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RESEARCH ARTICLE

The Impact of State Farm to School Procurement Incentives on School Purchasing Decisions

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ABSTRACT

BACKGROUND: The most recent Farm to School (FTS) Census reported that of the 42% of US schools that participate in FTS, 77% procure food locally. In 2019, Colorado joined many other states in passing legislation that provides per-meal incentives for purchasing local foods. However, little is known about how these incentives impact procurement decisions of school Food Service Directors (FSDs), and purported benefits of FTS cannot accrue without additional local purchases by school FSDs.

METHODS: We constructed a unique, primary dataset of fresh fruit and vegetable purchases from 18 months of school invoices in 3 Northern Colorado school districts and parameterized an optimization model that mimics FSD decisions. Subsequently, we simulated how procurement is impacted by local food reimbursements.

RESULTS: Assuming 2017 and 2018 purchasing behavior, at $0.05 per meal reimbursement, FSDs would increase fresh fruit and vegetable purchasing by 11-12% in August-October, but by only 0-1% in November-December, likely due to seasonality constraints.

CONCLUSIONS: While an increase in FTS procurement was expected, the magnitude of the potential increase when aligned with the Colorado growing season is notable. This work underscores that adequately funded reimbursement-based FTS policies can increase FTS procurement without disrupting normal cost-minimizing purchasing behavior.

Keywords: farm to school; local food; food policy; school food service; optimization model; state incentive.

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Farm to school (FTS) programs connect K-12 students and local farms to improve student nutrition, health outcomes, and agricultural literacy, as well as increase market opportunities for farms and ranches.[1] In the 2013-2014 school year, 23.6 million students in 42,587 schools, representing 42% of surveyed school districts, participated in 1 or more of 3 FTS program areas: (1) procurement of local food; (2) education activities related to agriculture, food, health, or nutrition; and/or (3) school gardens. Of these FTS activities, local food procurement was the most common, with 77% of responding schools participating.[2]

Legislative support has accompanied growing participation in FTS.[3-5] The 2010 Healthy Hunger Free Kids Act created the first mandatory Federal funding program that exclusively supports FTS.[4] Concomitantly, state policies have proliferated. Between January 1, 2017, and December 31, 2018, 32 states and the District of Columbia proposed 81 FTS bills and resolutions. Of these, 25 passed, 23 of which included support or incentives for local procurement.[4] Local procurement

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is of particular interest to policymakers given the perceived opportunity to leverage some of the National School Lunch Program's (NSLP) $13.6 billion annual budget[6] to support kids' access to more nutritious, high quality food; increase farms' access to new markets; and spur positive economic impacts in local communities. The National Farm to School Network (NFSN) classifies these purported impacts as ''kids win, farmers win, communities win.''[7]

Although some research assesses the extent to which kids and communities win from FTS,[3,8-10] little research looks at farm-level impacts. Further, and perhaps more importantly, almost no research assesses if policies supporting local food procurement change NSLP procurement practices at the school district level.[11-13] School district responses to FTS policies are unclear given trade-offs associated with the price, availability, and variety of locally procured items. However, understanding how school districts respond to these FTS incentives is critical if kid, farm, and community benefits are to occur.

In this paper, we consider the role of local food purchasing in the NSLP and ask if policies incentivizing local food procurement influence school food service purchasing decisions. To address this question, we use a unique, primary dataset that describes fresh fruit and vegetable (FFV) purchases made by Food Service Directors in 3 Northern Colorado school districts. We use these data to calibrate an optimization model mimicking decisions made by Food Service Directors (FSDs), and then simulate the impacts of a recently enacted FTS local procurement bill, Colorado House Bill 19-1132: School Incentives to Use Colorado Food and Producers, on FSDs' FFV procurement behavior. Results help to inform policymakers' understanding of whether different levels of subsidy change the composition of school FFV purchases, and by how much.

FSDs, considered the ''gatekeepers'' of FTS,[1] must balance many considerations in their purchasing decisions. First, FSDs must meet strict Federal NSLP nutrition standards in order to receive their Federal per-meal reimbursement. These reimbursements often comprise a critical portion of FSDs' budgets, with schools receiving reimbursements of $0.32 to $3.65 per meal in the contiguous United States.[14] Second, FSDs must operate break-even or better meal programs.[15] To do this, many FSDs focus on maintaining or increasing school meal participation rates, as high participation rates can help schools achieve economies of scale, reducing per-meal costs of production.[12,15] However, providing meals that satisfy NSLP regulations, students, and parents may require serving a variety of high-quality food choices that are attractive, culturally appropriate, and perceived to be appealing[16-18] but are also costlier to produce.[12] Previous research links customer satisfaction directly to both participation rates and program financial viability.[16-18]

Participation in the NSLP has declined since 2011, driven by fewer full-price lunch purchases,[19] and FTS procurement may provide an opportunity to increase school meal participation rates given the perception that local is synonymous with higher-quality products.[20] However, participating in FTS procurement may also create additional challenges for FSDs. Frequently cited challenges include higher pricing[12,21,22] and limited availability.[21-24] In the most recent FTS census, 45.3% of responding school districts cited pricing as a barrier to FTS procurement, and 67.5% of schools indicated availability was a significant barrier to local food purchasing.[25] There is also preliminary evidence that spending on local food is negatively correlated with profits of individual lunch programs.[26] Other identified challenges include burdensome school foodservice guidelines,[27] communication barriers between FSDs and producers, lack of regional supply chain infrastructure,[24,27,28] challenges with product quality and amount of processing required,[29] lack of parental support for FTS programs,[27] and lack of food safety certifications among local producers.[22,30]

