DISSERTATION

THREE ESSAYS ON FOOD POLICY ADOPTION AND ECONOMIC WELFARE

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ABSTRACT

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This dissertation contains three chapters that empirically explore policies supporting school meals and local food marketing as well as drivers of food demand with the goal of providing comprehensive insights into their complexities and implications, ultimately contributing to a deeper understanding of the food systems. Recognizing school meals as critical safety nets for children in low-income households, many states in the United States (U.S.) are passing legislation to adopt universal free school meals, linking their funding to the Community Eligibility Provision (CEP), a federally funded universal free school meal program. In the first chapter we develop a unique school district-level dataset and use a Cox regression model to demonstrate the importance of federal- and state-level policy factors in increasing the likelihood of CEP adoption. In the second chapter, we examine the relationships among stocks of community wealth, state legislation supporting farm to school (FTS), and the intensity of FTS activities. Leveraging the U.S. Department of Agriculture's 2019 FTS Census, a new disaggregated database on state-level FTS policies, a new dataset of stocks of local wealth, and using a Heckman selection model, we find positive associations between cultural and social capital and FTS intensity, and associations with state FTS policies. In the third chapter, we shift our focus to examining economic welfare implications in the event of an African Swine Fever (ASF) outbreak in the U.S. Although ASF is not a food safety risk and has never been detected in the U.S., little is known about changes in U.S. pork demand in case of an outbreak. Using an online survey experiment, we find that the demand for pork is predicted to shift downward by approximately 31% resulting in an annual welfare loss of $55.46 billion in the pork market, exacerbating the losses to pork producers. Results also indicate that government institutions are most trusted when it comes to sharing news about food safety, strongly suggesting its importance in generating awareness prior to and during an ASF outbreak.

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Introduction

Globally, food and nutrition insecurity remain a significant concern, with millions of people lacking access to sufficient, safe, and nutritious foods. In the United States (U.S.), approximately 17 million (12.8%) households were food insecure at some time during 2022, including about 6.4 million households with children (Rabbitt et al. 2023), despite being one of the world's largest food producers (Wunsch 2022). There is a complex interplay of factors beyond the food and agricultural system that contribute to this issue, including but not limited to income, education, climate, culture, information, and community resources. The COVID-19 pandemic underscored the vulnerabilities of the food systems, highlighting opportunities for more resilient local and regional food supply, accompanied by a robust policy environment (Thilmany et al. 2020).

The U.S. Department of Agriculture (USDA) collaborates with other federal agencies, state and local governments, industry stakeholders, universities, and non-profit organizations and plays a central role in supporting the food system, administrating programs that monitor and address food insecurity, food and nutrition education, and food safety. For example, the USDA administers the two largest nutrition assistance programs in the U.S., the Supplemental Nutrition Assistance Program (SNAP) and the National School Lunch Program (NSLP), which had a combined expenditure of $142 billion in 2022 (Toossi and Jones 2023). In 2019, the year before the pandemic, the NSLP provided 4.9 billion lunches at a total cost of $14.2 billion, out of which about three-quarters were served free or at a reduced price (USDA ERS 2023). Research shows that participation in school meal programs reduce food insecurity (Gundersen and Ziliak 2018) and improves health outcomes like obesity (Wang et al. 2017) and academic performance (Frisvold 2015).

One way that expansion of nutrition programs under the farm bill have become more politically palatable is to connect them to purchases of U.S. farm and ranch products. Given the scale of food purchases by governments, there is significant interest in leveraging these public dollars to support not just positive child nutrition outcomes, but also new markets for farms and ranches, and economic activity in local economies (Fitch and Santo 2016; Swensson and Tartanac 2020). However, the impacts of adopting school nutrition policies have been heterogenous across the country, in terms of outcomes like meals participation, attendance, and academic achievement (Hartline-Grafton and Levin 2022) as well as local procurement practices (Long et al. 2021). One reason for this may be that local factors affect outcomes by providing resources and opportunities that can be leveraged to address community needs (Pender, Marré, and Reeder 2012). The adoption of food systems programs and associated community outcomes are likely to be influenced by various factors other than financial support, like community resources, the policy environment, and program characteristics. Understanding this relationship is a key area of research addressed in this dissertation.

Food security is also intricately linked with issues related to food safety (Garcia, Osburn, and Jay-Russell 2020) and part of the focus on food and agricultural education has been the interest in informing consumers about these issues. Globalization has elevated transboundary animal diseases as a major focus in ensuring food safety and security. Outbreaks of such diseases not only lead to severe losses for farmers, but also exert notable effects on the cost and accessibility of food (Clemmons, Alfson, and Dutton 2021). There is extensive literature that studies the impact of food safety issues, food recalls, and outbreak of foodborne diseases on both producers and consumers (e.g., Yim and Katare, 2023). However, most of this research focuses on zoonotic diseases and little is known about the economic impacts resulting from the outbreak of transboundary animal diseases that are not zoonotic and thus do not pose a public health risk. In order to minimize the economic losses resulting from the outbreak of such diseases, studying changes in the affected market(s) is important.

This dissertation seeks to advance three distinct yet interrelated aspects of food systems economics: the adoption of school nutrition policies, the relationship of community resources and state policies with local foods promotion programs, and the role of food safety information in economic welfare outcomes. Insights into factors associated with increased participation in school nutrition programs as well as local foods programs will contribute to the well-being of students as well as the local agricultural economy. Further, understanding issues related to food safety will aid in supporting both the producers and consumers in the events of any disease outbreaks.

