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To cite this article: Sarah Kabay , Christina Weiland & Hirokazu Yoshikawa (2020) Costs of the Boston Public Prekindergarten Program, Journal of Research on Educational Effectiveness, 13:4, 574-600, DOI: [10.1080/19345747.2020.1799463](https://doi.org/10.1080/19345747.2020.1799463)

To link to this article: <https://doi.org/10.1080/19345747.2020.1799463>



Published online: 11 Nov 2020.



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Costs of the Boston Public Prekindergarten Program

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ABSTRACT

Though there is an expanding field of research on public prekindergarten, there is a relatively little comprehensive investigation into what public prekindergarten costs. We address some of the absences in the literature by analyzing public-sector expenditures for the city of Boston's public prekindergarten program, a particularly high-quality program. We identify the different components of the Boston program and explore how they translate into costs. We also examine how costs change over time, how costs are distributed across different levels of the education system, and how costs can be adjusted in order to calculate nationally representative estimates. Our findings are relevant for localities interested in learning from existing prekindergarten programs. Our findings are relevant for localities interested in learning from existing prekindergarten programs and can also serve as an example of cost analysis in education research.

ARTICLE HISTORY

Received 23 July 2019

Revised 4 July 2020

Accepted 5 July 2020

KEYWORDS

Prekindergarten; quality; cost

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Expansion of public preschool has become an issue of considerable local, state, and national debate. The focus of this debate is often on costs. In early 2015, the *Boston Globe* ran an editorial titled, “Universal pre-K in Massachusetts: Let’s start the conversation” in which they asked, “Can the state afford it?” and answered, “At this point, no” (Boston Globe, 2015). Their answer, however, depended upon a report which described its estimates for the costs of public prekindergarten as “only a very rough proxy for actual costs” (Bernstein & Schuster, 2014). Though there have been major advances in research on early childhood education, and specifically on public preschool (Weiland, 2016), research on the costs of such policies and programs is limited (Karoly & Whitaker, 2016; Levin & Belfield, 2015; Levin & Schwartz, 2007). In general, education research includes very few systematic attempts to quantify costs—a glaring deficiency given the substantial cost of the education sector and how important issues of cost are to decision making (Levin & Belfield, 2015).

In this study, we add to the literature by analyzing the public-sector costs of Boston’s public prekindergarten program—a program frequently cited as a particularly high-quality model for preschool (Mongeau, 2016). We identify and analyze the ingredients of

the program and use this information to determine the program's cost. Boston's program has shown some of the strongest short-term impacts on children's school readiness of any large-scale public prekindergarten program and also relatively high levels of observed instructional quality among comparable programs (Weiland et al., 2013; Weiland & Yoshikawa, 2013). Our primary objective is to investigate how this attention to quality translates into costs and to use this insight to inform future investments and replication.

A detailed picture of the costs and components of a well-known, high-quality model for public prekindergarten is useful for policymakers who need to make programmatic decisions across different contexts. With this in mind, we aim to align our analysis with policy-relevant concerns. We differentiate between the startup costs to initiate the program and the costs to keep classrooms running. We organize ingredients and costs by the three levels of the program—schools, the Department of Early Childhood (DEC), and the district. And we differentiate between “additive costs” that represent how a prekindergarten program creates new expenses for the district (such as kindergarten teachers' salaries) and “system costs” that illustrate how the prekindergarten program draws from the existing expenses of the K-12 education system (such as a percentage of principals' salaries). To further make our analysis useful beyond Boston—an expensive city with higher than average costs—we calculate not only what the city of Boston spent in order to implement its program, but we also two nationally representative cost estimates of the Boston program.

Interest in clear, detailed, and transparent cost analysis is undoubtedly growing and represents a key direction for future educational research. Notably, the revamped Institute of Education Sciences request for proposals (2019) includes cost analysis requirements, many of which align with our work on the Boston program.

Expansion of Public Prekindergarten in the United States and Its Costs

Inspired at least in part by decades of evidence on the short- and long-term effects of preschool on later education and life-course outcomes (Philips et al., 2017; Yoshikawa et al., 2013), there has been a substantial increase in the provision of public preschool in the United States in recent years. Between 2002 and 2015, the percent of 4-year-olds enrolled in publicly provided prekindergarten doubled (Barnett et al., 2015). Large-scale programs now exist in cities such as Washington, DC, San Antonio, Seattle, and New York, as well as in states such as Oklahoma and Georgia, and there is growing interest in universal prekindergarten programs. At the same time, only 33% of 4-year-olds nationwide are currently enrolled in public prekindergarten and six states do not have any state prekindergarten program (Friedman-Krauss et al., 2019). There is still considerable policy debate about whether to invest in public prekindergarten at the state and city levels, with limited government funding as a key concern (Bernstein & Schuster, 2014; Wong, 2014).

The benefits versus costs of public prekindergarten are central to the policy debate as it has unfolded in recent years. Media headlines include “10 Years In, Tulsa's Pre-K Investment is Paying Off” (Sanchez, 2015), “Is Pre-K worth the investment?” (Levy, 2014), and “Hey Congress: Pre-K is a better investment than the stock market” (Matthews, 2013). This narrative has been strongly influenced by a few high-profile,

rigorous cost-benefit analyses of early childhood interventions, namely the Perry Preschool Project, the Abecedarian Project, and the Chicago Child-Parent Centers (García et al., 2017; Heckman et al., 2010; Reynolds et al., 2002). Research finds that the costs of these programs (teachers' salaries, supplies) are far outweighed by the benefits (higher earnings, lower crime rates). However, these interventions are known for being very intensive and were implemented at a small scale several decades ago. They are accordingly very different from most preschool programs and especially publicly provided prekindergarten (Morrissey & Warner, 2007).

The scientific evidence base on the costs and benefits of more standard, current-day public preschool programs is limited. Two recent studies synthesize existing literature on the cost-benefit analysis of preschool programs, analyzing the results of impact assessments for 11 state and three district-level preschool programs and reviewing more than 25 different studies (Karoly & Whitaker, 2016; Kay & Pennucci, 2014). In general, this work devotes far more attention to other aspects of cost-benefit calculations (namely the impact assessment component) than to costs. Only one of the 25 reviewed studies includes the estimation of costs (i.e., Bartik et al. (2012) cost-benefit analysis of Tulsa's program).

Across existing studies, there are four key limitations of current cost analysis that may limit attempts to learn from or replicate any given prekindergarten program or elements of given programs. Current cost analysis does not (1) provide adequate detail on program components; (2) consider the systems in which programs are implemented; (3) address change over time; or (4) consider the generalizability of costs. We describe each of these limitations in detail.

First, research provides very little information on the costs of specific components of different prekindergarten programs and models (Levin & Schwartz, 2007). Rather, many cost estimates for public prekindergarten simply divide the total amount of funding by the number of children served. For example, the cost estimates cited by the *Boston Globe* were calculated by dividing districts' total operating costs by average pupil membership across the state of Massachusetts (Bernstein & Schuster, 2014). As districts do not report spending by separate grades, this estimate is an average per pupil cost for prekindergarten through 12th grade. Such an estimate gives no indication of the components of the prekindergarten program, what they cost, or even whether per-pupil expenditure in prekindergarten might differ from that in 12th grade. Bartik et al.'s (2012) study of Tulsa's public prekindergarten program is an important contribution in that it distinguishes between costs of full-day and half-day programs. But across studies, with little to no information on the individualized components of programs and how they translate into costs, policymakers gain limited insight into critical decisions in prekindergarten program design and implementation.

Second, existing cost studies do not consider the larger systems in which prekindergarten can be situated, which can significantly affect the educational experiences children receive and their costs. For example, to estimate the costs of Tulsa's public prekindergarten program, Bartik et al. (2012) use state funding formulas and information on federal and local funding to calculate the total amount of funding for prekindergarten and then divide by the number of children served. It is unclear how much of this estimate concerns the prekindergarten classes vs. the broader costs of the

elementary schools in which they were placed. Is a percentage of an elementary school principal's or nurse's salary, for instance, included in the costs of the prekindergarten program? Accounting for the costs of integrating prekindergarten into district public schools and separating the costs of running an elementary school from the costs of a preschool classroom is essential for accurately estimating large-scale program costs.

