62 ***	$ 12.65 *	
				(R) $ 27.06 **	(R) $ 22.92 ***				
		(S) $ 32.26 *		(S) $ 22.54 ***	(S) $ 5.29 ***		(S) $ 18.93 ***	(S) $ 3.30 *	
			(U) $ 28.78 **		(U) $ 18.32 ***	(U) $ 16.43 **	(U) $ 18.67 ***	(U) $ 28.44 ***	
Hospitals	$ 12.91 ***	$ 8.90 **	$ 17.81 ***	$ 20.47 ***	$ 14.17 ***	$ 12.20 **	$ 21.78 ***		$ 13.34 ***
			(R) $ 16.57 **	(R) $ 40.51 **	(R) $ 24.77 *		(R) $ 27.80 **		(R) $ 22.58 **
		(S) $ 14.79 *	(S) $ 15.77 **		(S) $ 7.72 **	(S) $ 7.87 *	(S) $ 17.62 ***		
	(U) $ 7.71 *	(U) $ 13.73 ***	(U) $ 21.31 ***	(U) $ 21.37 ***	(U) $ 14.79 ***	(U) $ 18.75 **	(U) $ 21.56 ***	(U) $ 15.49 ***	(U) $ 9.87 *
Medical Groups / Physician Practices	$ 18.57 ***	$ 10.89 ***	$ 9.36 ***	$ 39.88 ***	$ 16.66 ***		$ 31.62 ***	$ 9.34 ***	$ 9.43 *
			(R) $ 11.93 **	(R) $ 44.69 *			(R) $ 31.96 **		
	(S) $ 20.72 ***	(S) $ 11.57 *					(S) $ 27.82 ***	(S) $ 21.42 ***	(S) $ 20.48 ***
	(U) $ 12.95 **	(U) $ 12.26 **	(U) $ 12.13 ***	(U) $ 40.56 ***	(U) $ 25.24 ***	(U) ($ 1.94) *	(U) $ 34.18 ***	(U) $ 3.88 ***	
Community Health Centers	$ 9.21 **	$ 8.60 ***	$ 5.95 **	$ 23.69 ***	$ 9.04 **		$ 20.96 ***	$ 9.54 *	$ 13.36 **
				(R) $ 32.48 **					
		(S) $ 15.95 **					(S) $ 14.56 ***		
	(U) $ 17.14 **	(U) $ 13.15 ***	(U) $ 11.34 ***	(U) $ 27.71 ***	(U) $ 13.32 ***	(U) ($ 4.80) *	(U) $ 19.79 ***	(U) $ 22.30 ***	(U) $ 19.41 ***
Other Providers	$ 9.63 ***	$ 7.62 **	$ 7.43 ***	$ 20.71 ***	$ 16.94 ***		$ 12.84 ***	$ 2.06 **	$ 9.34 *
						(R) ($ 15.18) *			
		(S) $ 14.05 **		(S) $ 24.19 ***			(S) $ 22.05 ***		
	(U) $ 14.96 **	(U) $ 9.85 **	(U) $ 9.75 ***	(U) $ 23.19 ***	(U) $ 20.34 ***		(U) $ 12.19 ***	(U) $ 6.50 ***	
Health Insurers	$ 16.76 ***	$ 15.92 ***	$ 12.18 ***		$ 27.84 **		$ 34.38 ***	$ 8.13 ***	$ 10.60 ***
	(R) $ 15.42 *	(R) $ 19.79 ***	(R) $ 10.30 *			(R) $ 58.77 *	(R) $ 43.19 ***	(R) $ 35.93 *	
	(S) $ 9.87 **	(S) $ 17.05 ***	(S) $ 6.05 **				(S) $ 17.01 ***		
	(U) $ 22.90 ***	(U) $ 14.41 ***	(U) $ 15.57 ***	(U) ($ 16.73) **	(U) $ 28.54 **		(U) $ 38.64 ***	(U) $ 4.37 ***	(U) $ 20.14 ***
Emergency Responders		$ 8.66 ***	$ 11.00 ***	$ 23.40 ***	$ 10.79 ***		$ 11.35 **		
				(R) $ 25.06 **	(R) $ 11.46 *		(R) $ 26.12 **		
		(S) $ 19.55 **						(S) ($ 5.17) *	
		(U) $ 12.34 ***	(U) $ 17.74 ***		(U) $ 15.52 ***		(U) $ 9.95 **	(U) $ 23.12 ***	
Development Agencies	$ 9.38 ***	$ 10.65 ***	$ 4.56 **	$ 22.48 **	$ 26.15 ***		$ 56.89 *		$ 13.35 **
		(R) $ 15.98 **							
		(S) $ 24.33 ***						(S) $ 11.31 **	
	(U) $ 9.86 **	(U) $ 4.02 *	(U) $ 5.75 **		(U) $ 32.62 **				(U) $ 18.74 ***

Expenditure per Capita Mean Difference over Urbanization, Partners, and Activities (1 of 3)