The first chapter of the dissertation conducts an empirical assessment of factors associated with the adoption of universal free school meals in the U.S., focusing on the Community Eligibility Provision (CEP). Recognizing the benefits of school nutrition programs, many states are introducing legislation to adopt statewide universal free school meals wherein all students will be provided with daily meals at no cost to them. The CEP is a federally funded program that reimburses schools with a high proportion of low-income students to serve meals at no cost to all students (FRAC 2020). While the research examining the impacts of CEP adoption on student outcomes are limited, what exists suggested that program uptake improves meal participation, food security, and academic scores while at the same time reduces stigma associated with participating in school meal programs (e.g., Hecht et al. 2021). As of April 1, 2023, thirty states and the District of Columbia had introduced legislation to advance statewide universal free school meal programs and the states require eligible school districts to participate in CEP to leverage the available federal funds prior to utilizing state funds. However, despite being available since school year (SY) 2014-15, close to half of all school districts eligible for CEP were not participating in SY 2018-19 (FRAC 2019).

Providing statewide universal free school meals is expensive and this makes it important to maximize participation in CEP to make it financially feasible for the states. The state of Colorado for example adopted a universal free school meal program starting SY 2023-24, but statewide participation in CEP was only about 30 percent. Consequently, this work argues that understanding factors associated with the adoption of CEP will be critical for successfully implementing statewide universal free school meals programs. Specifically, the research examines whether policy factors at the federal and state levels are associated with higher program adoption. For the empirical analysis, the research uses a unique dataset that measures school district eligibility and adoption of CEP between SY 2014-15 and SY 2018-19, making this study the first longitudinal school district-level analysis of factors associated with the adoption of CEP since its countrywide rollout in SY 2014-15. These findings carry significant policy implications for states that are implementing universal free school meal legislation, providing insights into policy strategies to increase adoption of CEP.

The second chapter focuses on examining community and policy factors that explain heterogenous participation in the Farm to School (FTS) program. FTS is a widely adopted local foods program in the U.S. (Botkins and Roe 2018) and includes activities that take place in the school cafeteria (e.g., procurement of local foods and cafeteria promotions), the classroom (e.g., integrating nutrition and/or agricultural education), and outside the classroom (e.g., school gardens, farm visits, and community programs). In addition to the federal grant, a growing number of state policies support school districts in adopting FTS activities by providing grants, reimbursements, and other programming assistance. Forty-six states, the District of Columbia, and one US territory have introduced a total of 546 bills and resolutions supporting FTS activities between January 1, 2002, and December 31, 2020. Of these, 170 bills were enacted, and another 70 resolutions adopted (NFSN and CAFS 2021). However, participation in FTS activities by school districts vary within and across states and studies that examine the relationship between state FTS policies and uptake of FTS activities report inconclusive results. These disparities in program participation make it challenging for policymakers to understand where, when, and how to incentivize FTS.

This chapter examines whether the success of FTS (as defined by intensity of program participation) is strongly related to community assets and the associated policy environment. Pender, Marré, and Reeder (2012) describe community wealth as consisting of multiple types of assets that include human, financial, social, cultural, built, and natural capital. FTS is a unique local foods promotion program as it not only establishes linkages with direct and intermediate food markets, but it also promotes agricultural education and community development activities, and is supported by several state policies. Yet, community resources are often overlooked when pursuing and evaluating programs like FTS. Accordingly, this analysis asks whether the stocks of community wealth and different types of state-level FTS policies explain FTS program adoption and intensity. The research develops the first disaggregated, state-level FTS policy database, and leverages the USDA's 2019 FTS Census and a new comprehensive dataset of stocks of local wealth to assess this relationship. The findings support policymakers and practitioners implementing FTS activities by identifying endowment-specific investment and policy areas related to the success of FTS.

The final chapter focuses on examining potential changes in pork demand and welfare outcomes resulting from an African Swine Fever (ASF) outbreak in the U.S., and whether consumers respond differently if they learn about the disease from different news sources. Being described as the most significant threat to the pork industry (Niederwerder et al. 2020), ASF was found in the Dominican Republic and in Haiti in 2021, with numerous outbreaks being reported in countries across Asia and the European Union between 2018 and 2023. ASF has never been detected in the U.S., the largest exporter of pork in the world. An anticipated immediate outcome resulting from an ASF outbreak in the U.S. is likely to include loss of export markets, excess domestic supply of pork, and possible death of infected pigs. These impacts are estimated to result in losses to the U.S. pork industry to the amount of $50 billion (Carriquiry et al. 2020). Even though ASF is not known to be a food safety concern, the increasing occurrences of food-borne illnesses in the U.S. (Tack et al., 2020) and the perception of risk associated with consumption of pork during a disease outbreak is likely to affect consumer behavior. However, there is no estimate of what the shift in demand for pork could be, if at all resulting from the outbreak. In addition to the losses that the pork producers would incur due to an outbreak, any reduction in demand would only exacerbate these losses.

This study uses an online survey experiment to examine U.S. pork consumers' perception of ASF and estimate the extent to which demand for pork may shift following an outbreak. Survey respondents were randomly exposed to information about ASF from different news sources, which allowed the examination of whether the information treatment led to any difference in purchase decisions following the outbreak.

Estimates for changes in welfare resulting from the shift in pork demand were obtained, thereby presenting further insights into the impacts in the pork sector resulting from an ASF outbreak. Besides informing pork producers of possible market outcomes, given that the average U.S. pork consumer is likely uninformed about ASF (Lee et al. 2023), findings from this study will aid in approaching awareness strategies for consumers through its analysis of different news sources.

By addressing three interconnected topics in the food systems, this dissertation aims to contribute to a more comprehensive understanding of these issues and their implications for public policy, community development, and individual well-being. The findings are pertinent to policymakers, practitioners, and other stakeholders engaged in designing and implementing policies focused on nutrition assistance as well as to farmers and ranchers.