Third, existing cost research does not consider the dynamics of spending. One primary distinction is between the costs to initiate a program and the costs to maintain it. Initial startup costs might be very different from recurring costs. This distinction is highly relevant to policy makers and practitioners who need to be able to anticipate how costs might vary over different implementation periods. To estimate the costs of Washington State's Early Childhood Education and Assistance Program (ECEAP), for instance, Kay and Pennucci (2014) combine the current state funding per slot for the ECEAP with the state's childcare subsidies. Washington's ECEAP, however, dates back to 1985. It is possible that in 2011–2012, the year for which costs are estimated, the program was able to take advantage of this long period of establishment, using buildings, trained staff, and other resources that represent a previous investment. It is also unclear how the costs for that year might differ from the program's period of expansion in 2017–2018, for example.

And finally, to our knowledge, no existing cost studies of public prekindergarten address the generalizability of costs. Using the specific expenses of any individual program fails to account for variation in costs of living and other factors across locations. Without addressing this source of contextual variation across states or localities, comparing the total costs of different programs and their specific ingredients might be defined more by the variation in prices between different locations rather than by the different components or characteristics of the programs. Systematic analysis that attends to these four areas—i.e., specific ingredients and their costs; costs of situating prekindergarten programs within other systems (like elementary schools); the dynamics of spending over time; and generalizability of costs—may facilitate easier replication of existing prekindergarten programs in other contexts and be broadly useful as an example for other educational programs and interventions beyond prekindergarten.

The Boston Prekindergarten Program

We focus our study on Boston's public prekindergarten program because of its explicit attention to quality, demonstrated effectiveness, and high profile. The Boston program's research-based curriculum and teacher coaching program have been widely documented, making it a key reference for cities and states considering public prekindergarten (Minervino, 2014; Philips et al., 2017). Research on the short-term impacts of the program found effect sizes of 0.45–0.62 *SD* for literacy and numeracy outcomes and 0.18–0.27 *SD* for social emotional and executive function outcomes (Weiland & Yoshikawa, 2013). Effect sizes for subgroups such as Hispanic and special needs children were even larger (Weiland & Yoshikawa, 2013; Weiland, 2016). Given its history and specific model choices, a better understanding of the program's components and costs will be valuable for researchers, policymakers, and practitioners. We briefly summarize its history and approach here.

Boston began major expansion of public prekindergarten in 2005–2006, under then-Mayor Thomas Menino’s directive to “provide all 4-year-olds in the city with full-day school within five years” (Sachs & Weiland, 2010). Known for his commitment to education (“I want to be judged as your mayor by what happens now in the Boston Public Schools” (Vaznis, 2013, para 17), Mayor Menino argued that such a program could have long-term benefits for children and could help attract families to the public-school system.

The program expanded gradually, increasing the total number of classrooms by about 40% each year across 4 years (from an initial 38 classrooms in 2004 to 101 classrooms in 2007, a 2-year overlap with the years of our study). The goal to reach all children was ultimately scaled back due to the economic recession with Menino stating in 2011, “We’re going to continue to try to make [seats] available, but I’m not going to say I’ll have it done in a year or two” (Ebbert, 2011).

A few key features define the Boston program during the years of this study. It was based entirely in public schools and was open to any child in the city, regardless of income. Its prekindergarten teachers were paid on the same scale as K-12 teachers, were subject to the same requirements (e.g., master’s degree within 5 years), and were members of the same union. The program was highly standardized in that the district’s DEC directed and managed all aspects of the prekindergarten program (for example, curriculum and professional development), except for the hiring of teachers which was managed by individual schools. The DEC supported teachers with regular in-classroom coaching and trainings.

In terms of curricula, the DEC implemented two play-based curricula in our focal years: *Opening the World of Learning* (OWL), which targets children’s early language and literacy skills and includes a social-skills component embedded in each unit, and *Building Blocks*, an early mathematics curriculum which covers both numeracy and geometry and has a heavy focus on verbal mathematical reasoning (Clements & Samara, 2007; Schickedanz & Dickinson, 2005). As the program expanded, the Boston coaches worked to integrate these two curricula and created trainings, a coaching system, and materials to accompany it. As has been detailed elsewhere (Weiland, 2016; Weiland & Yoshikawa, 2013), these features make the program quite distinctive within the national landscape, which is generally characterized by less well-educated teachers, less uniform professional development, and use of curricula that do not as explicitly follow children’s language, literacy, and math developmental trajectories. Across our four focal years, the coaching program was significantly scaled back due to the economic recession. Our cost estimates accordingly reflect the changing nature of the program.

As a well-researched, high-quality program, Boston’s prekindergarten is one of a couple particularly well-known public prekindergarten programs (Minervino, 2014; Philips et al., 2017) and there are a few existing estimates for the program’s costs. Karoly and Whitaker (2016) provide an estimate of \$12,390 for the 2013–2014 school year, citing the National Institute for Early Education Research’s *The State of Preschool 2014: State Preschool Yearbook* as its source. The *Yearbook*, though, only provides information on states, and Massachusetts reports public spending on prekindergarten as \$3,958 per child, Head Start as \$9,775 per child, and K-12 as \$16,337 per child, so it is unclear exactly how \$12,390 was derived (Barnett et al., 2015). Similarly, Minervino (2014)

provides an estimate of \$12,000 per child for Boston's program, but it is also unclear how this figure was derived. And finally, the Massachusetts State and Budget Center estimates that the state's Early Education and Care subsidy was \$8,500 per child and that public prekindergarten, estimated as per child public costs for prekindergarten through 12th grade, was \$13,999 for the 2013 financial year (Bernstein & Schuster, 2014). These studies represent important efforts to bring costs into the discourse on public prekindergarten, but more research is needed.

Present Study

In the present study, we conduct several different types of analyses in order to identify, analyze, and cost the Boston program's key components and also to address limitations in existing prekindergarten cost analysis more generally. To develop our understanding of the Boston program and its individual components, we conduct detailed analysis of Boston Public Schools expenditure data and calculate what Boston Public Schools (BPS) spent in order to implement its public prekindergarten program from the 2007–2008 school year until the 2010–2011 school year. This results in four different estimates, one for each year. We refer to this as our expenditure analysis. As part of this work, we analyze how the program's specific ingredients are integrated into and distributed across the different levels of the K-12 education system. Determining an estimate for each of the four different years also enables us to investigate how the ingredients and costs of the program changed over this time period.

Building on our understanding of the program that we develop in our expenditure analysis, we then calculate two nationally representative estimates, one to represent the public sector costs to initiate the Boston program and one to represent the public-sector costs to maintain the Boston program. Our specific research questions are:

1. What are the different components of the Boston program and how do they translate into public-sector costs?
2. How do the startup costs of the Boston program differ from the recurring costs of the program?
3. What are nationally representative estimates of the public-sector costs of the Boston model?

Methods

Our objective is to identify the ingredients of an effective prekindergarten program and to analyze those ingredients and their associated costs over time and in relation to the structure of the education system. We start by describing the different data sources we used to develop our estimates and then provide some detail on the sample of children who attended Boston's public prekindergarten and the parameters we used to define our study (time period, classroom type, etc.) We then organize our analysis into our two approaches: expenditure analysis and nationally representative analysis.

Importantly, our work is informed by the ingredients method put forth by Levin and colleagues (2018). Also known as the resource cost model (Chambers & Parish, 1994),

the ingredients method offers a relatively straightforward approach to estimating the costs of a particular intervention. The basic premise is to generate a list of all of the “ingredients” of an intervention and to assign a value to each ingredient. This method is typically used in cost-benefit and cost-effectiveness analysis and the values represent what resources would be required to replicate the observed treatment effect of the intervention. Due to the specific goals of our research and data limitations, our study deviates from the ingredients method in a few key ways, which we describe at the end of this section.

Data Sources

To identify the different components of the Boston program and to estimate their costs, we used three different sources of data: official administrative data from BPS; reports, internal documents, and records from the BPS Department of Early Childhood (DEC); and key-informant interviews we conducted with members of the DEC. Our primary source of expenditure data was BPS’s “all funds” budget data. These records include all expenditures reported by any school or office within BPS, regardless of the source of the funding (e.g., state, federal, private grant), and contain more than 9,000 different line items per year, from individual teachers’ salaries to superintendent costs to the district’s legal fees.