State-level policies to support local procurement in schools have been considered a means of alleviating some of the above-cited barriers cited, particularly around pricing.[31,32] According to the NFSN, between 2002 and 2018, 7 states passed legislation providing incentive or reimbursement programs to support FTS procurement.[4] Of those that passed, per-meal incentives range between $0.02 and $0.10. Appendix S1 (Supporting Information) provides a summary of local food procurement reimbursement legislation in the United States. As an example, Michigan appropriated $375,000 for a pilot program to help schools purchase locally grown produce through State Bill 0133 in 2017. The bill authorized the Michigan Department of Education to reimburse schools an additional 10 cents per meal if they purchased local fruits, vegetables, or legumes.[4]

Despite the proliferation of local procurement policies, existing research on state FTS legislation has focused on rates of adoption at the district level, rather than their ability to deliver the desired outcomes of kids win, farmers win, communities win. For example, Schneider et al.[33] and McCarthy et al.[31] reported that FTS programs are more common, and districts are more likely to serve local products, in states with FTS legislation. Nicholson found overall FFV availability to be higher in these states.[34] By contrast, Lyson found that state legislation had no statistically significant impact on FTS participation rates.[13] Several authors call for more research on the relationship between FTS policies and impacts.[3,11,13,35]

Colorado House Bill (CO HB) 19-1132 provides the opportunity to analyze how a specific FTS policy impacts local food procurement rates. CO HB 19-1132, which was introduced in the Colorado legislature in the spring of 2019, establishes a program that reimburses schools for the purchase of ''Colorado Foods'' for use in school lunches.[36] As such, we built a model that mimics the purchasing behavior of FSDs in 3 Northern Colorado school districts using data from the 2017-2018 school years. Using the calibrated model, we simulated reimbursement scenarios under CO HB 19-1132. The results provide the first case study evidence of how FDMs might respond to different levels of state policies that incentivize local procurement.

METHODS

This research involved 3 stages. First, we collected and digitized purchase receipts from 3 Northern Colorado school districts describing FFV procurement decisions made by FSDs. Second, we used the dataset to parameterize an optimization model, mimicking FSD decision-making by solving for a product mix similar to that observed in our dataset. Third, we simulated a range of local food reimbursement scenarios to estimate how CO HB 19-1132 may alter FSDs' observed procurement decisions, with a focus on the quantity of local FFV items purchased.

Data Collection

We collected data on FFV purchases for NSLP meals from 3 school districts in Northern Colorado, representing the fall 2017, spring 2018, and fall 2018 semesters of purchasing. We selected FFVs as the focus because the FSDs in the 3 districts indicated that most of their FTS procurement focused on FFVs. This also aligns with FTS census responses indicating that FFVs are the most common locally procured item in US schools.[2]

The 3 districts are in adjacent counties, all participate in the NSLP and FTS, and have access to the same vendors, though each transacts with a unique subset. For the 2017-2018 school year, the districts ranged in size from 16,278 to 30,019 students and are all classified as ''urban-suburban'' districts by the Colorado Department of Education.[37] The 3 districts have rates of free- or reduced-price-lunch eligible students between 30% and 64% and similar demographics, except the Greeley school district, which has a 60% proportion of Hispanic or Latino students compared to 18% for Poudre and 21% for Thompson.[37] School district characteristics and demographics are presented in Table 1.

Table 1. **School District Characteristics and Demographics, 2017-2018 School Year**

	School District (Colorado)		
	Poudre R-1	**Thompson R2-J**	**Greeley 6**
District characteristics			
District setting	Urban-suburban	Urban-suburban	Urban-suburban
PK-12 student count	30,019	16,278	22,325
Free lunch eligible (%)*	24	31	55
Reduced lunch eligible (%)†	6	9	9
Offer vs. serve‡	Yes	Yes	Yes
Additional 6 cents per meal§	Yes	Yes	Yes
Demographics			
American Indian or Alaskan Native (%)	1	0	0
Asian (%)	3	1	2
Black or African American (%)	1	1	2
Hispanic or Latino (%)	18	21	60
White (%)	73	73	33
Native Hawaiian or other Pacific Islander (%)	0	0	0
2 or more races (%)	4	3	2
Minority (%)	27	27	48
Female (%)	49	48	49
Number of reimbursable meals served			
August-October, 2017	162,973	291,753	456,673
November-December, 2017	120,285	218,078	290,055
August-October, 2018	513,889	280,346	485,744
November-December, 2018	350,183	225,036	297,276

District and demographic data from CDE.[37] Reimbursable meals served data was provided by each of the 3 school districts.