Chapter 1

Universal Free School Meals: Examining Factors Influencing Adoption of the Community Eligibility Provision

1.1. Introduction

Many low-income children in the United States (U.S.) eat the most nutritious meal of their day at schools (Liu et al. 2021). Administered by the U.S. Department of Agriculture (USDA), the National School Lunch Program (NSLP) and the School Breakfast Program (SBP) are critical safety nets for school-aged children from low-income households (USDA ERS 2017; Forrestal et al. 2021). They have been found to play an essential role in improving nutrition and food security (e.g., Arteaga and Heflin 2014; Bartfeld and Ahn 2011; Huang and Barnidge 2016). In 2019, 13.6 percent of U.S. households with children were food insecure at some point during the year (Coleman-Jensen et al. 2020). Previous research shows that child food insecurity is negatively associated with academic performance, physical and psychosocial health, and behavioral and emotional development (Ryu and Bartfeld 2012; Shankar, Chung, and Frank 2017), lowering overall well-being (Shepard, Setren, and Cooper 2011) and leading to higher healthcare and public education costs. Furthermore, recent studies indicate that the COVID-19 pandemic pushed more households into food insecurity and affected young children at unprecedented levels (Ahn and Norwood 2021; Gundersen et al. 2021).

Despite the documented benefits and nationwide coverage of school meal programs for children from low-income households, factors like stigma associated with participation and unpaid meal debts prevent some eligible low-income children from participating (Hecht, Porter, and Turner 2020; Marcus and Yewell 2022). Many advocates endorse universal free school meals to address the barriers associated with participation in the NSLP by low-income households. As of April 1, 2023, thirty states and the District of

Columbia had introduced legislation to advance universal free school meals, with five states enacting it as permanent state policy: California, Colorado, Maine, Minnesota, and New Mexico (Spangler and Bull 2023).

Universal provision of school meals is expensive. Accordingly, the states that have passed this legislation require eligible school districts to participate in the federally funded Community Eligibility Provision (CEP) to leverage federal funds prior to accessing state funds. The CEP, which became available in all states in school year (SY) 2014-15, allows schools with high levels of low-income students that participate in the NSLP and SBP to serve meals to all enrolled students at no cost (FRAC 2020). Thus, CEP serves as a de facto universal free school meal program, available to approximately 44% of the school districts participating in school meal programs (Billings and Carter 2020). Although research on the impacts of CEP is limited, there is preliminary evidence that it improves meal participation, food security, and academic scores, while lowering stigma associated with participation (FRAC 2020; Hecht et al. 2021).

Despite the program's availability, in SY 2018-2019, prior to the outbreak of COVID-19 and five years since countrywide roll-out of the program, 46.2% of school districts eligible for CEP did not participate (FRAC 2019). Further, program adoption varied substantially across states, from over 90% participation in North Dakota and Louisiana to under 30% in Iowa, Colorado, and Nebraska (FRAC 2019) (Figure 1.1). Understanding factors associated with adoption of CEP is critical if state policies of universal free school meals are to be successfully implemented.

Our research provides the first longitudinal, school district-level analysis of the factors associated with CEP adoption in the U.S. to examine the policy characteristics related to higher rates of participation. Specifically, we aim to explore whether the eligibility and policy factors that federal and state policymakers determine (i.e., identified student percentage that determines eligibility and reimbursement, and direct certification rates) are related to program adoption. To the best of our knowledge, only Hecht, Stuart, and Porter (2022) have empirically analyzed the determinants of CEP adoption, though it is cross-sectional and at the school level.

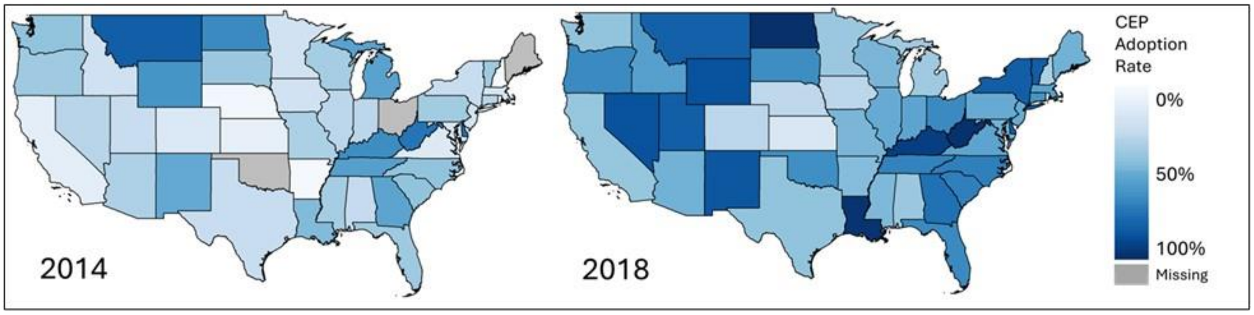


Figure 1.1. State-level spatial depiction of CEP adoption rates by school districts in the U.S.

We draw a conceptual and analytical framework from the policy adoption and diffusion literature to identify variables associated with CEP adoption at the school district level, then use a Cox regression model to obtain empirical estimates of the associations. We find that a school district's "identified student percentage" (ISP) and the state's direct certification rate are associated with CEP adoption by school districts. The findings are robust to different specifications and indicate correlations that are not necessarily causal in nature. Collectively, the results suggest that policymakers could advocate for improving the count of students directly certified for free school meals, thereby expanding CEP adoption by increasing the number of eligible school districts while also increasing the ISP of many others. The findings from this study validate and complement the findings of previous cross-sectional research (Hecht, Stuart, and Porter 2022), agency annual reports (FRAC 2020), anecdotal evidence, and case studies that report similar findings.

Our results have important policy implications for states adopting universal free school meal legislation, informing them of policy levers to increase uptake of CEP. Our study is the first empirical analysis of factors associated with CEP adoption that is longitudinal and at the school district level. This allows us to examine factors associated with CEP adoption over a longer period of time and for eligible school districts across the country. Longitudinal data allows us to examine the timing of adoption and enables the inclusion of school districts that became eligible for CEP in different years. Since a school district could wait several years to adopt CEP since becoming eligible, conducting a longitudinal analysis provides a more comprehensive understanding of factors associated with policy adoption. Furthermore, we add to the literature of policy eligibility and diffusion by explicitly modeling factors at the school district level to study adoption.