We combined these all-funds budget data with administrative data on student enrollment, teacher-student ratios, and personnel salaries. A complete understanding of the various ingredients and costs of the program required triangulation of these different data sources. For example, prekindergarten teachers in Boston are paid a kindergarten teacher’s salary and are accordingly not distinguishable from kindergarten teachers in budget data. To determine how many prekindergarten teachers were working in each school and accordingly in the district as a whole, we combined data on student enrollment and student-teacher ratios, and then were able to identify prekindergarten teachers’ and paraprofessionals’ costs in the budget data.

We conducted ten key-informant interviews with people in varying roles in the DEC (we do not describe them here in order to protect confidentiality). The data from these interviews served several different purposes. They explained, supplemented, and challenged the administrative data, and they helped us to develop an understanding of the program itself beyond other work on the program (Bardige et al., 2018; Duncan & Murnane, 2014; Manship et al., 2016; Weiland & Yoshikawa, 2013), highlighting what defines the intervention in the eyes of its implementers and what might make Boston’s program unique. They also helped us to develop a sense of how issues of cost influenced decision-making about the program.

Finally, we used data and documents provided to us by the BPS Department of Early Childhood, including internal memos, budgets, presentations, grant applications, and reports. As with the key informant interviews, we used these data to develop a more comprehensive and meaningful understanding of the costs of the program than what the administrative data could provide.

To generate our nationally representative estimates, we primarily used two sources of data: the Education Research Service (Protheroe et al., 2012) and the Bureau of Labor

Statistics, (2017). These sources provided national averages for personnel salaries we could use directly, such as school principal, kindergarten teacher, and cafeteria worker, and also the base from which we would estimate a salary, such as for a bilingual teacher. We used additional sources for data on national versus Boston costs for individual ingredients such as the renovation of a bathroom to serve young children.

Sample

Our sample of prekindergarten students is defined by three factors: the time period, the characteristics of the students served, and the schools in which prekindergarten programs were placed. Our study focuses on 4 years: the 2007–2008 through 2010–2011 school years. Our reason for focusing on this time period is to be able to analyze startup costs and years of expansion, as well as years in which budget cuts and other constraints stalled expansion and curtailed certain aspects of program implementation. This 4-year time period serves as a unique window into the life cycle of Boston public prekindergarten. Our sample includes all children in regular education classrooms, Sheltered English Immersion (SEI) classrooms, and also children in inclusion classrooms but without special education codes, for whom we calculated their percentage of those classroom's expenses.

As the motivating issue behind our work is the cost of provision of public prekindergarten, we chose to focus on a sample of children who would otherwise not be served by public education. Federal law requires that children with disabilities receive services starting at the age of three; children with disabilities should accordingly receive services with or without a public prekindergarten program. Special education is also typically implemented with separate funding sources and is subject to somewhat separate decision-making from that which would determine whether and how to implement a public prekindergarten program. For these reasons, we focus our analysis on children without special education codes, but as mentioned, we include children in all three types of prekindergarten classrooms: regular education, SEI, and inclusion classrooms.

With these inclusion and exclusion criteria, over the 4 years of our study, our sample ranges from 70% to 80% of the total population of Boston prekindergarten students. For example, in the 2007–2008 school year, we calculate expenses for 1,565 children of the total 2,223 children enrolled in Boston prekindergarten. Across the 4 years, 69% of children in our sample were free/reduced price lunch eligible, 42% were Hispanic, 29% were Black, 17% were White, and 10% were Asian.

Analytic Approach

We first calculate what Boston spent to implement its prekindergarten program for each of the 4 years of our study (termed “expenditure analysis” below). We use this work to identify and analyze the different ingredients of the program. Second, we develop two nationally representative estimates of the public costs of the Boston program and its ingredients, one to represent the costs to initiate the program and one to represent the costs to maintain the program.

Expenditure Analysis

Given that Boston prekindergarten classrooms were located in a diverse sample of schools that differed in their personnel, we average across the district to approximate the costs of the educational experience of an average child in the Boston program. Support personnel includes a range of specializations. For example, during the 2007–2008 school year, across the 56 schools in our enrollment data, there were 31.5 art teachers, 12 community field workers, 27 computer teachers, 41 nurses, 24 music teachers, 10 parent support services workers, and 33 science teachers.

Based on our qualitative work, we assume that principals, specialist teachers, and other school-level personnel devote approximately 10% of their time to prekindergarten students. In our qualitative interviews, we learned that some principals strongly believed in the importance of prekindergarten and would regularly visit classrooms and interact with students and teachers. In other schools, it seemed like principals were hardly aware of the prekindergarten classrooms in their school. We accordingly felt that 10% best captured this variation, as well as the range of the prekindergarten share of schools' total student populations (from 4% to 40%). We provide more detail on this issue in our results and test our assumption in our sensitivity analysis.

In our estimates, we categorize expenses in two ways (see [Table 2](#)). First, we categorize them as either *additive* or *system* expenses. We define additive expenses as those expenses that exist only because of prekindergarten students and that exclusively serve prekindergarten students—e.g., a prekindergarten teacher's salary and professional development related to the implementation of the prekindergarten curriculum. These expenses represent what a district could expect to add to its budget in order to implement prekindergarten. A system expense we define as an expense allocated to the prekindergarten program from the greater public-school system. These costs would not be expected to increase the district's budget. For example, the inclusion of a prekindergarten classroom in a school did not change a principal's salary or a nurse's salary. It similarly did not change the superintendent office budget or the district's legal advisory services, but we include a percentage of these expenses in our estimate of the costs of Boston's prekindergarten as the program includes these ingredients. These costs are drawing from the existing expenses of the public-school system in which prekindergarten has been placed.

Second, we categorize expenses into three different system levels: school, DEC, and district (see section headings in [Table 2](#)). This reflects the structure of the Boston prekindergarten program, which is implemented through a centralized department, the DEC. School-level expenses, specific to each school, are comprised mostly of personnel salaries: teachers, secretaries, administrators, and food service staff. DEC-level expenses include coaching, curriculum, and the initial outfitting and renovation of classrooms for early childhood. Finally, district-level expenses refer to the centralized expenses of the district. For the 2008–2009 school year, we included 1,942 item lines for central expenses, including, for instance, those from the Office of Budget Management, Food and Nutrition, Family and Student Engagement, and School Safety Services. In Boston, personnel benefits are pooled centrally, so all employee benefits, which might be as much as 30% of a teachers' salary, are included as district-level expenses.

Nationally Representative Estimates

We develop two nationally representative estimates—one to represent the costs to initiate the Boston program and one to represent the costs to maintain it. To calculate these estimates, we extrapolate from Boston’s actual expenditures to approximate a theoretical “initiate” estimate and a theoretical “maintain” estimate (Boston did not actually initiate the program in all schools in one year and then switch to maintain). These estimates are important for a policymaker who wants to know the per-child costs to start a new classroom and the per-child costs to maintain an existing classroom. For our estimate of the costs to initiate the program, we focus on the 2007–2008 school year, which represents the largest expansion of the program in the period of our study and thus includes the most information on startup costs, such as materials to outfit new classrooms. We calculate our estimate assuming every classroom is a new classroom. For the costs to maintain the program, we focus on the 2009–2010 school year, as that year reflects a point at which the Boston program stopped major expansion and also faced significant financial constraints due to statewide budget cuts. Other assumptions, such as the percent of specialist teachers’ and principals’ time, remain the same between our calculations of the costs to initiate and the costs to maintain. The governance structure and distribution across the education system also remain the same.

The work to develop nationally representative estimates is particularly important to our study as Boston is a high-cost area relative to most other U.S. contexts. Using our understanding of the Boston program developed during our expenditure analysis, we identify the ingredients of the program and assign nationally representative prices to each ingredient. For parsimony, more details on our approach are available in [Appendix A](#).

Departures from the Ingredients Method

Overall, there are central points of overlap between our approach and Levin and colleagues’ ingredients method (2018). The most notable alignment concerns our work to identify and enumerate individualized ingredients of the program and to develop nationally representative estimates. However, there are also key distinctions in our approach.

First, our analysis is focused exclusively on the public-sector costs of the Boston public prekindergarten program and accordingly does not represent the entire costs of the program, as Levin and colleagues would recommend. A more complete costing would include additional resources such as parents’ contributions that are not available to us. We provide more information on this in our Study Limitations Section.