		2005				2008			
	Overall	Exchange Information	Work Together	Provide Financial Resources	Provide Leadership	Shared Personnel/ Resouces	Written Agreement	Regular Meetings	Exchange Information
Housing Agencies	$ 3.96 **	$ 7.49 ***	$ 4.21 **	$ 0.52 **			$ 55.37 ***		
		(S) $ 21.70 ***			(S) ($ 30.30) ***				
	(U) $ 11.07 **	(U) $ 3.60 **	(U) $ 10.13 ***	(U) $ 2.14 **	(U) $ 19.72 **		(U) $ 71.24 ***	(U) $ 28.60 **	(U) $ 15.49 ***
Utilities									
	(S) ($ 7.87) **		(S) ($ 16.55) **					(S) ($ 19.32) **	(S) ($ 8.54) **
			(U) $ 7.09 **	(U) ($ 21.01) **					
Environmental Organizations			$ 2.12 *	$ 26.15 ***	$ 19.52 **			($ 4.25) ***	
							(R) ($ 17.34) *	(R) ($ 26.99) **	
		(S) $ 15.45 *						(S) ($ 16.08) **	
			(U) $ 6.27 ***		(U) $ 32.47 ***				(U) $ 9.22 *
Coop Extensions	$ 6.68 ***	$ 3.99 **	$ 10.67 ***	$ 21.55 ***	$ 16.44 ***	$ 5.65 ***	$ 10.68 ***	$ 1.86 **	$ 6.56 ***
		(R) ($ 11.88) **		(R) $ 20.17 **					
		(S) $ 15.92 ***	(S) $ 23.13 ***		(S) $ 12.28 **	(S) $ 3.48 **	(S) $ 3.25 **		
	(U) $ 10.80 ***	(U) $ 6.61 **	(U) $ 8.90 ***	(U) $ 7.84 **	(U) $ 16.93 ***	(U) $ 4.97 **	(U) $ 16.93 ***	(U) $ 2.50 **	(U) $ 14.11 ***
Schools	$ 22.50 **	$ 8.16 *	$ 16.10 ***	$ 24.41 ***	$ 19.64 ***	$ 4.98 **	$ 17.49 ***	$ 12.98 ***	
				(R) $ 28.94 ***	(R) $ 27.07 **			(R) $ 35.28 ***	
			(S) $ 16.26 *	(S) $ 16.57 **	(S) $ 12.85 ***				
		(U) $ 14.79 ***	(U) $ 20.68 ***	(U) $ 25.57 **	(U) $ 20.33 ***	(U) $ 5.27 *	(U) $ 27.10 ***	(U) $ 8.46 ***	
Parks & Recreation	($ 1.01) *	$ 6.83 **		$ 25.80 ***					$ 1.89 *
	(R) ($ 1.15) **			(R) $ 42.19 *			(R) ($ 29.38) *		
		(S) $ 15.74 **					(S) $ 8.17 ***	(S) $ 9.93 **	
		(U) $ 11.37 ***	(U) $ 5.08 **	(U) $ 21.52 ***	(U) $ 6.76 *			(U) $ 2.71 **	
Transportation	$ 13.74 ***	$ 8.07 **	$ 6.28 ***	$ 46.29 **	$ 15.33 *	$ 22.18 ***	$ 31.24 ***	$ 26.75 ***	$ 17.19 ***
	(R) $ 26.43 **		(R) $ 20.89 *				(R) $ 83.36 *	(R) $ 76.54 *	(R) $ 16.46 *
	(S) $ 16.11 ***	(S) $ 18.34 **	(S) ($ 0.70) *	(S) $ 81.12 **			(S) $ 29.06 **	(S) $ 22.76 **	(S) $ 10.30 **
	(U) $ 19.75 ***		(U) $ 3.97 **	(U) $ 30.89 ***	(U) $ 23.21 **	(U) $ 15.61 ***	(U) $ 11.19 **	(U) $ 8.33 **	(U) $ 23.80 ***
Faith Communities	$ 12.70 ***	$ 8.21 ***	$ 13.47 ***	$ 30.37 ***	$ 25.52 ***	$ 7.27 ***	$ 25.23 ***	$ 10.98 ***	$ 8.74 **
	(R) $ 19.83 *		(R) $ 12.06 **	(R) $ 76.96 ***	(R) $ 32.80 *				
		(S) $ 11.99 **	(S) $ 16.26 **		(S) $ 17.43 *	(S) $ 12.83 **			
	(U) $ 9.09 ***	(U) $ 9.48 **	(U) $ 13.26 ***	(U) $ 29.50 ***	(U) $ 27.66 ***	(U) $ 10.64 ***	(U) $ 38.25 ***	(U) $ 8.42 ***	(U) $ 14.61 ***
Libraries	$ 2.80 **	$ 10.73 ***	$ 8.10 ***		$ 22.79 **	($ 12.69) **		$ 8.84 *	
		(R) $ 7.24 *	(R) $ 14.21 **					(R) $ 96.91 ***	(R) $ 17.20 *
		(S) $ 22.18 ***							(S) $ 4.14 *
		(U) $ 9.32 *	(U) $ 9.39 **	(U) ($ 6.45) ***	(U) $ 33.17 **			(U) $ 7.71 **	

Expenditure per Capita Mean Difference over Urbanization, Partners, and Activities (2 of 3)