* Children in households at or below 130% of the poverty line are eligible for free school lunches.[6]

† Children in households between 130% and 185% of the poverty line are eligible for reduced priced school lunches.[6]

‡ Offer versus serve allows students to decline some of the food offered while still meeting minimum requirements for a reimbursable meal.[38]

§ Schools are eligible for additional meal reimbursements when compliance with nutrition standards defined in the Healthy Hunger Free Kids Act is certified.[14]

We obtained FFV purchasing data from each school district in the form of paper procurement receipts (invoices). Each district also provided records of the number of reimbursable meals served across the district at all grade levels (Table 1). We aggregated over 650 receipts in a database comprised of approximately 7700 transactions, including more than 60 FFV products. Each entry in the database records the type of product, varietal, level of processing (eg, whole vs. shredded carrots), purchase price, quantity purchased, pack size, vendor, purchase date, and product source (eg, local vs. conventional). Once compiled, we converted all unit purchases to pounds purchased using US Department of Agriculture (USDA) and vendor-provided volume-to-weight conversions.[39] We then used USDA Food Buying Guide conversion rates to link pounds of product purchased to quarter-cup servings of products.[40]

We limited purchasing data observations to items served on salad bars, as FSDs reported serving the vast majority of FFVs there, and also as the way that they met the majority of their NSLP nutrition requirements in 4 nutrition categories: dark green, red orange, other vegetables, and fruit. The dark green category includes items such as broccoli and romaine lettuce; red orange includes items such as carrots and tomatoes; and other vegetables include nonlegume and nonstarchy items such as celery and cucumbers.[40] We dropped items purchased less than 5 times in a semester, such as kumquats and starfruit, as well as items ordered for activities other than student consumption, such as carving pumpkins. We aggregated product classifications to include all products considered similar (eg, red and green cabbage, field greens, and spring mix).

We tabulated receipt entries by product type, varietal, processing, source, and purchase month using Stata v.15.1. Substantial local purchasing occurred only in fall semesters, with less than 0.005% of the districts' spring semester purchasing from local sources, likely due to seasonality constraints of Northern Colorado. As such, we dropped spring semester data from the analysis. For each unique product type, we calculated the average price per pound and total quantity (pounds) purchased across all 3 districts by month. Comparison of prices and products purchased within each semester revealed differences in average product prices and types of products purchased, and therefore we split purchasing into 2 seasons within each semester: August-October and November-December (Table 2). We delineated the seasonal break where both the number of types of products purchased locally decreased to 7 or less and the percentage of local purchasing dropped below 5%. Additionally, we observed a lower level of local purchasing in 2018 than 2017, likely due to decreased availability of local products after several local farms closed between the

Table 2. **Selection of Total Observed Pounds of Locally Sourced FFV Purchased, by Season and Year, in the 3 Northern Colorado School Districts**

Local product	Lbs. Purchased August-October 2017	Lbs. Purchased November-December 2017	Average Price Per lb. August-October 2017 ($)	Average Price Per lb. November-December 2017 ($)	Lbs. Purchased. August-October 2018	Lbs. Purchased November-December 2018	Average Price Per lb. August-October 2018 ($)	Average Price Per lb. November-December 2018 ($)
Green leaf lettuce	286	264	0.77	0.91	0	0	-	-
Apples	53,960	27,440	0.01	0.01	68,600	55,160	0.01	0.01
Cantaloupe	4140	0	0.85	-	1668	0	1.52	-
Watermelon	20,618	7956	0.42	0.46	23,983	11,329	0.42	0.37
Baby carrots	2400	480	0.63	0.70	3680	720	0.63	0.57
Green or yellow bell peppers	1899	1084	0.88	0.85	6292	1470	0.75	1.13
Slicing tomatoes	2210	375	2.56	1.6	2275	705	1.39	1.50

2 school years. Accordingly, we recalculated average prices and total purchasing by season to parameterize the optimization model.

Optimization Procedure

As described in more detail above, FSDs grapple with trade-offs between nutrition and cost, as such linear optimization modeling provides a useful framework to examine FSD procurement decision-making. Similar approaches have been used in the nutrition literature to study the trade-offs between delivering nutritious diets and minimizing costs.[41-43] Our intent is to obtain some quantitative results capturing the trade-offs FSDs face and reveal how policies that effect pricing may impact procurement decisions.

Optimization methods are characterized by: (1) an objective function that is maximized or minimized; (2) a set of decision variables, the levels of which are selected to maximize/minimize the objective function; and (3) constraints, which represent factors that affect the problem but are external to it. In addition to finding the optimal FFV basket, optimization modeling provides shadow prices (SP), the cost reductions obtained by relaxing one of the constraints, and reduced costs (RC), the price reduction necessary to include an additional unit of a specific product, both of which can be useful in informing policy decisions around subsidies.

Model Development and Calibration

Our linear programming (LP) model considers trade-offs faced by FSDs in navigating local versus conventional purchasing of FFVs. We developed a model minimizing the cost of FFV purchasing, subject to per-meal constraints imposed by the NSLP serving and nutrition requirements. These include the required servings of FFVs and the minimum weekly offering of FFVs from each nutrition subgroup category the districts serve on salad bars: dark green, red orange, other vegetables, and fruits. We then used purchasing ratios observed from the data to calibrate the model and ensure that the level of variety of the chosen product mix was comparable to observed purchasing patterns, both in terms of the ratio of fruit and vegetable subgroups and the variety of the offerings within each subgroup. (The full model, parameterization, and calibration process are presented in detail in Appendix S2).