Second, in our expenditure analysis, we calculate exactly what Boston spent in order to implement the program, rather than developing an estimate for each ingredient of the program based upon the opportunity cost it represents. We chose this approach because we found analyzing Boston’s actual expenditure data to be one of the best ways in which to learn about the ingredients of the program, and also because we felt that there was value in providing documentation of exactly what was spent to implement the program across the 4 years of our study, especially for potential policy replication. Our nationally representative analysis and estimates are more closely aligned with the ingredients method, where we aim to develop an estimate that reflects the true market value of each ingredient.

Finally, we build on previous use of the ingredients method by completing additional analysis to investigate resource allocation over time and across the education system. Specifically, having identified the key ingredients of the program in our expenditure analysis, we theorized the startup and maintenance ingredients for our nationally representative estimates, as if Boston were to have initiated the program in all classrooms in the same year. In reality, Boston expanded the prekindergarten program over several years, so the ingredients do not represent exactly what happened in a particular year, but rather a more generalizable exploration of what was implemented to initiate the program and what was implemented to maintain it. In addition, previous use of the ingredients method does not include the organization of ingredients/costing by level of the education system (school, DEC, District) or the differentiation between *systems costs*, which are apportioned from existing resources of the entire school system, and *additive costs*, which are additional cost ingredients specific to the early childhood program. We made these analytic choices in order to align our work with decisions facing policy makers. For example, a district considering integrating prekindergarten into its K-12 system might be more interested in *additive costs*, the additional resources required to implement prekindergarten, as opposed to the ways in which prekindergarten might draw from existing resources (*system costs*) or the true cost of the program (the combination of *additive* and *systems costs*). Similarly, information on how costs vary over time is highly relevant to policymakers.

Results

In total, we calculate six different estimates: four estimates for our expenditure analysis (one for each school-year we study) and two estimates for our nationally representative analysis. All six estimates are summarized in Table 1. Each estimate is described in more detail in the following sections of our results. All estimates have been adjusted for inflation and are reported in 2018 dollars.

Expenditure Estimates

Our expenditure analysis responds to our first two research questions: (1) What are the different ingredients of the Boston program and how do they translate into public-sector

Table 1. Costs of Boston public prekindergarten program.

	Boston expenditure				Nationally representative	
	2007–2008	2008–2009	2009–2010	2010–2011	Initiate ^a	Maintain ^b
School level	\$6,920	\$7,370	\$7,240	\$7,340	\$5,960	\$5,930
Dpt. early child	\$4,090	\$2,360	\$870	\$910	\$2,840	\$740
District level	\$7,200	\$7,210	\$7,140	\$6,990	\$5,760	\$5,710
Total	\$18,210	\$16,940	\$15,250	\$15,240	\$14,560	\$12,380
<i>Additive costs</i>	<i>\$11,670</i>	<i>\$10,380</i>	<i>\$8,880</i>	<i>\$8,670</i>	<i>\$9,320</i>	<i>\$7,220</i>
<i>System costs</i>	<i>\$6,540</i>	<i>\$6,560</i>	<i>\$6,370</i>	<i>\$6,570</i>	<i>\$5,240</i>	<i>\$5,160</i>

Note. All figures have been adjusted for inflation and represent 2018 dollars. All estimates have also been rounded to the nearest 10 dollars in order to signal that these are all estimates with limited precision.
^aThese figures were primarily estimated using data from the 2007–2008 year.
^bThese figures were primarily estimated using data from the 2009–2010 year.
The total per child costs (in bold) is the sum of school-, Department of Early Childhood-, and district-level costs. The total can also be calculated as the sum of additive and systems costs (in italics).

Table 2. Expenditure analysis: Yearly estimates of Boston's reported expenses.

	School year			
	2007–2008	2008–2009	2009–2010	2010–2011
School level				
Total costs at school level	\$10,827,000	\$12,586,470	\$13,293,080	\$13,665,330
per student costs (total)	\$6,920	\$7,370	\$7,240	\$7,340
additive costs	\$5,180	\$5,620	\$5,630	\$5,430
system costs	\$1,740	\$1,750	\$1,610	\$1,910
Department of Early Childhood level				
Total costs of department	\$11,732,670	\$8,190,060	\$1,986,560	\$2,288,270
(minus kindergarten costs) ^a	\$9,087,890	\$5,490,020	NA	NA
per student costs (total) ^b	\$4,090	\$2,360	\$870	\$910
additive costs	\$4,090	\$2,360	\$870	\$910
system costs	\$0	\$0	\$0	\$0
District level				
Total costs at district level	\$406,810,800	\$402,113,770	\$404,020,490	\$398,976,810
per student costs	\$7,200	\$7,210	\$7,140	\$6,990
additive costs	\$2,400	\$2,400	\$2,380	\$2,330
system costs	\$4,800	\$4,810	\$4,760	\$4,660
Number of students				
Prekindergarten students	1,565	1,708	1,836	1,863
Students served by DES	2,223	2,330	2,272	2,522
Total students in BPS	56,530	55,800	56,600	57,050
Total per student costs				
additive costs	\$18,210	\$16,930	\$15,250	\$15,240
Systems costs	\$11,670	\$10,380	\$8,880	\$8,670
	\$6,540	\$6,560	\$6,370	\$6,570

^aIn the 2007–2008 and 2008–2009 school years, the Department for Early Childhood received a grant to cover the costs of paraprofessionals' salaries and benefits for the kindergarten classrooms. As this expense did not affect the prekindergarten program, we subtract it from the total costs of the department.

^bThe Department of Early Childhood covers multiple grades. We aim to identify any costs unique to a particular grade and exclude any that are not relevant for prekindergarten, such as the kindergarten costs noted in the previous footnote, but otherwise assume DEC costs are comparable across all children served by the department.

The total per child costs (in bold) is the sum of school-, Department of Early Childhood-, and district-level costs. The total can also be calculated as the sum of additive and systems costs (in italics).

costs? and (2) How do the startup costs of the Boston program differ from the recurring costs of the program?

In Table 2, we report the results of this analysis: four different estimates, representing the 2007–2008, 2008–2009, 2009–2010 and 2010–2011 school years. In this table, we categorize expenses as either additive or system (as previously defined) and illustrate how expenses were distributed across the three systems levels (school, DEC, and district).

As shown in Table 2, we find that per child expenses were highest in the 2007–2008 school year (\$18,210 per child, first of the four columns, in bold) when the district was expanding and classrooms were supported with regular coaching and professional development. In this year, 23% of the program's 101 classrooms were new classrooms. Expenses were lowest in 2010–2011 (\$15,240 per child, third column, bottom; approximately 16% lower). This difference is driven entirely by reductions in the expenses of the DEC. Accordingly, the share of additive expenses as a percent of total expenses decreased over this period, from 64% in 2007–2008 to 57% in 2010–2011.

To provide some information on what these expenses represent, we list the primary expenses for each of the three systems levels in Table 3 (we provide more individualized itemization of these expenses in our nationally representative results). A key feature of

Table 3. Itemization of expenses organized by level and categorized as additive or system.

School level expenses	Department of early childhood level expenses	District level expenses
<i>Additive Expenses</i>	<i>Additive Expenses</i>	<i>Additive Expenses</i>
Kindergarten Teacher	Administrative team salaries	Employee benefits
Kindergarten Aide	Administrative team benefits	
Bilingual Teacher	Coach salaries	<i>System Expenses</i>
Bilingual Aide	Curriculum development	Transportation
Special Ed Teacher	Professional development	Superintendent office
Special Ed Aide	Classroom supplies and materials	Food and nutrition
	Accreditation expenses	Business management
<i>System Expenses</i>	Research and evaluation	Legal services
Community field coordinator	Countdown to Kindergarten	School safety
Computer teacher	NAEYC accreditation	Building repair and maintenance
Food service worker		Budgeting and finance
Library		Custodial services
Lunch monitor		Information services
Music teacher		Parent support services
Nurse		Professional development
Physical Education teacher		
Principal		
Science teacher		
Secretary		

Boston's program was its implementation through the centralized DEC. As detailed in [Table 3](#), the DEC's expenses included coaching, professional development, curriculum development, and the initial outfitting of new classrooms. It also covered costs of NAEYC (National Association for the Education of Young Children) accreditation and an outreach program for enrolling children in prekindergarten and kindergarten called Countdown to Kindergarten. Together, these expenses represent a relatively small proportion of per child spending, ranging from 22% in 2007–2008 (\$4,090 out of \$18,210) to 6% in 2010–2011 (\$910 out of \$15,240; all reported in [Table 2](#)).