The rest of this chapter is organized into seven sections: background and literature, theoretical framework, data, empirical strategy, results, discussion and implications, and conclusion. First, the background and literature section provides a comprehensive overview of CEP and the existing research on the topic. The theoretical framework outlines the conceptual framework and hypotheses that guide the empirical analysis. The next section discusses the data accessed for the analysis. The empirical strategy discusses the regression models used to test the hypotheses. This is followed by a discussion of the results and their implications for policy. Finally, we discuss the conclusions from this study.

1.2. Background and Literature

In this section we provide key details about CEP necessary to frame our empirical analysis, including program eligibility, reimbursement structure, policy regulations, and adoption rates. We also discuss literature on the benefits and challenges of adopting CEP and on factors associated with adoption.

1.2.1. Eligibility and Adoption of CEP

School districts participating in the NSLP and/ or SBP serve meals that meet federal nutrition requirements and are subsidized by the federal government through reimbursements for each meal served. School districts are reimbursed for meals based on children's free, reduced-price, or paid eligibility status. Children are eligible for free meals if their family income is at or below 130% of the federal poverty level, whereas children in families with incomes between 130% and 180% of the federal poverty level are eligible for reduced-price meals (USDA FNS 2019b). Accordingly, the school districts receive reimbursements for the meals served under the three categories: free, reduced-price, and paid, and the respective reimbursement rates are referred to as 'federal free rate', 'federal reduced-price rate', and ‘federal paid’ rate. In SY 2018-19, school districts in the contiguous U.S. states received the federal free rate of $3.40 per lunch and $1.80 per free breakfast on average. The federal reduced-price rate was approximately $2.99 per lunch while the federal paid rate was about $0.40 per lunch on average (USDA FNS 2018).

Given concerns about stigma associated with participation in the NSLP and SBP by students from low-income households (Hecht, Porter, and Turner 2020; Marcus and Yewell 2022), the Healthy, Hunger-Free Kids Act of 2010 authorized the CEP. It was tested in selected states between SY 2011-12 and 2013-2014 before its national rollout in SY 2014-15. The CEP permits participating schools to offer free breakfasts and lunches to all students, like universal free school meals, but with a different federal reimbursement formula than the NSLP. Schools are eligible to participate in the CEP if they are participating in both the NSLP and SBP (Billings and Carter 2020; FRAC 2020).

To determine free and reduced-price NSLP and SBP eligibility, most school districts require families to fill out an application in which they provide the household’s demographic information, including income and household size, at the beginning of every school year. Alternatively, school districts participating in NSLP and SBP can directly certify the children without requiring households to submit applications by using state administrative data (Billings and Carter 2020). Using data of students participating in means-tested programs like the Supplemental Nutrition Assistance Program (SNAP), school districts work with state agencies (i.e., state educational and/or state SNAP agencies) to determine the proportion of students that qualify for free meals at schools (FRAC 2020; USDA FNS 2021b), a process referred to as “direct certification.”

A school district’s ISP is determined by the proportion of students that are directly eligible for free meals (excluding students that qualify for reduced-price meals) through direct certification and/or based on participation in other programs, like the Food Distribution Program on Indian Reservations or Temporary Assistance for Needy Families or having a status as a foster child, homeless child, or migrant child (Billings and Carter 2020). A school district, a group of schools within the school district, or individual schools are eligible to participate in CEP if they have an ISP of 40% or higher (Billings and Carter 2020; FRAC 2020). While this 40% threshold is determined by the federal government, direct certification is conducted by state agencies, and together they determine the CEP eligibility criteria for school districts.

Since eligibility for CEP is based on direct certification, eligible schools are no longer required to collect household applications. However, household applications still determine the number of students eligible for both free and reduced-price meals, whereas the ISP represents students that are eligible for free meals only, making it a subset of the former. As a result, a multiplier is used to determine the federal reimbursement the schools will receive if they adopt CEP. The percentage of meals that the school can claim at the federal free meal rate is calculated by multiplying the ISP by 1.6, a multiplier determined by Congress (Billings and Carter 2020; FRAC 2020).

This "claiming percentage" cannot exceed 100%, and the remaining meals are reimbursed at the lower federal paid meals rate. For example, a school district that has an ISP of 55% will receive reimbursement at the federal free rate (approximately $3.50 per lunch in SY 2018-19) for 88% of the meals served (i.e., 55 multiplied by 1.6), and the remaining 12% will be reimbursed at the federal paid rate (about $0.40 per lunch in SY 2018-19). The district must meet any additional costs exceeding the reimbursements using sources other than federal funds (Billings and Carter 2020).

Regulations set by the USDA require state agencies to publish an annual list of all school districts eligible and near-eligible (ISP of 30% or higher) for CEP and then notify them of their eligibility and the requirements they must meet in order to adopt CEP. Eligible and interested school districts can apply to adopt CEP by calculating and submitting school-level ISP rates. They can then choose to participate, as a group of schools with different ISPs that have an overall weighted ISP of 40% or more, or as individual schools (Billings and Carter 2020; FRAC 2020). Once the district adopts CEP, they enter a four-year cycle, wherein their ISP is recalculated annually. If their ISP increases after the starting year, they can choose to use the most recent ISP for claiming reimbursement. Schools continue with the starting year reimbursement if the ISP is unchanged or lower in the following years.

In SY 2015-16, one year after being available nationwide, CEP was adopted by 37% of the school districts and 50% of the schools that were eligible. By SY 2018-19,[1] adoption by eligible school districts and schools had increased to 53.8% and 64.6%, respectively (FRAC 2019; Segal et al. 2016). However, an estimated 15,486 eligible schools in 9,291 school districts did not participate in CEP in SY 2018-19 (Billings and Carter 2020; FRAC 2020). Under the eligibility requirements set by the federal policy, and given the state's direct certification process, it remains up to the eligible school districts to decide whether they participate in CEP or not.