		2005				2008			
	Overall	Exchange Information	Work Together	Provide Financial Resources	Provide Leadership	Shared Personnel/ Resouces	Written Agreement	Regular Meetings	Exchange Information
Universities	$ 12.35 ***	$ 9.52 ***	$ 14.58 ***	$ 14.24 ***	$ 9.49 ***		$ 5.71 ***		$ 7.08 *
							(R) $ 21.53 *		
		(S) $ 19.60 **	(S) $ 15.52 *						(S) ($ 10.66) *
	(U) $ 21.92 ***	(U) $ 13.76 ***	(U) $ 20.99 ***		(U) $ 15.35 ***	(U) $ 14.05 ***	(U) $ 5.71 ***	(U) $ 6.14 ***	(U) $ 15.70 ***
Business	$ 6.21 ***		$ 11.15 ***	$ 8.42 **	$ 14.82 **		$ 9.83 **		
			(R) $ 16.55 **						
			(S) $ 9.16 *			(S) ($ 14.67) *			(S) $ 11.63 *
			(U) $ 10.25 ***	(U) $ 12.36 ***	(U) $ 15.80 ***		(U) $ 10.43 ***	(U) $ 5.31 **	(U) $ 2.73 *
Media	$ 8.01 **	$ 6.63 *	$ 6.71 ***	$ 20.32 **	$ 12.14 ***	($ 11.10) *			
			(R) $ 7.69 *			(R) ($ 13.89) *	(R) $ 4.66 **		
		(U) $ 8.93 *	(U) $ 10.97 ***	(U) $ 23.57 ***	(U) $ 19.31 ***			(U) $ 18.14 **	
Tribal Government	$ 13.14 ***	$ 10.43 ***	$ 10.90 ***				$ 18.92 ***	$ 9.86 ***	$ 13.95 ***
			(R) $ 21.43 ***						
	(S) $ 16.48 ***	(S) $ 18.86 **	(S) $ 2.84 *			(S) $ 16.95 **	(S) $ 12.05 **	(S) $ 6.57 *	(S) $ 15.86 ***
	(U) $ 29.27 ***	(U) $ 7.26 *	(U) $ 8.34 **	(U) $ 0.00 **			(U) $ 19.78 ***	(U) $ 13.15 **	(U) $ 34.58 ***
Community-Based Organizations	$ 8.89 ***	$ 8.18 **	$ 18.19 ***	$ 18.55 ***	$ 19.74 ***	$ 8.36 **	$ 22.80 ***	$ 8.63 ***	$ 6.22 **
			(R) $ 16.10 **		(R) $ 23.47 **		(R) $ 37.89 ***		
			(S) $ 14.08 *	(S) $ 0.43 **	(S) $ 1.91 **		(S) $ 3.12 *		
	(U) $ 10.76 **	(U) $ 11.14 **	(U) $ 22.54 ***	(U) $ 22.60 **	(U) $ 25.94 ***	(U) $ 10.94 ***	(U) $ 31.46 ***	(U) $ 10.69 ***	(U) $ 16.68 ***

Note. 2005 inflation-adjusted dollars displayed. Statistical Significance: **p<0.05, ***p<0.01; Urbanization is indicated as (R) rural, (S) suburban, (U) urban.

Expenditure per Capita Mean Difference over Urbanization, Partners, and Activities (3 of 3)

Bibliography

[1] M. Acar and C. Guo. Understanding collaboration among nonprofit organizations: Combining resource dependency, institutional, and network perspectives. *Nonprofit and Voluntary Sector Quarterly*, 34(3):340–361, 2005.

[2] A.R. Andreasen. Profits for nonprofits: Find a corporate partner. *Harvard Business Review*, 74(6):47–59, 1996.

[3] A.D. Athanassopoulos. Decision support for target-based resource allocation of public services in multiunit and multilevel systems. *Management Science*, 44(2):173–187, 1998.

[4] J.E. Austin. Strategic collaboration between nonprofits and businesses. *Nonprofit and Voluntary Sector Quarterly*, 29:69–97, 2000.

[5] L. Bagnoli and C. Megali. Measuring performance in social enterprises. *Nonprofit and Voluntary Sector Quarterly*, OnlineFirst:1–17, December 2009.

[6] D.P. Baron and D. Besanko. Regulation, asymmetric information, and auditing. *RAND Jounal of Economics*, 15(4):447–470, Winter 1984.

[7] Y. Baruch and N. Ramalho. Commonalities and distinctions in the measurement of organizational performance and effectiveness across for-profit and nonprofit sectors. *Nonprofit and Voluntary Sector Quarterly*, 35(1):39–65, 2006.

[8] M. Baucells and R.K. Sarin. Group decisions with multiple criteria. *Management Science*, 49(8):1105–1118, 2003.

[9] S. Baum and R.C. Carlson. Multi-goal optimization in managerial science. *Omega*, 2(5):607–623, 1974.

[10] G.J. Bazzoli, R. Stein, J.A. Alexander, D.A. Conrad, S. Sofaerand, and S.M. Shortell. Public-private collaboration in health and human services delivery: Evidence from community partnerships. *Milbank Quarterly*, 75(4):533–561, 1997.

[11] B. Beamon and B. Balcik. Performance measurement in humanitarian relief chains. *International Journal of Public Sector Management*, 21(1):4–25, 2008.