School-level expenses consisted almost exclusively of personnel costs (see [Table 3](#)), which did not change significantly over the 4 years of our study. These costs reflect a couple key decisions. First and foremost is the decision to pay prekindergarten teachers an elementary school teacher's salary on the Boston Teachers Union pay scale. As previously mentioned, preschool teachers typically have significantly lower salaries than elementary school teachers. In 2009, for example, in Massachusetts, the average preschool teacher's salary was 56% of the state's average kindergarten teacher's salary (BLS, [2017](#)). In 2009, in Boston, the average prekindergarten teacher earned \$82,908 (in 2018 dollars), the same as an average district kindergarten teacher. For a classroom with 22 students, this represents an additional \$1,659 in per child spending than if prekindergarten teachers had been paid 56% of a kindergarten teacher's salary¹. These classrooms also included a full time paraprofessional. Boston's paraprofessional salary is comparable to a preschool teachers' salary in Head Start or community-based organizations (Barnett & Friedman-Krauss, [2016](#)), in addition to being afforded union rights and benefits. With an average salary of \$29,000 in 2009 (and benefits at as much as \$8,700), a paraprofessional represents an additional \$1,714 in per child spending.

¹The average prekindergarten teachers' salary in Boston in 2009 was \$70,625, but we report all dollar figures in this article as 2018 dollars, using the Consumer Price Index Inflation Calculator provided by the U.S. Bureau of Labor Statistics.

One strategy Boston used to help fund both teacher and paraprofessional salaries was to have slightly larger general education classrooms, with 22 instead of 20 children. However, as noted previously, Boston's prekindergarten program includes three different types of classrooms: general education, Sheltered English Immersion (SEI), and inclusion classrooms; the latter two have different student-teacher ratios and teacher salaries. During the 4 years of our study, approximately 20% of classrooms in the Boston program were SEI classrooms and approximately 15% were inclusion classrooms. SEI teachers earned about 3% more than general education teachers and worked in classrooms capped at 20 students, making per-child costs in these classrooms 13% higher than per-child costs in general education classrooms. Special education teachers earned about 2.4% more than general education teachers and worked in inclusion classrooms capped at 15 students.

Another important attribute of the Boston prekindergarten program is that it has been integrated into a public education system. This programmatic choice is reflected in its system costs—e.g., the expenses that we attribute to the prekindergarten program from the broader education system such as the percentage of a principal's salary and percentage of an art teacher's time. Systems expenses at both the school and the district levels comprise a significant percentage of total per-child spending. As shown in Table 2, in the 2007–2008 year, systems expenses comprised 36% of total per-child spending (\$6,540 of \$18,210 total). If a district were to start a new prekindergarten program in an existing K–12 school system, these costs would not represent additional costs but rather would be apportioned from existing costs.

Our understanding of the different components of the Boston prekindergarten program was informed by our qualitative interviews, which provide data on three key themes: system integration, unique aspects of the Boston setting, and sources of funding. First, our qualitative interviews describe the extent to which Boston's prekindergarten was integrated into the larger educational setting. As we mentioned in our methods section, our qualitative interviews helped us to determine the 10% of support staff's time that was devoted to the prekindergarten students and program. We also learned through our interviews that all specialist teachers work with prekindergarten students, that employee benefits are pooled centrally, that the DEC initially outfitted classrooms with supplies and many other specific points that directly informed our calculations.

Our qualitative interviews also gave us a general understanding of how the preschool program interacted with the schools in which it was placed. In some locations, the prekindergarten seemed to be separate, as one teacher described, "It felt like one more classroom in this giant place, that people are like *oh, there's a K1 [prekindergarten] thing here?*" More often, it seemed as though the inclusion of prekindergarten in an elementary school encouraged a new way of thinking throughout the school and early connections between families and the school. A teacher noted, "Our principal is giving it a lot of attention, maybe not in our classrooms, but she'll talk about our [pre]kindergarten to other grades, like *I saw this in [pre]kindergarten, you wouldn't believe what they're doing in [pre]kindergarten* so like I think that's making people kind of think about the learning happening." And a principal explained, "I think the payoff is long-term health and stability with teachers and kids and families ... Starting the relationships earlier only helps us in terms of building the connection with the family."

Second, the qualitative interviews helped us to identify what was unique about Boston as a city for the implementation of public prekindergarten. As one administrator described, “Space is a huge constraint.” Schools in Boston are often located in old buildings with small classrooms. One school had a prekindergarten classroom capped at 15 students due to the physical size of the classroom, even though the BPS model for a regular education prekindergarten classroom is one teacher and one paraprofessional for 22 students. These limitations determined where prekindergarten classrooms could be placed, what adjustments needed to be made to buildings in order to accommodate young children, and in general the costs of facilities and space.

Another unique aspect of Boston’s education system is its transportation costs. In one of our qualitative interviews, a BPS staff person noted, “We spend more on transportation than LA, not per pupil, total. They spend about 45 million; we spend 110 million, so this is not an insignificant ... this is a huge Boston uniqueness that our transportation is incredibly expensive.” In the 2007–2008 school year, LA Public Schools served a student body more than 10 times larger than that of Boston. The city’s unusually high transportation expenses are due to a number of different factors, such as an extensive school choice system, a long-standing bus-drivers’ union, and door-to-door transportation for students with special needs. We adjust transportation expenses like all district-level expenses by multiplying by the ratio of prekindergarten students to all students in BPS, but we further explore the issue of transportation in our sensitivity analysis.

And finally, our qualitative analysis highlights the importance of external funding sources to the Boston program. We learned that the DEC relies upon multiple sources of funding, most of which are external federal or state grants and private financing. In the 2007–2008 school year, for example, the DEC had eight primary sources of funding to cover its various activities. Over 14% of the DEC’s total budget came from private financing. Focusing just on the expenses for prekindergarten students, nearly a third of the DEC’s expenses were from private sources.

Nationally Representative Estimates

Costs to Initiate

Our third research question concerns the nationally representative public sector costs to initiate and maintain the Boston program. First, we report our estimates for the costs to initiate. As previously mentioned, to calculate the costs to initiate we use data and information primarily from the 2007–2008 school year, the year of greatest expansion of Boston prekindergarten. As with our expenditure analysis, we organize our estimates by systems level: school, DEC, and district. [Table 4](#) contains the first of these—school-level costs to initiate the model, with both additive costs and systems costs.

Our use of nationally representative figures for school-level expenditure generates a total per child cost estimate of \$5,960, the sum calculated in the final row of [Table 4](#). This estimate is 14% less than Boston’s actual per child expenditure for school-level expenses in 2007–2008 (\$6,920, as reported in [Table 2](#)). We believe this is a conservative estimate. To place this difference in context, the National Center for Education Statistics (NCES) reports that the salary of the average public-school teacher in the U.S. is 25% less than the average public-school teacher salary in Massachusetts (NCES, [2017](#)).

Table 4. Nationally representative school-level costs to initiate the program.

Personnel	A. Total no. of personnel	B. Nationally representative salary (\$)	C. Percent of full time equivalent	Total spent (A * B * C) (\$)
System costs				
Art teacher	26.4	\$62,688 ^c	0.1	\$165,500
Community field coordinator	12.4	\$46,912 ^a	0.1	\$58,170
Computer teacher	29.6	\$62,688 ^c	0.1	\$185,560
Food service worker	27	\$20,432 ^a	0.1	\$55,170
Guidance	2	\$62,871 ^a	0.1	\$12,570
Librarian	21.8	\$66,855 ^b	0.1	\$145,740
Lunch monitor	80	\$20,432 ^a	0.1	\$163,460
Music teacher	21	\$62,688 ^c	0.1	\$131,650
Nurse	37.6	\$54,046 ^b	0.1	\$203,210
Parent support services	4	\$46,912 ^a	0.1	\$18,770
Phys-Ed teacher	27.2	\$62,688 ^c	0.1	\$170,510
Principal	55	\$100,879 ^b	0.1	\$554,830
Science teacher	26.8	\$62,688 ^c	0.1	\$168,000
Secretary	46	\$33,831 ^b	0.1	\$155,620
			System total	\$2,188,770
			System per child	\$1,400
Additive costs				
Bilingual aide	16	\$27,666 ^c	1	\$442,660
Bilingual teacher	17	\$60,074 ^c	1	\$1,021,260
Kindergarten aide	61	\$27,666 ^a	1	\$1,687,630
Kindergarten teacher	56	\$58,444 ^a	1	\$3,272,860
Special Education aide	7.86	\$27,666 ^c	1	\$217,460
Special Education teacher	7.85	\$62,202 ^c	1	\$488,280
			Additive total	\$7,130,140
			Additive per child	\$4,560
			Total	\$9,318,910
			Total per child	\$5,960

^aSource: Salaries and Wages Paid Professional and Support Personnel in Public Schools, 2010–2011. National Survey of Salaries and Wages in Public Schools: A Reference Tool for School Administrators. 38th Edition.