1.2.2. Research on the Impacts of CEP

While there is considerable literature discussing the role played by the NSLP and SBP in improving food security (e.g., Arteaga and Heflin 2014; Fletcher and Frisvold 2017; Gundersen and Ziliak 2018), child health outcomes like obesity (e.g., Gundersen, Kreider, and Pepper 2012; Wang et al. 2017), and academic performance (Frisvold 2015; Hinrichs 2010), research on additional benefits resulting from universal free school meals is limited. In a systematic literature review of universal free school meals, Cohen et al. (2021) find that the policy improves meal participation, school attendance, and academic scores of low-income students, though most of these studies are for specific U.S. states and don't use national data. Gutierrez (2020) finds that universal free meals also increase lunch participation among higher-income students and improves perceptions of the school climate (e.g., around bullying and fighting).

A growing body of empirical research assesses the impacts of CEP adoption on student outcomes. Overwhelmingly, these studies find that CEP adoption led to increases in meal participation, both in the NSLP and SBP (Harkness et al. 2015; Hecht et al. 2021; Pokorney, Chandran, and Long 2019; Tan et al. 2020; Turner, Guthrie, and Ralston 2019). Tan et al. (2020) finds that this increase in participation is

[1] We discuss statistics up to SY 2018-19 to avoid any impact that the COVID-19 pandemic had on school nutrition programs. The USDA issued Child Nutrition COVID-19 Waivers in March 2020 that allowed all students in the U.S. to eat breakfast and lunch at school for free. The waivers ended on June 30, 2022.

particularly significant for students who were close to the income cutoff (both above and below) for free and reduced-price meals. Studies have also documented other benefits of CEP, including reduced stigma associated with school meal participation (Marcus and Yewell 2022), reduction in lunch shaming (FRAC 2020; Hecht, Porter, and Turner 2020), and improvements in disciplinary outcomes reflected in reduced suspensions (Gordon and Ruffini 2021; Radsky et al. 2022). There is also research showing improvement in academic outcomes as measured by increases in math performance, particularly among the low-income students, as a result of participation in CEP (Gordanier et al. 2020; Ruffini 2022). Research on the impact of CEP on attendance rates is inconclusive (Hecht et al. 2020).

There is also evidence that school participation in CEP has spillover benefits to low-income households with kids. Marcus and Yewell (2022) find an increase in dietary quality and a decline in monthly food expenditure for low-income households with kids in schools that participate in CEP. Ozturk, Pekgun, and Ruffini (2021) find that participation in CEP reduces the usage of food banks in a community. Using survey data from households in Maryland, Gross et al. (2021) show that students in schools that are eligible to adopt CEP but have not, are two times more likely to be food insecure than students in schools that have adopted CEP.

Reported direct benefits for schools that adopt CEP include lower administrative burden by way of reduction in application and reporting requirements, faster serving of food in the cafeteria, and elimination of unpaid school meal debt (FRAC 2020; Hecht et al. 2020). In a 2022 countrywide survey of school nutrition directors in 1,230 school districts, 97.9% of the districts that did not offer free meals reported unpaid meal debt, and the total unpaid meal debt reported by 847 districts was $19.2 million (SNA 2023). Studies have also found that participation in CEP is accompanied by increase in total food expenditures, lower per meal spending, and increase in federal reimbursement (Long, Marple, and Andreyeva 2021; Rothbart, Schwartz, and Gutierrez 2022).

However, eligible school districts face various challenges when deciding to adopt CEP. According to Marcus and Yewell (2022), low participation by school districts could be explained by such factors as lack of information, administrative issues, or financial considerations that arise due to changes in the reimbursement structure. Logan et al. (2014) found uncertainty about both the financial implications of CEP for the school districts arising from changes in meal reimbursement and total education funding to be major barriers to participation. These uncertainties arise from the fact that schools no longer collect household income applications if they participate in CEP, but some state and federal programs still use this information to allocate other funds. In their interviews with food service staff in Maryland, Hecht et al. (2021) identified the same issue as a barrier to participation.

Relying on SNAP participation rates to determine CEP eligibility can also be problematic. Billings and Carter (2020) discuss two factors associated with SNAP that could result in many high-poverty areas not being eligible for CEP. First, SNAP participation rates vary across states, going as low as 55% (USDA FNS 2020), which directly affects CEP eligibility. Second, since the ISP for a school largely depends on direct certification through SNAP, it is an imperfect proxy for measuring poverty, potentially excluding many schools that would benefit from CEP. Furthermore, state SNAP income limits vary between 130 - 200% of the poverty line, making CEP vulnerable to changes in SNAP policy at both the federal and state levels (Bartfeld 2020). Blagg, Rainer, and Waxman (2019) estimated that 1.05 million students could see their schools lose the meal reimbursement received from CEP due to the revision of categorical eligibility in SNAP proposed by USDA's Food and Nutrition Service.[2]

Hecht, Stuart, and Porter (2022), using data for the SY 2017-18, provide the only national analysis that assesses factors associated with uptake of CEP. Their results demonstrate that in addition to such school characteristics as enrollment and ethnicity, the ISP was critical in determining adoption. A report by the USDA's Economic Research Service that reviews the characteristics of school districts offering CEP in SY 2015-16 finds that schools with lower ISPs find it difficult to adopt CEP because reimbursement with a multiplier of 1.6 does not meet most or all of the meal costs (Rogus, Guthrie, and Ralston 2018).

[2] Revision of Categorical Eligibility in the Supplemental Nutrition Assistance Program (SNAP). 84 FR 35570. Document Number: 2019-15670.

Despite the anticipated benefits of adoption, financial considerations of the meal budget remain a major factor in a school district's decision to adopt CEP (Hecht et al. 2021).