After calibration, the model closely mimics observed FSDs' FFV purchasing. The optimal product mix falls within 37-44% of observed purchasing ratios, and local purchasing is within 3% of observed levels. We then modified the baseline model to simulate a range of policy incentive scenarios. We performed modeling in GAMS v.2.0.35.10 using MINOS LP Solver v. 5.1.

Data Analysis

Simulating the impact of Colorado House Bill 19-1132. Colorado HB 19-1132 established a program that reimburses schools for the purchase of ''products from Colorado growers, producers, and processors''[36] for use in school lunches, capping reimbursements at $500,000 per year for the entire state starting in FY2019/2020. Primary incentives for the first-year participants were estimated at about $1.2 million, based on an estimated 23.8 million meals reimbursed at $0.05 each. However, the bill limits total reimbursements to $500,000 and explicitly states that as more school lunch providers choose to participate, and as overall purchasing of Colorado products increases, demand for incentive payments are expected to increase in future years. The 23.8 million meals is based on a statewide needs assessment conducted by the Colorado Department of Education and the results of a national survey, which found that approximately 40% of school districts in Colorado purchased local food products to serve in school meal programs during the 2017-2018 school year. As 59.5 million school lunches were served in the 2017-2018 school year, the fiscal note estimates that about 23.8 million of these, or 40%, were prepared with some amount of purchased Colorado product.[36,44]

To predict how FSDs may respond to a variety of reimbursement rates, we reduced the prices of locally procured products by 1%, 5%, 10%, 15%, 50%, 75%, and 100% in tested model scenarios, which provides information about the amount of state expenditure required to see an accompanying change in local purchasing by FSDs. In addition, to reflect HB 19-1132, which offers a $0.05 reimbursement rate for 40% of reimbursable meals, we place emphasis on the results for the price reduction scenarios of 75% and 100% for the 2017 and 2018 fall semesters, respectively. These price reductions result in a reduction in the value of the objective function that approximates the expenditures required to provide a $0.05 reimbursement rate for the 3 districts studied in each of the 2 semesters. A $0.05 reimbursement rate would provide $18,228 and $12,568 in August-October and November-December of 2017, respectively, totaling $30,796 for the semester; in August-October and November-December of 2018, $25,600 and $17,450, totaling $43,050 for the semester, respectively, would be available to the 3 districts. (See the footnote in Appendix S1 Table 2 available in online supplementary materials for more details.)

RESULTS

Results indicate that funding provided under the current CO HB 19-1132 of a 75% local food price reduction in 2017 and a 100% reduction in 2018 would result in the 3 school districts' purchases of local

Table 3. **Modeled Change in Local Purchasing at Different Levels of State Expenditure on Local Purchasing Reimbursements for the 3 Districts in Northern Colorado**

Local Food Price Reduction	Required State Expenditure, August-December ($)*	Percent Local Purchasing, August-October	Increase in Local Purchasing, August-October (%)	Percent Local Purchasing, November-December	Increase in Local Purchasing, November-December (%)	Per meal Reimbursement Rate ($)	Total State Expenditure August-December ($)†
2017							
0%	0	13.14	0	3.60	0		
1%	215	13.14	0	3.60	0		
5%	1228	17.17	4	4			
10%	2515	17.17	4	4.25	1		
15%	3845	17.24	4	4.25	1		
50%	15,088	21.85	9	4.76	1		
75%	27,542	24.50	11	4.76	1	0.05	30,796
100%	40,637	24.50	11	4.76	1		
2018							
0%	$0	14.90%	0	0.79%	0		
1%	265	14.90	0	0.79	0		
5%	1334	14.90	0	1.18	0		
10%	2714	14.90	0	1.18	0		
15%	4102	15.10	0	1.18	0		
50%	13,912	16.40	2	1.18	0		
100%	37,570	26.60	12	1.20	0	0.05	43,050

* Values in this column are determined by modeling a variety of local food cost reductions and calculating changes in the objective function associated with changes in local procurement. As such, they are not perfectly equivalent to state expenditures calculated based on number of reimbursable meals served.

† Total reimbursements are calculated based on providing 5 cents for 40% of the number of reimbursable meals served in the districts during the period studied. As an example, for the period of August-October 2017, the 3 school districts reported serving 911,399 reimbursable meals (see Table 1). Accordingly, a $0.05 reimbursement rate would provide $18,228 to the 3 districts from August to October 2017 (ie, $18,228 = $0.05 [911,399 × 0.4]).

FFV increasing by 11% and 12% in August-October 2017 and August-October 2018, respectively. From November to December, however, school districts' purchases would only be expected to increase by 1% and 0% for 2017 and 2018, respectively (Table 3). These results are associated with approximately $30,796 in state expenditures on FFV for the 3 districts in fall 2017 and $37,570 in fall 2018.

Assuming a 10-month school year and equal distribution of meals across months, Colorado schools served approximately 29,750,000 meals from August-December in the 2017-2018 year,[44] approximately 5% of which were served in the 3 study districts (Table 1). If 40% of these meals included local products, and the FFV purchasing patterns of our 3 school districts were the same across the state, $594,970 would be needed to cover the $0.05 incentive to support local purchasing costs from August-December for FFV purchases alone.