^bSource: Bureau of Labor Statistics.

^cEdited estimate: When an exact estimate was not available to cite directly, we used available estimates and data from Boston to approximate a nationally representative figure.

Furthermore, teachers in the Boston municipality earn more than the Massachusetts state average teacher salary.

In Table 5, we present our nationally representative estimate for the DEC costs to initiate the program. As previously noted, in our nationally representative estimate we include startup costs for all classrooms, though in 2007–2008, only a third of Boston's prekindergarten classrooms were new. For this reason, our nationally representative DEC costs to initiate the program are not directly comparable to Boston's actual expenditures. At \$2,840 per child (bottom row, Table 5), the nationally representative estimate appears to be about 30% less than Boston's expenditure, \$4,090 (Table 2, second panel, first column); but this actually highlights how much lower the nationally representative estimate is, given that it includes the startup costs for an additional 52 classrooms.

As in the expenditure analysis, our nationally representative DEC costs are distributed across a number of different activities and programs. Coaches' salaries represent 13% of the DEC's costs; professional development, 7%; and purchase and adaptation of the OWL and Building Blocks curricula, 6%. Furniture to outfit classrooms comprises 10% of the DEC's costs. The single greatest expense of the nationally representative DEC is the renovation of bathrooms; at \$760,230 (\$19,493 per bathroom for half of all

Table 5. Nationally representative department of early childhood costs to initiate the program.

Personnel	No.	Prekindergarten/all children served by DEC	National estimate (\$)	Total amount (\$)
General				
Director	1	0.704	\$100,879	\$71,020
Subdirector	3	0.704	\$80,291	\$169,580
Assistants	2	0.704	\$31,482	\$44,330
Countdown to Kindergarten				
Director	1	0.704	\$77,868	\$54,820
Coordinators	4	0.704	\$53,735	\$151,320
Community partnership				
Coordinators	1	0.704	\$95,989	\$67,580
Technician	3	0.704	\$51,668	\$109,120
Instructional coaches				
Supervisor	1		\$81,941	\$81,940
Coaches	8		\$70,198	\$561,590
Startup costs (est. 78 new classrooms)				
OWL curriculum kit	78		\$1,497	\$116,780
OWL curriculum books	78		\$376	\$29,310
Extra books	78		\$411	\$32,060
Shipping	78		\$229	\$17,860
Supplies and materials	78		\$2,701	\$210,670
Extra books	78		\$705	\$54,960
Furniture	78		\$5,580	\$435,250
Building Blocks curriculum	78		\$1,082	\$84,360
10% shipping	78		\$108	\$8,430
Professional development	78		\$705	\$54,960
Curriculum development				
Creation of integrated curriculum				\$5,010
Further development				\$8,810
Consultants				\$11,230
Work sampling				
Work sampling OWL + BB alignment				\$29,360
K1 implementation				\$194,930
K1 online license				\$3,040
Facilities renovation				
Bathroom renovation	39		\$19,493	\$760,230
NAEYC accreditation				\$384,520
General expenses				\$110,820
Indirect charge on grants				\$121,150
Evaluation and research				\$148,400
Professional development				\$314,840
Total costs				\$4,448,280
Per child costs				\$2,840

classrooms), this represents 17% of the DEC's costs (from Table 5, \$760,230 divided by the total DEC cost of \$4,448,280). In Boston, funding for bathroom renovations came from the District's Facilities department, but because it was an additive expense intended for the prekindergarten program, we wanted to distinguish it from the general funding of the Facilities department, and so included it in the DEC budget for our nationally representative estimates.

To complete our nationally representative estimate of the costs to initiate the Boston program, we calculate district-level costs by applying a 20% reduction to the district-level costs found in our expenditure data (not tabled; see Appendix A for more details on this adjustment). This reduces district-level per child expenditure for 2007–2008 from \$7,200 per child (from Table 2) to \$5,760. Our total estimate for the per-child costs to initiate a public prekindergarten program by integrating it into an existing K-12

Table 6. Nationally representative school-level costs to maintain the program.

Personnel	A. Total number of personnel	B. Nationally representative salary (\$)	C. Percent of full time equivalent	Total spent (A * B * C) (\$)
Systems costs				
Art teacher	32.4	\$61,714 ^c	0.1	\$199,950
Community field coordinator	12.8	\$50,160 ^b	0.1	\$64,210
Computer teacher	26.3	\$61,714 ^c	0.1	\$162,310
Food service worker	57	\$22,055 ^b	0.1	\$125,720
Librarian	21.5	\$68,015 ^a	0.1	\$146,230
Lunch monitor	59	\$22,100 ^b	0.1	\$130,390
Music teacher	24.6	\$61,714 ^c	0.1	\$151,820
Nurse	42.8	\$54,944 ^a	0.1	\$235,160
Parent support services	12	\$50,160 ^b	0.1	\$60,190
Phys-Ed teacher	29.4	\$61,714 ^c	0.1	\$181,440
Principal	60	\$102,576 ^a	0.1	\$615,460
Science teacher	36.1	\$61,714 ^c	0.1	\$222,790
Secretary	54	\$34,859 ^a	0.1	\$188,240
			System total	\$2,483,910
			System per child	\$1,350
Additive costs				
Bilingual aide	16	\$28,460 ^b	1	\$455,360
Bilingual teacher	19	\$58,968 ^b	1	\$1,120,390
Kdg aide	64	\$28,460 ^b	1	\$1,821,450
Kdg teacher	63	\$58,968 ^b	1	\$3,714,970
SPED aide ^d	12.75	\$28,460 ^b	1	\$362,870
SPED teacher	14.7	\$63,166 ^b	1	\$928,540
			Additive total	\$8,403,580
			Additive per child	\$4,580
		Total		\$10,887,490
		Total per child		\$5,930

^aSource: Salaries and Wages Paid Professional and Support Personnel in Public Schools, 2007–2008. National Survey of Salaries and Wages in Public Schools: A Reference Tool for School Administrators. 36th Edition.

^bSource: Bureau of Labor Statistics.

^cEdited estimate.

^dAs previously mentioned, we do not include children with special education codes in our analysis. However, Boston's prekindergarten program has inclusion classrooms, in which children with and without special education codes are in the same classrooms, taught by a SPED certified teacher and aide. We calculate the share of these classrooms expenses that can be attributed to the children without special education codes. For this reason, we do not have a whole number for SPED teachers and aides, as we are including a percentage of their time.

education system is accordingly \$14,560. We explore an alternative to the 20% reduction in our sensitivity analysis.

Costs to Maintain

To calculate nationally representative estimates for the public sector costs to maintain the program, we focus on the 2009–2010 school year. In Table 6, we report the school-level costs to maintain the program. School-level costs do not differ significantly between the costs to initiate (\$5,960, bottom line, Table 4) and the costs to maintain (\$5,930, bottom line, Table 6). Many of those expenses are determined by unchanging standards such as student-teacher ratios. The DEC, however, anticipated a funding cut of about 20% in 2009. We report the DEC's expenses in Table 7. The DEC reduced the number of coaches and removed a sub-director position. Expansion to new classrooms was limited to seven classrooms. Supplies and materials were greatly reduced. As before, our estimate is a reflection of what the Boston program actually implemented but adjusted to reflect only the costs to maintain (for example, not including supplies costs for the seven new classrooms). It costs the DEC \$740 total per child costs, in nationally representative prices, to maintain the program. And finally,

Table 7. Nationally representative department of early childhood costs to maintain the program.