[12] K. Beatty, J.K. Harris, and P.A. Barnes. The role of inter-organizational partnerships in health services provision among rural, metropolitan and urban local health departments. *The Journal of Rural Health*, 26(3):248–258, 2010.

[13] M.J. Berland. Compassion counts more than ever. *Parade*, (Special Report: What America Cares About), 2010.

[14] P.M. Bernet. Local public health agency funding: Money begets money. *Journal of Public Health Management and Practice*, 13(2):188–193, 2007.

[15] A. Blackwood, K.T. Wing, and T.H. Pollak. The nonprofit sector in brief: Facts and figures from the Nonprofit Almanac 2008: Public charities, giving, and volunteering. Technical report, The Urban Institute, Washington, DC, 2008.

[16] A.E. Boardman, D.H. Greenberg, A.R. Vining, and D.L. Weimer. *Cost-Benefit Analysis: Concepts and Practice*. Pearson Prentice-Hall, Upper Saddle River, NJ, third edition, 2006.

[17] BoardSource and Independent Sector. The Sarbanes-Oxley Act and implications for nonprofit organizations. White paper, January 2006.

[18] T. Boyaci and G. Gallego. Supply chain coordination in a market with customer service competition. *Production and Operations Management*, 13(1):3–22, 2009.

[19] B. Bradley, P. Jansen, and L. Silverman. The nonprofit sector's $100 billion opportunity. *Harvard Business Review*, 81(5):94–103, 2003.

[20] P. Brest and H. Harvey. *Money Well Spent: A Strategic Plan for Smart Philanthropy*. Bloomberg Press, New York, NY, 2008.

[21] S. Bridge, B. Murtagh, and K. O'Neill. *Understanding the Social Economy and the Third Sector*. Palgrave MacMillan, London, 2009.

[22] J.W. Buehler and D.R. Holtgrave. Who gets how much: Funding formulas in federal public health programs. *Journal of Public Health Management and Practice*, 13(2):151–155, 2007.

[23] G.P. Cachon. Supply chain coordination with contracts. In A.G. de Kok and S.C. Graves, editors, *Supply Chain Management: Design, Coordination and Operation*, volume 11 of *Handbooks in Operations Research and Management Science*, chapter 6, pages 229–340. Elsevier, Amsterdam, The Netherlands, 2003.

[24] G.P. Cachon and M.A. Lariviere. Capacity allocation using past sales: When to turn-and-earn. *Management Science*, 45(5):685–703, 1999a.

[25] G.P. Cachon and M.A. Lariviere. Capacity choice and allocation: Strategic behavior and supply chain performance. *Management Science*, 45(8):1091–1108, 1999b.

[26] California Government Code. Nonprofit Integrity Act of 2004. Section 12586(e), 2007 edition.

[27] J.G. Carman. Nonprofits, funders, and evaluation: Accountability in action. *The American Review of Public Administration*, 39(4):374–390, July 2009.

[28] K.J. Chabotar. Financial ratio analysis comes to nonprofits. *The Journal of Higher Education*, 60(2):188–208, March-April 1989.

[29] M. Chang and J.E. Harrington Jr. Centralization vs. decentralization in a multi-unit organization: A computational model of a retail chain as a multi-agent adaptive system. *Management Science*, 46(11):1427–1440, 2000.

[30] B. Chapman and C.W. Hardt. Purchasing lessons for schools. *The McKinsey Quarterly*, 4, 2003.

[31] Public Sector Consultants. Economic benefits of Michigan's nonprofit sector. Technical report, Michigan Nonprofit Association, 2009.

[32] C.J. Corbett. Stochastic inventory systems in a supply chain with asymmetric information: Cycle stocks, safety stocks, and consignment stock. *Operations Research*, 49(4):487–500, 2001.

[33] C.J. Corbett and X. de Groote. A supplier's optimal quantity discount policy under asymmetric information. *Management Science*, 46(3):444–450, 2000.

[34] C.J. Corbett, D. Zhou, and C.S. Tang. Designing supply contracts: Contract type and information asymmetry. *Management Science*, 50(4):550–559, 2004.

[35] J.J. Cordes and P.M. Rooney. *Fundraising Costs*, pages 83–100. Effective Economic Decision-Making by Nonprofit Organizations. National Center for Nonprofit Enterprise and The Foundation Center, New York, 2004.

[36] R. Cowan, N. Jonard, and J. Zimmermann. Bilateral collaboration and the emergence of innovation networks. *Management Science*, 53(7):1051–1067, 2007.

[37] P. Crama, B. De Reyck, and Z. Degraeve. Milestone payments or royalties? Contract design for R&D licensing. *Operations research*, 56(6):1539–1552, 2008.

[38] F. de Vericourt and M. Lobo. Resource and revenue management in nonprofit operations. *Operations Research*, 57(5):1114–1128, 2009.

[39] J.G. Dees. Enterprising nonprofits. *Harvard Business Review*, 76(1):55–67, 1998.

[40] G.H. DeFriese, J.S. Hetherington, E.F. Brooks, C.A. Miller, S.C. Jain, F. Kavaler, and J.S. Stein. The program implications of administrative relationships between local health departments and state and local government. *American Journal of Public Health*, 71(10):1109–1115, 1981.

[41] S. Dewan and H. Mendelson. User delay costs and internal pricing for a service facility. *Management Science*, 36(12):1502–1517, 1990.