Results from the model also provide shadow prices of FFVs, which we can use to estimate how increases in local purchasing may affect the cost of FFV procurement. As fruit was the only binding variety constraint, it is the only category with a shadow price. Results of the shadow price for fruit demonstrate that increasing local product reimbursements decreases the costs associated with providing additional fruit by $0.003 and $0.011 in August-October of 2017 and 2018, respectively (Table 4). There was no change in fruit shadow prices in November-December of both years, as a nominal amount of fruit was purchased locally, and local food price reductions did not impact costs associated with fruit procurement. Further, and somewhat intuitively, reduced costs show a willingness to pay for additional units of local products as local reimbursements increase. Finally, all products with upper bounds imposed to meet nutrition and variety requirements show negative reduced costs, indicating that providing less variety of products across fewer nutrition categories would reduce meal costs.

DISCUSSION

This pilot case study provides important preliminary evidence of how FSDs may respond to state procurement incentives designed to increase the purchase of locally procured items by reducing purchasing costs. While potential increases in local procurement may align with the FTS goal of providing fresh, healthy meals to students, our results do not provide additional insight into the relationship between FTS and student FFV-related outcomes.[45] Rather, our model results reveal a different avenue through which kids may ''win.'' Specifically, shadow prices of nutrition and variety constraints indicate that local procurement reimbursements can decrease costs associated with providing additional servings of fruit in school meals. Further, the database compiled through this research

Table 4. **Shadow Prices of Binding Nutrition Constraints by Year and Season**

	Fruit Category Shadow Price (USD)					
	August-October			November-December		
	Baseline ($)	100% Local Price Reduction ($)	Shadow Price Decrease ($)	Baseline ($)	100% Local Price Reduction ($)	Shadow Price Decrease ($)
2017	0.216	0.213	0.003	0.199	0.199	0
2018	0.183	0.172	0.011	0.137	0.137	0

Complete tables of shadow prices and reduced costs are available in the supplemental files provided or from the corresponding author upon request.

provides important information on school spending that could be used to support additional research to determine the optimal level of state purchasing support required to realize FTS benefits and assess FSDs' NSLP procurement and spending behaviors.

Our research also has implications for the ''farmers win'' FTS assertion, as this methodological approach provides insight into how sales to schools may be increased. Specifically, the reduced costs revealed in our model results provide the price point at which a local product becomes cost competitive with a conventional substitute. Access to this information may support more transparent information for local producers in making marketing decisions, including determining if a school market will work for their operations given costs of production.

Given our finding that the availability of locally grown products was a binding constraint in the Northern Colorado context, finding opportunities to increase the availability and affordability of locally grown products, particularly during certain underrepresented seasons that overlap with the school year, may result in increases in local purchasing by FSDs. To the extent that these efforts are fruitful, it is feasible that $0.05 reimbursements could increase local purchasing by the highest modeled percentage of 12%, resulting in approximately $30,000-$38,000 in additional local purchasing by the 3 school districts based on fall 2017 and 2018 modeled purchasing (Table 3). Finally, it is reasonable to assume that such an increase in local purchasing will positively contribute to local economic impacts of FTS procurement,[3,10,46] though without accounting for the potential opportunity cost of how the public dollars could otherwise be spent.

Limitations

The primary limitation of this study is the scope of our model, which only analyzes the purchase of FFVs for use on salad bars and does not take into account trade-offs made across nutrition categories. Further, our model does not incorporate other aspects of FSD decision-making that have been identified as significant, including labor requirements and availability of kitchen facilities and equipment.[47] Finally, the data used in our model does not incorporate pre-consumer waste. According to a study on pre-consumer waste conducted by Prescott et al.[48] in the same 3 Northern Colorado School Districts, accounting for pre-consumer waste would have required that an additional 37 g of FFVs be purchased per meal served.

Conclusion

As state FTS legislation focused on increasing local food purchasing proliferates, it is essential to gain a better understanding of outcomes associated with this type of legislation. As such, this study assessed how the amount of local FFVs procured in 3 Northern Colorado school districts may change in response to a state policy providing reimbursements for the purchase of Colorado foods. Results from our optimization model reveal that local food purchasing may increase by 11-12% in response to a Colorado policy providing a $0.05 per meal reimbursement for the purchase of local foods. While this is a significant increase, these results are dependent on sufficient availability of local foods within the state. Further, shadow prices and reduced costs provide insight into both reducing costs associated with providing additional FFVs in school meals and price points at which local producers may be competitive when selling FFVs to schools. While this study provides the first research that applies optimization modeling to questions of FTS procurement, we are aware of the fact that we omit other important aspects of FSD decision-making due to data limitations. We recommend that future research focus on the development of models that incorporate more aspects of FSD decision-making, including purchasing decisions across nutrition groups, not just FFV, as well as costs associated with potential additional labor requirements associated with local sourcing and availability of appropriate facilities.

IMPLICATIONS FOR SCHOOL HEALTH

States considering adoption of a FTS reimbursement incentive should considering if their per unit funding is adequate such that it will not disrupt normal cost-minimizing purchasing behavior. Considering the budgetary limitations most school foodservice operations face, this is important information for those advocating increases in local food purchasing, and

is even more important given increased budgetary challenges in light of COVID-19.