The School Nutrition and Meal Cost Study conducted by the USDA during SY 2014-15 found that the average reported cost of a school lunch was $3.81, and in addition to the cost of purchasing food, it included cost for labor, equipment, utilities, and other indirect costs (Fox and Gearan 2019). This cost exceeds the federal free rate of $3.40 in SY 2018-19, so if a school district has an ISP of 40%, it will only be reimbursed for 64% of the meals at the federal free rate, leaving the school district to cover the remaining expenses from other sources.

Although the body of research assessing the benefits and challenges of CEP is only indicative of the first five years of policy implementation, the findings underscore CEP's contribution to improving food security and reducing the stigma associated with school meals. However, close to half of all school districts eligible to participate in CEP did not adopt the program until SY 2018-19 due to various challenges, and there is little empirical research to understand adoption. Low rates of adoption of CEP create challenges for states adopting legislation for universal free school meals, as it leads to less-than-optimal use of federal meal reimbursement. Accordingly, an examination of the factors that affect adoption of CEP by eligible school districts since its countrywide rollout in SY 2014-15 remains a key area of research. This study adds to the research by examining factors related to higher CEP adoption.

1.3. Theoretical Framework

Research on policy adoption and diffusion provides a conceptual and analytical framework to model the adoption and spread of policies. Policy innovation occurs when a policy is adopted by an entity, like a state or a firm (Walker 1969), and the theory of policy adoption characterizes various conditions present in the entity that leads to diffusion of the policy (Lyson 2016; Mosier and Thilmany 2016). Theorists identify three broad categories of variables that are likely to affect the adoption of a policy: internal determinants, external determinants, and the characteristics of the policy itself (Berry and Berry 2018; Boushey 2010; Graham, Shipan, and Volden 2013).

The characteristics and endowment of resources of an entity are factors that characterize the internal determinants to explain policy adoption. These characteristics could be either conducive or act as impediments to policy adoption (Matisoff 2008; Mohr 1969). External determinants (or regional diffusion) include factors that could affect policy adoption by the entity but originate from outside the entity. These include learning or competition from neighboring entities, state legislation, and federal policies (Berry and Berry 2018; Rogers, Singhal, and Quinlan 2019; Septiono et al. 2019).

The policy diffusion approach has been used in research to inform adoption of various policies by different entities. These include examining the impact of state farm to school[3] legislation on program adoption (Lyson 2016), the enactment of organic food policies in U.S. states (Mosier and Thilmany 2016), and the diffusion of charter schools in Florida (Zhang and Yang 2008). Given the hierarchy of the U.S. government, nutrition mandates under programs like the NSLP and SBP, federal reimbursements, and regulations in other programs like SNAP are likely to have an impact on uptake of CEP. Research shows that the policy environment a school district experiences impacts the adoption of a school nutrition policy (Lyson 2016; Zhang and Yang 2008). Thus, when adoption of CEP is understood, both internal and external determinants are plausible.

1.3.1. Policy Characteristics

In a review of literature that looks at factors associated with implementation of nutrition policies in schools across the world, McIsaac et al. (2019) find that addressing financial implications of a program (including school food revenues and expenditures, grants, and reimbursement structure) is a major determinant of successful adoption. They also note the importance of considering school and community

[3] Farm to School is a program through which schools procure locally produced foods to serve in cafeterias, engage students in school gardens, and incorporate education activities related to food and nutrition (NFSN, n.d.).

characteristics, staffing, and infrastructure as factors when determining implementation. In the case of CEP, since the school district's ISP determines the total revenue earned by schools from federal meal reimbursement, it plays an important role in determining the financial feasibility of adopting the program. Accordingly, we expect school districts with higher ISPs to be associated with higher uptake of CEP.

1.3.2. Internal Determinants

School food service directors (or nutrition directors) play an important role in assessing the overall feasibility of participation in CEP. They oversee the meal budget, procurement of foods, food service staff, and day-to-day meal planning in accordance with local, state, and federal policies. In determining the feasibility of the decision to adopt CEP, they weigh the potential revenue from meal reimbursements based on the ISP and the anticipated meal participation against the potential costs following adoption. This is reflected in the total food revenue they make from federal, state, and local sources in the year of adoption.

A school district's ability to adopt a nutrition program like CEP is likely to be determined in part by the school food environment and school district characteristics. The school food environment describes the infrastructure at schools that supports preparation and serving of meals to the students. Such school district characteristics as enrollment, student demographics, and rurality (e.g., Nanney, Davey, and Kubik 2013; USDA FNS 2021a), as well as such school infrastructure as cafeteria capacity (Prescott et al. 2022), have been shown to affect program outcomes. Adequate staffing of food service workers and cafeteria workers is likely an important factor in the uptake of CEP, especially considering the possibility of increased meal participation by students. The administrative staff at a school district is responsible for enumerating the ISP for individual schools within the district to determine eligibility and is likely to affect the school district's willingness to adopt CEP.

We therefore incorporate school district characteristics, including enrollment, district administrative staffing, and the sources of meal revenue from federal, state, and local sources, as well as certain school food expenditures, into our model. These represent the internal determinants of CEP adoption by school districts, which we control for in our empirical model to gain insight into the effect of the ISP on adoption.

1.3.3. External Determinants

States require a robust direct certification system to identify school districts that are eligible based on SNAP participation (Billings and Carter, 2020; FRAC 2020), and the direct certification in each state is likely to affect CEP adoption (Gutierrez 2021). Even though direct certification rates using SNAP participation data have improved over time, nineteen states were still below the national average in SY 2018-19 (Ranalli, Templin, and Applebaum 2021). States differ in the way they conduct direct certification, and this could be due to differences in matching methodology, frequency of matching, and program data used for directly certifying children (Harkness et al. 2015). In our study, the system of direct certification by the state is an external determinant of policy adoption, the effectiveness of which is expected to be positively associated with higher adoption of CEP.