[42] D. Easley and M. O'Hara. The economic role of the nonprofit firm. *The Bell Journal of Economics*, 14(2):531–538, Autumn 1983.

[43] M. Ehrgott. *Multicriteria Optimization*. Springer, New York, 2 edition, 2005.

[44] F. Erhun. Collaborative procurement. In J.J. Cochran, L.A. Cox, Jr., P. Keskinocak, J.P. Kharoufeh, and J.C. Smith, editors, *Wiley Encyclopedia of Operations Research and Management Science*. John Wiley & Sons, 2009.

[45] F. Erhun and P. Keskinocak. Collaborative supply chain management. In K. Kempf, P. Keskinocak, and R. Uzsoy, editors, *Handbook of Production Planning*, Kluwer International Series in Operations Research and Management Science. Kluwer, New York, 2007.

[46] F.J. Fabozzi, P.N. Kolm, D.A. Pachamanova, and S.M. Focardi. *Robust Portfolio Optimization and Management*. John Wiley & Sons, New Jersey, 2007.

[47] Federal Emergency Management Agency (FEMA). Urban areas security initiative grant program. Technical report, 2009.

[48] Trust for America's Health. Ready or not? protecting the public's health from disease, disasters and bioterrorism. Bioterror report, 2006.

[49] M.K. Foster and A.G. Meinhard. A regression model explaining predisposition to collaborate. *Nonprofit and Voluntary Sector Quarterly*, 31(4):549–564, 2002.

[50] W. Foster and J. Bradach. Should nonprofits seek profits? *Harvard Business Review*, 83(2):92–100, 2005.

[51] Foundation Center. Highlights of foundation yearbook. Foundation Today Series 2008 Edition, 2008.

[52] Foundation Center. Email Communication, September 29 2009.

[53] K.A. Froelich and T.W. Knoepfle. Internal Revenue Service 990 data: Fact or fiction? *Nonprofit and Voluntary Sector Quarterly*, 25(1):40–52, March 1996.

[54] P. Frumkin and E.K. Keating. Reengineering nonprofit financial accountability: Toward a more reliable foundation for regulation. *Public Administration Review*, 63(1):3–15, January 2003.

[55] P. Frumkin and M.T. Kim. Strategic positioning and the financing of nonprofit organizations: Is efficiency rewarded in the contributions marketplace? *Public Administration Review*, 61(3):266–275, May-June 2001.

[56] D. Gammal. Before you say "I Do". *Stanford Social Innovation Review*, 5(3):47, 2007.

[57] N. Gans. Customer loyalty and supplier quality competition. *Management Science*, 48(2):207–221, 2002.

[58] R.L. Gordon, R.B. Gerzoff, and T.B. Richards. Determinants of us local health department expenditures, 1992 through 1993. *American Journal of Public Health*, 87(1):91–95, 1997.

[59] T. Gordon, S.B. Khumawala, M.Kraut, and J. Meade. The quality and reliability of Form 990 data: Are users being misled? *Academy of Accounting and Financial Studies Journal*, 11(Special Issue):27–49, 2007.

[60] M. Gottfredson, S. Schaubert, and E. Babcock. Achieving breakthrough performance. *Stanford Social Innovation Review*, 6(3):32, 2008.

[61] D. Granot and G. Sosic. Formation of alliances in internet-based supply exchanges. *Management Science*, 51(1):92–105, 2005.

[62] A. Grossman and V.K. Rangan. Managing multisite nonprofits. *Nonprofit Management & Leadership*, 11(3):321–337, 2001.

[63] A.Y. Ha. Supplier-buyer contracting: Asymmetric cost information and the cutoff level policy for buyer participation. *Naval Research Logistics*, 48(1):41–64, February 2001.

[64] M. Hager and T. Flack. The pros and cons of financial efficiency standards. Technical report, Urban Institute, August 1 2004.

[65] D. Haider. Uniting for survival. *Stanford Social Innovation Review*, 5(3):52, 2007.

[66] P.K. Halverson, G.P. Mays, and A.D. Kaluzny. Working together? organizational and market determinants of collaboration between public health and medical providers. *American Journal of Public Health*, 90(12):1913–1916, 2000.

[67] T.M. Hammett. Public health/corrections collaborations: Prevention and treatment of hiv/aids, stds, and tb. Technical report, National Institute of Justice Centers for Disease Control and Prevention, July 1998. Research in Brief.

[68] H.B. Hansmann. The role of nonprofit enterprise. *Yale Law Journal*, 89, 1980.

[69] H.B. Hansmann. *Economic Theories of Nonprofit Organizations*, pages 27–42. The nonprofit sector: a research handbook. Yale University Press, New Haven, CT, 1987.

[70] M. Harris, C.H. Kriebel, and A. Raviv. Asymmetric information, incentives and intrafirm resource allocation. *Management Science*, 28(6):604–620, 1982.

[71] T.D. Harrison and K.M. Lybecker. The effect of the nonprofit motive on hospital competitive behavior. *Contributions to Economic Analysis & Policy*, 4(1):1–15, 2005.

[72] L.G. Hart, E.H. Larson, and D.M. Lishner. Rural definitions for health policy and research. *American Journal of Public Health*, 95(7):1149–1155, 07 2005.