Implications for Purchasing

This research provides important information for FSDs to use in assessing the relationship between per unit price and nutrition requirements, therein helping to identify pricing that will enable local purchasing.

- Using the data and analysis contained in the research will support identification of products that are the best fit not only for the school food program, but also for the farmer.
- Assessing program costs by nutrition category may reveal where targeted spending of local foods reimbursements may be most beneficial to overall program budget constraints.
- Given ongoing concerns regarding the cost of meeting FFV nutritional requirements, especially in smaller districts,[15] it is significant that this work shows that local food reimbursement policies may support broader NSLP nutrition goals.
- Transaction costs of local procurement and processing should be incorporated into purchasing decisions such to ensure local food reimbursements are going towards meeting program nutrition goals.

Implications of Local Food Reimbursement Policies and COVID-19

The recommendations above assume school nutrition programs are operating under normal circumstances, which is not the case given the on-going COVID-19 pandemic. In light of growing budget constraints and shortfalls,[49] our research are holds important implications.

- Increasing purchases of some local foods in order to receive state reimbursement incentives for FTS will result in additional revenue per meal, even if less meals overall are being served.
- Inasmuch as expansion of summer meal service continues into 2021, there will be more opportunities for local sourcing as more of the meal service calendar overlaps with summer growing seasons. FSDs may be able to offset budget shortfalls with local purchasing to a more significant degree in these months and can plan to take advantage of seasonally low prices.
- While supply chains have largely recalibrated since the advent of the COVID-19 pandemic FSDs may avoid some future supply chain disruptions by proactively leveraging local food reimbursements to form relationships with local producers.
- State budget shortfalls may threaten funding for local food reimbursement programs, but given the amount of emergency feeding that has been shifted to schools since the onset of the pandemic,[50] FSDs have justification for advocating to maintain funding for these programs, particularly to the extent that FTS may increase the number of parents who continue to frequent schools for access to meals.

Human Subjects Approval Statement

This research, protocol number 18-7812H, was approved by the Colorado State University Institutional Review Board (IRB) for the protection of human subjects on April 6, 2018.

Conflict of Interest

B.B.R.J. was paid a small honorarium by ABT Associates to serve on the Farm to School Census and Comprehensive Review Advisory Panel. ABT Associates work is funded through an agreement with the US Department of Agriculture, Food and Nutrition Service. The authors declare no other conflicts of interest.

REFERENCES

1. Joshi A, Azuma AM, Feenstra G. Do farm-to-school programs make a difference? Findings and future research needs. *J Hunger Environ Nutr*. 2008;3(2-3):229-246.
2. US Department of Agriculture Food and Nutrition Service (USDA FNS). *Farm to School Census*. Washington, DC: USDA Food and Nutrition Service; 2014. Available at: https://farmtoschoolcensus.fns.usda.gov/. Accessed December 12, 2020.
3. Christensen LO, Jablonski BBR, Stephens L, Joshi A. Evaluation of the economic impacts of farm-to-school procurement: an approach for primary and secondary financial data collection of producers selling to schools. *J Agric Food Syst Community Dev*. 2019;8(C):73-94.
4. National Farm to School Network (NFSN). National Farm to School Policy Handbook: 2002-2019. 2019. Available at: http://www.farmtoschool.org/resources-main/statepolicyhandbook. Accessed December 12, 2020.
5. Ralston K, Beaulieu E, Hyman J, Benson M, Smith M. *Daily Access to Local Foods for School Meals: Key Drivers*. Washington, DC: US Department of Agriculture Economic Research Service; 2017.
6. US Department of Agriculture Economic Research Service (USDA ERS). *National School Lunch Program*. Washington, DC: USDA-FNS; 2019. Available at: https://www.ers.usda.gov/topics/food-nutrition-assistance/child-nutrition-programs/national-school-lunch-program.aspx. Accessed June 19, 2019.
7. National Farm to School Network (NFSN). *What Is Farm to School? National Farm to School Network*. 2019. Available at: http://www.farmtoschool.org/about/what-is-farm-to-school. Accessed June 19, 2019.
8. Bontrager Yoder AB, Foecke LL, Schoeller DA. Factors affecting fruit and vegetable school lunch waste in Wisconsin elementary schools participating in farm to school programmes. *Public Health Nutr*. 2015;18(15):2855-2863.
9. Jones SJ, Childers C, Weaver AT, Ball J. SC farm-to-school programs encourage children to consume vegetables. *J Hunger Environ Nutr*. 2015;10(4):511-525.
10. Becot F, Kolodinsky JM, Roche E, et al. Do farm-to-school programs create local economic impacts? *Choices*. 2017;32(1):1-8.