Personnel	FTE	Prekindergarten students/all children served by the DEC	National estimate (\$)	Total amount (\$)
General				
Director	1	0.704	\$102,483	\$72,150
Subdirector	2	0.704	\$85,248	\$120,030
Assistants	2	0.704	\$33,426	\$47,060
Countdown to kindergarten				
Director	1	0.704	\$82,675	\$58,200
Coordinators	4	0.704	\$57,052	\$160,660
Community partnership				
Coordinators	1	0.704	\$101,915	\$71,750
Technician	3	0.704	\$54,858	\$115,860
Instructional coaches				
Supervisor	1		\$87,000	\$87,000
Coaches	2		\$74,532	\$149,060
Professional development				\$235,050
Work sampling materials				\$5,720
NAEYC accreditation				\$236,100
Total costs				\$1,358,640
Per child costs				\$740

as before, we calculate district level expenses by reducing actual Boston expenditure by 20%. This results in an estimate of \$5,710 per child expenditure for district-level costs.

Sensitivity Analysis

We explore the sensitivity of our results to three key assumptions (for parsimony, we include a basic summary here. A detailed discussion of this work appears in [Appendix B](#)). First, we adjust the percent of principals' salary we attribute to prekindergarten by 5% in either direction. We do the same for specialist teachers. Second, we alter the reduction to Boston's district-level costs that we used to calculate nationally representative district-level costs. We change our reduction by 5% in either direction, thus reducing Boston's district level costs by 15% and 25% instead of 20%. A significant component of district-level costs in Boston is transportation, so we also experiment with reducing transportation costs by 50%. And finally, we reduce our estimation of employee benefits by 4%, as Boston employee benefits are approximately 30% of an employee's salary but nationwide, teachers' benefits tend to be closer to 26% of their salary. The results of these analyses indicate that had we used different approximations along these key dimensions, our reported estimates for total per-child expenditure would have varied in each case only slightly (generally under 5%). Accordingly, our estimates are relatively stable in relation to our key assumptions.

Study Limitations

Our study has three important limitations. First, because it was retrospective, records, key-informants, and information were not as readily available and complete as they would have been if we were focusing on a more contemporary period. Cost analysis should ideally be conducted concurrently with program implementation (Levin et al., 2018). A second limitation of the study concerns sources of funding. Through our partnership with BPS, we were able to analyze data on all official sources of funding,

including multiple private grants and in aiming to develop estimates that are immediately relevant for policy makers, we focused on public sector costs. However, there are two key additional sources of funding for the prekindergarten program: teachers and parents. In our qualitative interviews, it was clear that teachers spend significant amounts of their own personal money outfitting their classrooms. One teacher estimated she would spend between \$1,000 and \$2,000 on a new classroom, and at least \$500 each year. Another teacher described, “at least \$2,000, maybe more, maybe \$2,500. Now because I have a mortgage and my daughter is 8 and I pay for a lot of lessons I’ve cut back significantly, I’m under \$1000.” This would suggest an additional \$20–\$100 in per-child costs, which we did not include in our estimates as we focused on the public-sector costs of the Boston program.

Parents also contribute both resources and time that are not reflected in our estimates. Although BPS includes a few early childhood centers that have a 10-hour day, the presence and extent of after-school programs are negotiated at each school. This might require parents to secure extra services and supports. Alternatively, some schools in Boston offer additional services such as dental work which would offset parents’ expenses. These costs are hard to estimate, especially retrospectively. Future studies should gather data from parents to estimate this aspect of public prekindergarten costs.

And finally, we note that by necessity our average cost estimates conceal a great deal of variation at the school level. This is particularly true of the system-level and more general costs, of which we calculated fractions being devoted to prekindergarten. For example, several schools had Community Field Coordinators or other types of outreach services. One K-8 school had three Community Field Coordinators, one working in Parent Support Services and two in Student Support Services. This school also had a guidance counselor, more than one nurse, more than one librarian, six arts teachers, and a music teacher. Due to a large student body, though, per-child costs at this school were actually lower than at other schools.

Discussion

In this study, we estimate the public sector costs of Boston Public School’s (BPS) universal prekindergarten program over 4 years, from 2007–2008 through 2010–2011. We provide detailed documentation of the individualized ingredients of the program, how these ingredients draw upon and add to existing resources in Boston’s education system, how they are distributed across the system, and how they change over time. We accordingly provide comprehensive and nuanced analysis of the components of an effective program and an example of cost analysis that speaks to new Institute of Sciences requirements (2019).

In conducting this research and analysis, we aim to address four key limitations in existing cost research: insufficient detail on the definition of programs and how the ingredients of programs translate into costs, little understanding of how prekindergarten might be integrated into a larger K-12 education system, little investigation into how costs might change and vary, and little consideration of how location might influence certain costs and thus make estimates ungeneralizable. We review each of these issues in light of our results.

First, we consider how the key elements of Boston's program translate into costs. Understanding the ingredients and costs of public programs is a necessary first step for bringing rigorous cost effectiveness analysis to the prekindergarten sector (Caronongan et al., 2016). The total per-child costs of Boston prekindergarten, which ranged between \$15,240 a year during a time of maintenance and \$18,210 a year during a time of expansion, were spent across the school level, the district level, and the unit within the district specific to early childhood.

The centralized unit devoted to early childhood—the DEC or Department of Early Childhood—covered the coaching program, curriculum purchase and development, classroom supplies, its own administrative staff, and some specific programs like the NAEYC accreditation program and an outreach program for the transition to kindergarten. These cover what many perceive as the central characteristics associated with the high levels of quality of the Boston prekindergarten model—the integration of coaching and curricular supports (Duncan & Murnane, 2014; Minervino, 2014; Philips et al., 2017). Yet interestingly the DEC expenditures accounted for only 5.7% of total expenditure (during the 2009–2010 year of maintenance of the program) and 22% (during the 2007–2008 year of expansion). As cities and states around the US consider expansion of public prekindergarten programs, these findings suggest that high-quality models might not be prohibitively expensive. However, it is important to note that the Boston model also includes relatively high teacher's salaries (i.e., the bulk of the school-level expenses), which may or may not have been critical to the success of the coaching and curricula model implementation. In addition, 35% of Boston's prekindergarten classrooms were either Sheltered English Immersion or inclusion classrooms, which have higher teacher and paraprofessional salaries and lower student-teacher ratios than general education classrooms. Both bilingual and inclusion classroom strategies are supported by research, including in Boston (Espinosa, 2013; Odom, 2000; Odom et al., 2011; Weiland, 2016).

In relation to the second limitation in the existing literature—how prekindergarten might be integrated into a larger k-12 education system—we define two broad categories of expenditures to distinguish between the additional expenses incurred by a district to implement prekindergarten and how prekindergarten draws on existing expenditures. *Additive* expenditures are those that are entirely specific to early childhood, such as the prekindergarten teachers and aides, curricula, early childhood coaches, and staff in the DEC. *System* expenses are proportions of more general supports such as librarians, arts teachers, health professionals, principals, and the superintendent's office that we attribute to the prekindergarten program. Across all of our estimates, systems costs comprised approximately 40% of the total costs of prekindergarten. We believe it is important for policymakers to recognize that the additional costs to the district for including prekindergarten accordingly represent only about 60% of the total cost of prekindergarten. Another reason why we believe that it is important to make this distinction is because a key decision facing policy makers is to choose between different provider systems for prekindergarten—e.g., the public-school system vs. community-provider-based or early-childhood-only systems like Head Start centers. Comparative cost analyses that highlight different additive versus system costs by setting may be informative in designing mixed-auspice preschool systems.

Regarding the third limitation—variation in costs over time—change over time was a key factor in our analysis of the costs of Boston’s public prekindergarten that has not been previously reported in any prekindergarten cost studies. In response to external budget pressure and the transition from startup to maintenance costs, the Boston program changed significantly over time. Per-child costs for prekindergarten in Boston were \$2,970 (or 16%) less expensive in the 2010–2011 school year than in the 2007–2008 school year (even though there were still some new classrooms at this time). While school-level and district-level costs remained fairly constant across the 4 years of the study, the costs of the DEC varied significantly. This variation is explained in part by the difference between initiating and maintaining the program. Another influence on the DEC’s costs was the 2008 recession and the influence of a time period of financial austerity. In the 2010 school year, in response to the recession, many states made significant budget cuts to public education (Johnson et al., 2011). Due to declining tax revenue, Massachusetts faced a \$600 million budget gap at the end of 2009; the governor’s plan to close that gap included a \$16.4 million cut in funding for early education and childcare (Massachusetts Budget & Policy Center, 2009).

In our nationally representative estimates, in which the startup costs were estimated as if every classroom were a new classroom, the per-child costs of maintaining existing classrooms were 15% less expensive (\$2,180 less per child) than the startup costs. Details around how costs change over time are helpful both for localities in planning their funding models and to researchers in defining what are often dynamic programs.