Policy decisions are also guided by the political ideology of the residents in a region and can determine the allocation of funds for different sectors or programs (Beland and Oloomi 2017; Zhang and Yang 2008). For example, in Colorado, a majority Democratic state, the statute called "Healthy Meals for All Public-School Students" that provides universal free school meals as well as funding support for staffing and local food purchasing was passed through a ballot initiative in November 2022. Following Zhang and Yang (2008), who hypothesize that Democrats are more likely to support charter schools because they are likely to benefit disadvantaged students, we expect political ideology and affiliation to affect adoption of CEP in a region.

CEP adoption by a school district may be related to adoption rates in the state. The policy diffusion literature discusses that an entity deciding to adopt a policy looks to its neighbors in the process of making its decision, and the entity is more likely to pursue the policy if the neighboring entities are doing so (Berry and Berry 2018). School districts in a state are likely to face similar policy conditions in terms of state agencies conducting direct certification, eligibility conditions for SNAP, and the state's culture of promoting nutrition assistance programs. We therefore incorporate average adoption of CEP in the state into our model, along with direct certification rate in the state and political ideology in the county as external determinants of CEP adoption by school districts.

1.4. Data

We construct a novel data set that is an unbalanced panel of school districts in all 48 contiguous U.S. states and District of Columbia over five years from 2014 to 2018 (covering SY 2014-15 to SY 2018-19). We omit data from school years 2019-20 to 2021-22, as COVID-19 led to closure of schools and changes in delivery of school meals to children, which are not inherently reflective of CEP participation. The data set consists of information on CEP eligibility, year of adoption, school food revenues and expenditures, administrative staffing of a school district, political ideology at the county level, and direct certification at the state level. The description of the variables and respective source are given in Table 1.1 and summary statistics in Table 1.2.

Data on CEP eligibility and participation for the school years 2014-15 to 2018-19 come from Food Research & Action Center's (FRAC) Community Eligibility Database (FRAC 2022). The database contains data for 50 states and the District of Columbia for school years 2014-15 to 2021-22. FRAC obtained all information contained in the database from state education agencies and other state agencies that administer federal school nutrition programs. The data are collected at the school level and include the school name, school district, eligibility for CEP (represented by the ISP for each school), binary CEP participation status in a given year, and student enrollment. This database includes schools that are eligible (i.e., ISP at or above 40%) and those that are nearly eligible (ISP between 30% and 40%). Additionally, we obtain average adoption rates in each state as a proportion of eligible school districts in the state for each year from this database.

Table 1.1. Description of variables for years 2014 to 2018.

Variables	Description	Source
Dependent Variable		
Adoption of CEP	Year of adoption of CEP by a school district after becoming eligible	Food Research & Action Center's CEP Database
Policy Characteristics		
Identified Student Percentage	The proportion of students in a school district that are directly eligible for free meals, as determined through direct certification	Food Research & Action Center's CEP Database
Internal Determinants		
Federal revenue for child nutrition programs per student	Cash revenues per student for school district from Child Nutrition Act programs like the National School Lunch Program	National Center for Education Statistics
State revenue for school meal programs per student	State revenues per student for school district for school meal programs and school meal matching payments	National Center for Education Statistics
Local school meal revenue per student	Gross receipts per student for school district from sale of school breakfasts, lunches, and milk to students and school staff	National Center for Education Statistics
Food service spending per student	Includes expenditures per student for cafeteria operations, but excluding purchase of food service equipment	National Center for Education Statistics
District administrative staff per student	The count of administrators and supporting staff with district-wide responsibilities	National Center for Education Statistics
Student enrollment	Number of students enrolled in the school district in a given year	National Center for Education Statistics
External Determinants		
Direct Certification rate in the state	Percent of school-age SNAP participant children directly certified for free school meals in the state	USDA FNS's annual reports of direct certification in NSLP
Average CEP adoption rate in the state	Measures the adoption rate of CEP in the state as a proportion of eligible school districts	Food Research & Action Center's CEP Database
Political ideology	County level three-point partisan identity response that includes: Democrat, Republican, Independent, and not sure	Cooperative Election Study administered by YouGov

Our unit of analysis in the empirical model is the school district because the decision to adopt CEP is made at the school district level. To examine adoption data at the school district level, we aggregate the ISP of each school in a district to obtain the ISP for the school district from the FRAC CEP database. We weight the ISP of each school by its respective student enrollment in each district. However, enrollment data are available only for a few schools in the FRAC CEP database. Accordingly, we obtain student counts for all public schools in the U.S. from the Elementary/ Secondary Information System of the National Center for Education Statistics (NCES 2022). Using a fuzzy matching technique, we merge the two data sets and obtain the weighted ISP for each school district for all five years. We retain all school districts with ISPs above 30%. We did not drop school districts with ISPs between 30% and 40%, because some of these districts have one or a few schools that have ISPs over 40% that are participating in CEP even though the district as a whole is not eligible.

Even though the CEP database and the school district universe data from the NCES contained the same schools, many were spelled differently, written in different formats, ordered differently, and/ or abbreviated. Thus, to improve matching between the two data sets, we chose to use a fuzzy matching technique instead of making exact matches. We used the R package "fuzzyjoin"[4] for fuzzy matching, which we conducted based on the school name and state, followed by reviewing the matches manually to determine the accuracy. We used the Jaro-Winkler distance for the match, as it is a commonly used approach to measure the distance between two strings in determining their similarity. This process allowed us to obtain the student enrollment data for all school districts eligible for CEP.

We acquire data on school food revenues and expenditures, administrative staff, support service staff, student enrollment, and location for all school districts in the U.S. from the Elementary/ Secondary Information System of the National Center for Education Statistics for the years 2014-18. Again, using a fuzzy matching technique, we match the school district universe data to the CEP database, which allows us to add the school food environment and policy factors to the information about eligibility and decision to adopt CEP by school districts into FRAC's CEP database. The sample contains 11,428 unique school districts between the years 2014 and 2018.