11. Conner DS, King B, Koliba C, Kolodinsky J, Trubek A. Mapping farm-to-school networks' implications for research and practice. *J Hunger Environ Nutr*. 2011;6(2):133-152.
12. Conner DS, Izumi BT, Liquori T, Hamm MW. Sustainable school food procurement in large K-12 districts: prospects for value chain partnerships. *J Agric Resour Econ*. 2012;41(1):100-113.
13. Lyson HC. National policy and state dynamics: a state-level analysis of the factors influencing the prevalence of farm to school programs in the United States. *Food Policy*. 2016;63(C):23-35.
14. US Department of Agriculture Food and Nutrition Service (USDA FNS). *National School Lunch, Special Milk, and School Breakfast Programs, National Average Payments/Maximum Reimbursement Rates*. Washington, D.C.: US Department of Agriculture Food and Nutrition Service; 2019. Available at: https://www.federalregister.gov/documents/2019/08/07/2019-16903/national-school-lunch-special-milk-and-school-breakfast-programs-national-average-paymentsmaximum. Accessed December 12, 2020.
15. Ralston K, Newman C. *School Meals in Transition*. Washington, DC: US Department of Agriculture Economic Research Service; 2015.
16. Meyer MK, Conklin MT. Variables affecting high school students' perceptions of school foodservice. *J Am Diet Assoc*. 1998;98(12):1424-1431.
17. Meyer MK. Top predictors of middle/junior high school students' satisfaction with school foodservice and nutrition programs. *J Am Diet Assoc*. 2000;100(1):100-103.
18. Gordon A, Crepinsek MK, Nogales R, Condon E. School nutrition dietary assessment study-III: Vol. II student participation and dietary intakes. *J Acad Nutr Diet*. 2009;109(2):S129-S135.
19. Golino G, Ralston K, Guthrie J. Participation trends for full price meals in the national school lunch program. *Appl Econ Perspect Policy*. 2020;1-15.
20. Yang Z, Sun S, Lalwani AK, Janakiraman N. How does consumers' local or global identity influence price-perceived quality associations? The role of perceived quality variance. *J Mark*. 2019;83(3):145-162.
21. Izumi BT, Wright DW, Hamm MW. Market diversification and social benefits: motivations of farmers participating in farm to school programs. *J Rural Stud*. 2010;26:374-382.
22. Motta V, Sharma A. Benefits and transaction costs of purchasing local foods in school districts. *Int J Hosp Manag*. 2016;55:81-87.
23. Boys KA, Fraser AM. Linking small fruit and vegetable farmers and institutional foodservice operations: marketing challenges and considerations. *Renew Agric Food Syst*. 2019;34:226-238.
24. Thornburg GK. Embeddedness, marketness, and economic instrumentalism in the Oklahoma farm-to-school program. *J Rural Commun Dev*. 2013;8(3):321-334.
25. Botkins ER, Roe BE. Understanding participation in farm to school programs: results integrating school and supply-side factors. *Food Policy*. 2018;74:126-137.
26. Motta V. The impact of local food expenditure on school foodservice revenues. *J Sch Health*. 2019;89:722-729.
27. Lee E, Smathers C, Zubieta AC, Ginnetti S, Shah A, Freedman DA. Identifying indicators of readiness and capacity for implementing farm-to-school interventions. *J Sch Health*. 2019;89:373-381.
28. Feenstra G, Ohmart J. The evolution of the school food and farm to school movement in the United States: connecting childhood health, farms, and communities. *Child Obes*. 2012;8(4):280-289.
29. Nurse G, Thilmany McFadden D, Gunter A. *Understanding the Effectiveness of Farm to School Programs through Food Service Professionals*. Ft. Collins, CO: Colorado State University Agricultural and Resource Policy Report No 1; 2011.
30. Thompson JJ, Brawner AJ, Kaila U. ''You can't manage with your heart'': risk and responsibility in farm to school food safety. *Agric Hum Values*. 2016;34(3):683-699.
31. McCarthy AC, Steiner AS, Houser RF. Do state farm-to-school related laws increase participation in farm-to-school programs? *J Hunger Environ Nutr*. 2017;12(4):466-480.
32. National Farm to School Network (NFSN). State farm to school legislative survey: 2002-2017. 2017. Available at: http://www.farmtoschool.org/Resources/State%20Farm%20to%20School%20Legislative%20Survey%202002-2017.pdf. Accessed December 12, 2020.
33. Schneider L, Chriqui J, Nicholson L, Turner L, Gourdet C, Chaloupka F. Are farm-to school programs more common in states with farm-to-school-related laws? *J Sch Health*. 2012;82:210-216.
34. Nicholson L, Turner L, Schneider L, Chriqui J, Chaloupka F. State farm-to-school laws influence the availability of fruits and vegetables in school lunches at US public elementary schools. *J Sch Health*. 2014;84:310-316.
35. Boys KA, Hughes DW. A regional economics-based research agenda for local food systems. *J Agric Food Syst Commun Dev*. 2013;3(4):145-150.
36. Colorado General Assembly. HB 19-1132: School Incentives to Use Colorado Food and Producers. 2019. Available at: https://leg.colorado.gov/bills/hb19-1132. Accessed February 17, 2021.
37. Colorado Department of Education (CDE). *Colorado Education Statistics*. Denver, Colorado: Colorado Department of Education; 2019. Available at: https://www.cde.state.co.us/2017-18pupilmembership. Accessed December 12, 2020.
38. US Department of Agriculture Food and Nutrition Service (USDA FNS). *Offer vs. Serve*. Washington, DC: US Department of Agriculture Food and Nutrition Service (USDA FNS); 2015. Available at: https://www.fns.usda.gov/updated-offer-vs-serve-guidance-nslp-and-sbp-beginning-sy2015-16. Accessed December 12, 2020.
39. Washington State Department of Agriculture (WSDA). *Standard Pack Size - Weight-Count Converter Chart for Fruit*. Olympia, Washington: Washington State Department of Agriculture (WSDA); 2012. Available at: http://www.wafarmtoschool.org/Page/89/farmer-processor-toolkit. Accessed December 12, 2020.
40. US Department of Agriculture Food and Nutrition Service (USDA FNS). *Food Buying Guide*. Washington, DC: US Department of Agriculture Food and Nutrition Service (USDA FNS); 2018. Available at: https://www.fns.usda.gov/tn/food-buying-guide-for-child-nutrition-programs. Accessed December 12, 2020.
41. Carlson A, Lino M, Fungwe T. *The Low-Cost, Moderate-Cost, and Liberal Food Plans, 2007*. Washington, DC: US Department of Agriculture, Center for Nutrition Policy and Promotion; 2007.
42. Ferguson EL, Darmon N, Briend A, Premachandra IM. Food-based dietary guidelines can be developed and tested using linear programming analysis. *J Nutr*. 2004;134(4):951-957.
43. Frega R, Lanfranco JG, De Greve S, et al. What linear programming contributes: world food Programme experience with the ''cost of the diet'' tool. *Food Nutr Bull*. 2012;33(3 Suppl):S228-S334.
44. Legislative Council Staff. *Final Fiscal Note HB 19-1132*. Denver, Colorado: Legislative Council Staff; 2019. Available at: https://leg.colorado.gov/sites/default/files/documents/2019A/bills/fn/2019a_hb1132_f1.pdf. Accessed December 12, 2020.
45. Prescott M, Cleary R, Bonanno A, Costanigro M, Jablonski BBR, Long A. A systematic review of the impact of farm-to-school activities on student outcomes. *Adv Nutr*. 2019;11(2):357-374.
46. Bauman A, Thilmany MFD. Exploring localized economic dynamics: methods-driven case studies of transformation and growth in agricultural and food markets. *Econ Dev Q*. 2017;31(3):244-254.
47. Hwang JH, Sneed J. Developing a performance criteria model for school foodservice. *J Hosp Tour Res*. 2007;31(1):111-129.