[73] B.C. Hartman and M. Dror. Allocation of gains from inventory centralization in newsvendor environments. *IIE Transactions*, 37(2):93–107, 2005.

[74] R.D. Herman and D.O. Renz. Theses on nonprofit organizational effectiveness. *Nonprofit and Voluntary Sector Quarterly*, 28(2):107–126, June 1999.

[75] R.E. Herzlinger. Can public trust in nonprofits and governments be restored? *Harvard Business Review*, pages 97–107, March-April 1996.

[76] C.J. Hill and L.E. Lynn. Producing human services: Why do agencies collaborate? *Public Management Review*, 5(1):63–81, 2003.

[77] D.S. Hochbaum and A. Levin. Methodologies and algorithms for group-rankings decision. *Management Science*, 52(9):1394–1408, 2006.

[78] P.A. Honoré and B.W. Amy. Public health finance: Fundamental theories, concepts and definitions. *Journal of Public Health Management and Practice*, 13(2):89–92, 2007.

[79] J.P. Ignizio. A review of goal programming: A tool for multiobjective analysis. *The Journal of the Operational Research Society*, 29(11):1109–1119, 1978.

[80] N. Jalandoni, M. Weitzman, L. Lampkin, and T. Pollak. *New Nonprofit Almanac & Desk Reference*. Jossey-Bass, 2002.

[81] C.L. Jones and A.A. Roberts. Management of financial information in charitable organizations: The case of joint-cost allocations. *The Accounting Review*, 81(1):159–178, January 2006.

[82] W.B. Werther Jr. and E.M. Berman. *Third Sector Management: The Art of Managing Nonprofit Organizations*. Georgetown University Press, Washington, D.C., 2001.

[83] S. Karabuk and S.D. Wu. Incentive schemes for semiconductor capacity allocation: A game theoretic analysis. *Production and Operations Management*, 14(2):175–188, Summer 2005.

[84] E. Kayış, F. Erhun, and E.L. Plambeck. Delegation vs. control of component procurement under asymmetric cost information and price-only contracts. Working paper, Department of Management Science & Engineering and Graduate School of Business, Stanford University, Stanford, CA, 2009.

[85] E.K. Keating, L.M. Parsons, and A.A. Roberts. Misreporting fundraising: How do nonprofit organizations account for telemarketing campaigns? *The Accounting Review*, 83(2):417–446, 2008.

[86] E.K. Keating, G. Pradhan, G.H. Wassall, and D. DeNatale. Passion & purpose: Raising the fiscal fitness bar for Massachusetts nonprofits. White paper, The Boston Foundation, June 2008.

[87] P. Keskinocak and S. Savasaneril. Collaborative procurement among competing buyers. *Naval Research Logistics*, 55(6):516–540, 2008.

[88] K. Klamroth and K. Miettinen. Integrating approximation and interactive decision making in multicriteria optimization. *Operations Research*, 56(1):222–234, 2008.

[89] R. Krishnan, M.H. Yetman, and R.J. Yetman. Expense misreporting in nonprofit organizations. *The Accounting Review*, 81(2):399–420, 2006.

[90] N. Kulatilaka and L. Lin. Impact of licensing on investment and financing of technology development. *Management Science*, 52(12):1824–1837, 2006.

[91] J.J. Laffont. The new economics of regulation ten years after. *Econometrica*, 62(3):507–537, May 1994.

[92] J.J. Laffont and D. Martimort. *The Theory of Incentives: The Principal-Agent Model*. Princeton University Press, Princeton, NJ, 2002.

[93] J.J. Laffont and J. Tirole. Using cost observation to regulate firms. *Journal of Political Economy*, 94(3):614–641, 1986.

[94] M. Lariviere and E. L. Porteus. Selling to the newsvendor: An analysis of price-only contracts. *Manufacturing & Service Operations Management*, 3(4):293–305, 2001.

[95] R.D. Lasker, the Commitee on Medicine, and Public Health. *Medicine & Public Health: the power of collaboration*. The New York Academy of Medicine, 1997.

[96] S. Lawrence. Foundations' year-end outlook for giving and the sector. Technical report, Foundation Center, November 2009.

[97] J. Levi, C. Juliano, and M. Richardson. Financing public health:diminished funding for core needs and state-by-state variation in support. *Journal of Public Health Management and Practice*, 13(2):97–102, 2007.

[98] H.M. Levin. *Cost-Effectiveness: A Primer*, volume 4 of *New Perspectives in Evaluation*. Sage Publications, Beverly Hills, 1983.

[99] X. Li and Q. Wang. Coordination mechanisms of supply chain systems. *European Journal of Operational Research*, 179(1):1–16, 2007.

[100] L. Lin and N. Kulatilaka. Network effects and technology licensing with fixed fee, royalty, and hybrid contracts. *Journal of Management Information Systems*, 23(2):91, 2006.

[101] Y. Liu and C.B. Weinberg. Are nonprofits unfair competitors for businesses? An analytical approach. *Journal of Public Policy & Marketing*, 23(Spring):65–79, 2004.

[102] H. Lutze and Ö. Özer. Promised lead-time contracts under asymmetric information. *Operations Research*, 56(4):898–915, 2008.