We addressed the last of the four limitations of previous preschool cost studies—that of generalizability—using insights from the ingredients method (Levin et al., 2018). The city of Boston is unique in many ways that influence the workforce and other characteristics of its prekindergarten program. To address the generalizability of our estimates, we calculated both Boston-specific expenditure and nationally representative costs. As was to be expected, we found that costs and expenses in Boston are significantly higher than national averages. Whether it was the salary of a kindergarten teacher or the costs of renovating a bathroom, we consistently found that the ingredients of a prekindergarten program would be about 15–25% higher in Boston than in the U.S. as a whole. These adjustments are important in order to reflect more representative estimates for policy makers.

In closing, cost issues are of particular and growing importance to the field of public prekindergarten (National Academy of Sciences, Engineering and Medicine, 2018), given that access to publicly provided prekindergarten is still relatively low but expanding. Important debates surround who should become a prekindergarten teacher, the provider system in which public prekindergarten should be placed, and the definition of a high-quality classroom. Each of these issues has substantial cost implications and ultimately, issues of cost are critically important to children’s educational experience. Although the field of preschool education has been significantly influenced by the cost-benefit analysis of a few early childhood education programs, these programs have marked differences from today’s large-scale public prekindergarten programs. Research needs to include more comprehensive cost analysis in order to better inform the decisions of policy makers and practitioners. The current study represents a step in this direction.

Acknowledgments

Thanks to the Boston Public Schools, Jason Sachs, Brian Gold, Blaire Horner, the BPS Department of Early Childhood coaches and staff, the BPS Office of Data and Accountability, and the Center for Benefit Cost Studies in Education at Teachers College and the CBSE's Methods Training Course. Special thanks to Sara Staszak, Anna Shapiro, Shana Rochester, Rebecca Unterman, Eleanor Martin, Henry Levin, and Jere Behrman.

Funding

This study is funded by the Institute of Education Sciences [RFA R305A140059].

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Appendix A. More Details on Nationally Representative Costs Estimates

Our goal in attaching nationally representative estimates to each ingredient of the Boston program is to reflect the programmatic decisions of the Boston program in a way that is generalizable beyond that city. For example, an important characteristic of the Boston program is that pre-K teachers are included in the same salary scale as kindergarten teachers. This has an important cost implication. According to the Bureau of Labor Statistics (BLS), in 2008, the average U.S. preschool teacher's salary was \$31,248; the average kindergarten teacher's salary was \$58,444 (BLS, 2017). At the same time, teachers' salaries in Boston differ significantly from teachers' salaries in other states and cities. The National Center for Education Statistics (NCES) reports that in the 2009–2010 school year, the average public-school teacher's salary was \$63,145. In Massachusetts, for the same year, the average public-school teacher's salary was \$79,241, a difference of \$16,096, or 25% (NCES, 2017). In the same year, the average kindergarten teacher's salary in Boston was \$88,505. To develop a cost estimate that will be most useful to policy- and decision-makers across the US, we use a nationally representative estimate for a kindergarten teachers' salary to represent the cost of pre-K teachers in Boston's program, signaling programmatic decisions but not Boston prices.

²As with all of the figures in the paper, we have adjusted for inflation and report these salaries in 2018 dollars.

For some ingredients or budget items, there are no nationally representative data available. Bilingual prekindergarten programs, for instance, do not appear to be prevalent enough for there to be nationally representative data on the salaries of bilingual kindergarten teachers. To estimate a nationally representative salary, we calculate the relationship between a general education prekindergarten teacher and a bilingual prekindergarten teacher salary in Boston and apply this ratio to the nationally representative estimate we use for general education prekindergarten teachers. In other cases, we do not adjust Boston expenses because there is a standard national price. Curricular materials, furniture, and books were shipped from outside Massachusetts and therefore would likely cost the same in other U.S. contexts.

As in our expenditure analysis, in our two national estimates, we distinguish between additive and systems costs and organize costs by system level (school, Department of Early Childhood (DEC) and district). While we enumerate individual ingredients for the school and DEC expenses, for parsimony we do not enumerate each individual ingredient at the district level. We do not, for example, investigate national variation in superintendent office expenses and district legal fees. Similarly, it would not be very informative to identify all personnel in Boston Public Schools, such as superintendents, janitorial staff, financial and legal advisers, bus drivers, etc. and then adjust each of these costs to nationally representative data. Instead, to complete our estimates and calculate nationally representative district-level costs we apply a 20% reduction in district level costs to our expenditure data. We chose 20% as a conservative estimate based upon the data on public education sector salary differentials between Massachusetts and national estimates for the United States as a whole (NCES, 2017).

Appendix B. Sensitivity Analyses

In our sensitivity analysis, we explore three aspects of our calculations: the percentage of support staff's time devoted to the prekindergarten program, the adjustment of Boston's district expenses to represent nationally representative costs, and employee benefits. We do the same for specialist teachers.

In the main results of our expenditure analysis, we estimate that principals devoted 10% of their time to the prekindergarten program. If we were to adjust our estimate of principals' time by 5% for the 2007–2008 school year, in either direction, the per-student costs of prekindergarten would increase or decrease by \$214. We also estimate that all specialist teachers, such as computer, art, and science teachers, devoted 10% of their time to the prekindergarten program. If we were to adjust that estimate by 5% in either direction, the per student costs for the 2007–2008 school year would increase or decrease by \$344. Five percent of principals' and specialists' time accordingly represents approximately 1% and 2% of Boston's total per student expenditure, respectively. Making these same adjustments in relation to principals' and specialists' time in our nationally representative estimates would result in increases or decreases of \$177 (1%) and \$284 (2%) in per-student costs, respectively.

In order to calculate a nationally representative estimate for district-level costs, we reduced Boston-specific prices by 20%. If we were to adjust this reduction by 5% in either direction, the per-student costs to initiate the program would change by \$360, or 2% of total per-student costs. One component of these district-level costs seems particularly important. As stated previously, we learned in our qualitative interviews that transportation costs are unusually high in Boston. Indeed, our estimate for per student transportation costs in 2007–2008 for prekindergarten students was \$1,510, or 8% of the total per student costs to initiate the program. If we were to reduce transportation costs by 50% for the national estimate, this would reduce the per-student costs to initiate the program by \$755, or 4%.

³Transportation is a complex issue. We adjusted transportation costs in the same way as all district-level expenses, by multiplying them by the ratio of students in our sample to all students in the district. However, two additional adjustments might be important. First, a significant percentage of the transportation budget services special education children. In 2007–2008 budget, 47% of the transportation budget went towards serving these students, who are not

Another important issue in the Boston context is benefits: employee benefits are estimated to be approximately 30% of an employee's salary. All pension, health, and other benefits in Boston are pooled centrally. In each year of our expenditure analysis, employee benefits represented about a third of all district-level expenses. In our main results, we multiply benefit costs, like all other district-level expenses, by the ratio of prekindergarten students to all students. In our nationally representative estimates, we then reduced benefit costs by 20%, as we did to all district-level expenditure. Analysis of public-school teachers' benefits in the U.S. in 2015 found that on average benefits represent 26% of teachers' total compensation (Allegreto & Mishel, 2016). If we were to reduce district expenditure on benefits by 4% in our nationally representative estimate of the costs to maintain the Boston program, this would decrease per-student expenditure by \$95, or 0.8%.

Our sensitivity analysis thus illustrates the general robustness of our estimates to several changes in assumptions, when taken singly. Had we used different approximations along several key dimensions, our reported estimates would have varied in each case only slightly (under 5%). If we were to change most or all of these assumptions, of course, the differences would be cumulatively larger.

included in our sample. This would reduce our transportation estimate for prekindergarten students. Second, transportation services in Boston do not service high school students, who are expected to take public transportation. In the 2007–2008 year, 32% of students were in high school. This would increase our estimate for transportation costs for the prekindergarten students, as the ratio of students in our sample to all students served by the transportation department would increase. Another additional point is that we have categorized transportation costs as systems-level expenses. While we know that other systems level costs did not increase as a result of the inclusion of prekindergarten, we are not sure if the transportation budget changed to accommodate the influx of students. In the prekindergarten lottery, students in walk-zones are given priority and parents might be more likely to transport younger children, possibly making these students less likely to incur transport costs.