48. Prescott MP, Herritt C, Bunning M, Cunningham-Sabo L. Resources, barriers, and tradeoffs: a mixed methods analysis of school pre-consumer food waste. *J Acad Nutr Diet*. 2019;119(8):1270-1283.
49. Roessner, B. Facing Covid-19 with courage, commitment, compassion: the financial blows of Covid-19. 2020. Available at: https://schoolnutrition.org/covid19/webinar-series-and-resources/. Accessed December 12, 2020.
50. Jablonski BBR, Casnovsky J, Clark JK, et al. Emergency food provision for children and families during the COVID-19 pandemic: examples from five US cities. *Appl Econ Perspect Policy*. 2020;43:e13096.

SUPPORTING INFORMATION

The following Supporting Information is available for this article:

Table S1. Table of Decision Variables With Associated Nutrition Category and Description

Table S2. Average Price[1] and Total Quantity of FFV Purchased by the Three Northern Colorado School Districts, by Season and Source, Fall 2017 and Fall 2018

Table S3. Baseline Model Output With No Policy Testing, Fall 2017 and Fall 2018

Table S4. Model Output With Prices of Local Products Reduced by 1% and 5%, Fall 2017 and Fall 2018

Table S5. Model Output With Prices of Local Products Reduced by 10% and 15%, Fall 2017 and Fall 2018

Table S6. Model Output With Prices of Local Products Reduced by 50% and 100%, Fall 2017 and Fall 2018

Table S7. Model Output With Prices of Local Products Reduced by 75%, Fall 2017

Table S8. Nutrition Constraint Shadow Prices (SP) Across Local Product Price Reduction Scenarios, Fall 2017 and Fall 2018

Table S9. Variety Constraint Shadow Prices[1] (SP) in 1%, 5%, and 10% Local Price Reduction Scenarios, Fall 2017

Table S10. Variety Constraint Shadow Prices[1] (SP) in 15%, 50%, 75%, and 100% Local Price Reduction Scenarios, Fall 2017

Table S11. Variety Constraint Shadow Prices[1] (SP) in 1% and 5% Local Price Reduction Scenarios, Fall 2018

Table S12. Variety Constraint Shadow Prices[1] (SP) in 10%, 15%, 50%, and 100% Local Price Reduction Scenarios, Fall 2018

Table S13. Decision Variable Reduced Costs (RC) in 0%, 1%, 5%, and 10% Local Price Reduction Scenarios, Fall 2017

Table S14. Decision Variable Reduced Costs (RC) in 15%, 50%, and 100% Local Price Reduction Scenarios, Fall 2017

Table S15. Decision Variable Reduced Costs (RC) in 1%, 5%, and 10% Local Price Reduction Scenarios, Fall 2018

Table S16. Decision Variable Reduced Costs (RC) in 15%, 50%, and 100% Local Price Reduction Scenarios, Fall 2018

Appendix S1. Summary of Local Food Procurement Reimbursement Legislation in the United States as of 2018[32] Plus Colorado's 2019 Legislation[2]

Appendix S2. Empirical Model and Calibration

Additional supporting information may be found online in the Supporting Information section at the end of the article.