[103] S. Mallik and P.T. Harker. Coordinating supply chains with competition: Capacity allocation in semiconductor manufacturing. *European Journal of Operational Research*, 159:330–347, 2000.

[104] M.B. Mandell. Modelling effectiveness-equity trade-offs in public service delivery systems. *Management Science*, 37(4):467–482, 1991.

[105] L.L. Martin and P.M. Kettner. *Measuring the Performance of Human Service Programs*, volume 71 of *Sage Human Services Guides*. Sage Publications, Inc., Thousand Oaks, 1996.

[106] N.P. Marwell. Privatizing the welfare state: Nonprofit community-based organizations as political actors. *American Sociological Review*, 69(2):265–291, 2004.

[107] G.P. Mays, P.K. Halverson, E.L. Baker, R. Stevens, and J.J. Vann. Availability and perceived effectiveness of public health activities in the nation's most populous communities. *American Journal of Public Health*, 94(6):1019–1026, 2004a.

[108] G.P. Mays, M.C. McHugh, K. Shim, N. Perry, D. Lenaway, P.K. Halverson, and R. Moonesinghe. Institutional and economic determinants of public health system performance. *American Journal of Public Health*, 96(3):523–531, 2006.

[109] G.P. Mays and S.A. Smith. Geographic variation in public health spending: Correlates and consequences. *Health Services Research*, 44(5):1796–1817, 2009.

[110] K.F. McCardle, K. Rajaram, and C.S. Tang. A decision analysis tool for evaluating fundraising tiers. *Decision Analysis*, 6(1):4–13, March 2009.

[111] M. McGuire. Collaborative public management: Assessing what we know and how we know it. *Public administration review*, 66(s1):33–43, 2006.

[112] K. Meredith. Current Executive Director of Stanford University Center on Philanthropy and Civil Society and former Chief Development Officer for Planned Parenthood Federation of America. Personal Communication, October 1 2009.

[113] R. Murray, W.E. Hart, C.A. Phillips, J. Berry, E.G. Boman, R.D. Carr, L.A. Riesen, J. Watson, T. Haxton, J.G. Herrmann, R. Janke, G. Gray, T. Taxon, J.G. Uber, and K.M. Morley. U.S. environmental protection agency uses operations research to reduce contamination risks in drinking water. *Interfaces*, 39(1):57–68, 2009.

[114] E. Nee. Emmett Carson. *Stanford Social Innovation Review*, 5(3):31, 2007.

[115] A. Neuhoff and R. Searle. More bang for the buck. *Stanford Social Innovation Review*, 6(2):33–37, Spring 2008.

[116] K.E. Newcomer. Using performance measurement to improve programs. In K.E. Newcomer, editor, *Using Performance Measurement to Improve Public and Nonprofit Programs*. Jossey-Bass, San Francisco, 1997.

[117] National Association of City and County Health Officials. 2005 national profile of local health departments. Technical report, National Association of City and County Health Officials (NACCHO), 2006.

[118] National Association of City and County Health Officials. 2008 national profile of local health departments. Technical report, National Association of City and County Health Officials (NACCHO), 2009.

[119] Institute of Medicine. *Future of the Public's Health in the 21st Century*. National Academies Press, Washington, DC, USA, 2002 2002.

[120] M. O'Flanagan and L.K. Taliento. Nonprofits: Ensuring that bigger is better. *The McKinsey Quarterly*, 2, 2004.

[121] S. M. Oster. Nonprofit organizations and their local affiliates: A study in organizational forms. *Journal of Economic Behavior & Organization*, 30(1):83–95, 1996.

[122] A.H. Packer. Applying cost-effectiveness concepts to the community health system. *Operations Research*, 16(2):227–253, 1968.

[123] Panel on the Nonprofit Sector. *Principles for Good Governance and Ethical Practice: A Guide for Charities and Foundations*. Independent Sector, October 2007.

[124] D.J. Perez and M.A. Larkin. Commentary: Partnership for the future of public health services and systems research. *Health Services Research*, 44(5):1788–1795, 2009.

[125] Philanthropy and Civil Society Research Workshop. Center for Philanthropy and Civil Society, Stanford University. Haas Center for Public Service, 562 Salvatierra Walk, Stanford, CA, 2008–2010.

[126] W.W. Powell and J. Owen-Smith. *Universities as creators and retailers of intellectual property: Life-sciences research and commercial development*. To Profit or Not to Profit: The Commercial Transformation of the Nonprofit Sector. Cambridge University Press, New York, 1998.

[127] K. Prewitt. Foundations. In W.W. Powell and R. Steinberg, editors, *The Nonprofit Sector: A Research Handbook*, chapter 15, pages 355–377. Yale University Press, second edition, 2006.

[128] K.G. Provan, M.A. Veazie, L.K. Staten, and N.I. Teufel-Shone. The use of network analysis to strengthen community partnerships. *Public administration review*, 65(5):603–613, 2005.

[129] Quality 990. Form 990 in 2K. http://www.qual990.org, 2000.

[130] S.T. Rachev, S.V. Stoyanov, and F.J. Fabozzi. *Advanced stochastic models, risk assessment, and portfolio optimization: The ideal risk, uncertainty, and performance measures*. John Wiley & Sons, 2008.

[131] M. Rajan and S. Reichelstein. A perspective on "Asymmetric information, incentives and intrafirm resource allocation". *Management Science*, 50(12):1–9, 2004.

[132] S.U. Raymond. *The Future of Philanthropy: Economics, Ethics, and Management*. John Wiley & Sons, Hoboken, N.J., 2004.

[133] R. Ritchie and C.B. Weinberg. Competition in the nonprofit sector: A strategic marketing framework. Working paper, University of Western Ontario and University of British Columbia, 2003.

[134] S.T. Roussos and S.B. Fawcett. A review of collaborative partnerships as a strategy for improving community health. *Annual Review of Public Health*, 21:369–402, 2000.

[135] L.M. Salamon. *Partners in Public Service: Government-Nonprofit Relations in the Modern Welfare State*. Johns Hopkins University Press, Baltimore, 1995.

[136] B. Schulz RN MPH. Clinical services manager, communicable disease control officer. Personal communication, San Mateo County Health Services Agency, February 26 2010.

[137] E. Schwinn and G. Williams. A challenge for the IRS. *Chronicle of Philanthropy*, pages 27–29, August 23 2001.

[138] F.D. Scutchfield, G.P. Mays, and N. Lurie. Applying health services research to public health practice: An emerging priority, 10/15 2009.

[139] M.F. Sherlock and J.G. Gravelle. An overview of the nonprofit and charitable sector. Technical Report R40919, Congressional Research Service, 2009.

[140] M.I. Singer and J.A. Yankey. Organizational metamorphosis: A study of eighteen nonprofit mergers, acquisitions, and consolidations. *Nonprofit Management & Leadership*, 1(4):357–369, 1991.

[141] T.A. Smith, K.J. Minyard, C.A. Parker, R.F. Van Valkenburg, and J.A. Shoemaker. From theory to practice: What drives the core of business in public health. *Journal of Public Health Management and Practice*, 13(2):169–172, 2007.

[142] K.C. So. Price and time competition for service delivery. *Manufacturing & Service Operations Management*, 2(4):392–409, 2000.

[143] G. Speckbacher. The economics of performance management in nonprofit organizations. *Nonprofit Management and Leadership*, 13(3):267–281, 2003.

[144] R. Steinberg. The revealed objective functions of nonprofit firms. *The Rand Journal of Economics*, 17(4):508–526, 1986.

[145] R. Steinberg. *Economic Theories of Nonprofit Organizations*, page 659. The nonprofit sector: a research handbook. Yale University Press, New Haven, 2nd edition, 2006.

[146] D.L. Stufflebeam. Evaluation models. *New Directions for Evaluation*, (89):7–98, Spring 2001.

[147] M. Tavana. CROSS: A multicriteria group-decision-making model for evaluating and prioritizing advanced-technology projects at NASA. *Interfaces*, 33(3):40–56, 2003.

[148] The William and Flora Hewlett Foundation and McKinsey & Company. The nonprofit marketplace: Bridging the information gap in philanthropy. Technical report, 2008.

[149] K.M. Tingley and J. S. Liebman. A goal programming example in public health resource allocation. *Management Science*, 30(3):279–289, 1984.

[150] J. Trussel. Assessing potential accounting manipulation: The financial characteristics of charitable organizations with higher than expected program-spending ratios. *Nonprofit and Voluntary Sector Quarterly*, 32(4):616–634, 2003.

[151] A.A. Tsay and N. Agrawal. Channel dynamics under price and service competition. *Manufacturing & Service Operations Management*, 2(4):372–391, 2000.

[152] H.P. Tuckman. *Competition, Commercialization and the Emergence of Nonprofit Organizational Structures.* To Profit or Not to Profit: The Commercial Transformation of the Nonprofit Sector. Cambridge University Press, New York, 1998.

[153] E.A. Van der Laan, M.P. De Brito, and D.A. Vergunst. Performance measurement in humanitarian supply chains. *International Journal of Risk Assessment and Management*, 13(1):22–45, November 2009.

[154] D.M. Varda, A. Chandra, S.A. Stern, and N. Lurie. Core dimensions of connectivity in public health collaboratives. *Journal of Public Health Management and Practice*, 14(5):E1–E7, 2008.

[155] P. Verheyen. The missing link in budget models of nonprofit institutions: Two practical Dutch applications. *Management Science*, 44(6):787–800, 1998.

[156] A. Vernis, M. Iglesias, B. Sanz, and A. Saz-Carranza. *Nonprofit Organizations Challenges and Collaboration*. Palgrave Macmillan, New York, 2006.

[157] B. A. Weisbrod. *Modeling the nonprofit organization as a multiproduct firm: A framework for choice*. To Profit or Not to Profit: The Commercial Transformation of the Nonprofit Sector. Cambridge University Press, New York, 1998.

[158] F. Zakaria. We all have a lot to learn. *Newsweek*, 147(1):37, 2006.

[159] G.S. Zaric and M.L. Brandeau. Resource allocation for epidemic control over short time horizons. *Mathematical Biosciences*, 171(1):33–58, 2001.

[160] G.S. Zaric and M.L. Brandeau. A little planning goes a long way: Multilevel allocation of HIV prevention resources. *Medical Decision Making*, 27(1):71–81, January/February 2007.