We obtain the political ideology data for each county from the Cooperative Election Study, formerly called the Cooperative Congressional Election Study (CCES), which is administered by YouGov (Harvard

[4] See https://cran.r-project.org/package=fuzzyjoin for more information.

University 2020). The CCES is a national stratified sample survey of more than 50,000 people that consists of two waves in an election year, asking about political attitudes, voting choices, demographic factors, and other political information in pre- and post-election waves. From this dataset, we use a three-point partisan identity response that covers the years 2006 to 2021. The responses indicating partisan identity include: Democrat, Republican, and Independent. We collect state-level annual data of direct certification rate from the USDA's Food and Nutrition Service's annual reports on the direct certification in the NSLP (USDA FNS 2021b).

Table 1.2. Summary statistics of variables.

Variables	Mean	St. Dev.	Min	Max	Observations
Identified Student Percentage	0.46	0.12	0.30	1	21,605
log (federal revenue from child nutrition programs per student)	6.40	0.98	-0.69	14.30	19,880
log (state revenue from school meal programs per student)	2.80	1.42	-2.94	10.55	16,999
log (local school meal revenue per student)	5.06	1.48	-1.57	12.03	18,957
log (food service spending per student)	6.83	1.01	-0.84	14.43	20,333
log (district administrative staff per student)	-4.52	1.18	-12.45	2.11	19,515
Student enrollment	1,548.42	2,592.10	20	19,92	21,605
Direct certification rate in the state	92.14	7.63	65	100	21,605
Average CEP adoption rate in the state	0.42	0.18	0	1	21,392
Partisan identity: Democrat					10,258 (52.33%)
Partisan identity: Republican					6,960 (35.50%)
Partisan identity: Independent					1,975 (10.07%)
Partisan identity: Not sure					410 (2.10%)

1.5. Empirical Strategy

We estimate a Cox proportional hazards model to test the associations between the decision to adopt CEP by eligible school districts in a given year and factors characterizing program eligibility, school food revenue and expenditure, food service staffing, and political ideology in the region. Since we are interested in modeling the probability of program adoption where the time elapsed since availability of the program differs between school districts, duration modeling is an appropriate statistical technique. The Cox regression model is one of the most widely used approaches in duration analysis to examine such dynamic processes empirically (Klein et al. 2014). Duration analysis (also referred to as survival analysis or event history analysis) models the time-to-adoption (i.e., the time it takes for an event to occur and the likelihood of the event occurring in any given period; Greene 2003). Such models originate in biostatistics, where the survival time refers to the time until death (or failure), usually observed following a treatment of a disease to study intervention effects (Jiang and Fine 2007). These models are increasingly used in economics and social science research to examine adoption of policies, along with other phenomena, like employment, birth, and migrations (Allison 2018).

The Cox proportional hazards regression model (Cox 1972) allows us to exploit the temporal information contained in program adoption data, with significant advantages over traditional cross-sectional and panel approaches. The major advantages include the Cox model's ability to account for time-varying covariates and handle censored observations (Klein et al. 2014). Since we are using longitudinal data to model the association of certain factors on CEP adoption up until SY 2018-19, we have many right-censored observations. This may occur because (i) eligible school districts do not adopt CEP until the end of the study period, (ii) some school districts that may have been previously eligible but had not adopted CEP drop out of consideration, perhaps becoming ineligible because of a decrease in their ISP, or (iii) school districts are not being directly certified, and thus the requirements are overly burdensome.

Right-censoring is a form of missing data and, depending on the share of censored cases in the data, choosing to drop or substitute these observations could alter the distribution of survival times, introduce non-random measurement error, and lead to biased estimates (Avram 2020). With right-censored data, the least squares regression is not feasible. The Cox model incorporates information from the uncensored as well as censored observations and provides consistent estimates (Klein et al. 2014). Thus, informed by the characteristics of our data, we can use this approach to fit a multiple regression model on CEP adoption data to assess the effect size of the covariates under consideration while controlling for any observed confounding factors.

Following the terminology from Klein et al. (2014), let *T* represent the survival time (i.e., time until the occurrence of an event or, in this case, the adoption of CEP by an eligible school district). *T* is a non-negative random variable with a density function of *f(t)*, where *t* represents time. The survival function measures the probability of survival up to time *t* or longer (i.e., the probability that an eligible school district has not adopted CEP by duration *t*). The survival function can be defined by the equation:

$$s(t) = Pr\,\{T \geq t\} = 1 - f(t)$$

In the limit, we obtain the hazard function:

$$\lambda(t) = \lim_{dt \to 0} \frac{Pr\{t \leq T < t + dt | T \geq t\}}{dt}$$

The hazard function represents the instantaneous risk of failure, or the probability that the event occurs in time *t+1* given survival up until time *t*. An increasing hazard function can be interpreted as a higher probability of the event occurring with the passage of time, and vice versa. The Cox model is a semi-parametric method of estimating the hazard function, as it does not require any assumption about the shape of the hazard function. The model makes parametric assumptions about the associations between the covariates and the hazard function. We use partial likelihood estimation techniques to obtain consistent parameter estimates.

A specification of the Cox model to be estimated can be written as:

$$\lambda(t|X) = \lambda_0(t)\, exp\left(\sum_i \beta_i X_i\right)$$

Where the hazard function is the product of the baseline hazard $\lambda_0(t)$ and the exponential of the covariates X_i. The baseline hazard determines the shape of the survival function, and no assumptions are made about its functional form. It measures the hazard when $X_i = 0$. The coefficients β_i measure the magnitude of the covariates' effect on the hazard function. β_i does not depend on time because the ratio $\frac{\lambda(t|X)}{\lambda_0(t)}$ is always constant. The regression constant gets absorbed by the baseline hazard.

Taking the natural log on both sides of the Cox model gives:

$$ln\big(\lambda(t|X)\big) = \alpha_t + \sum_i \beta_i X_i$$

The outcome variable in our model is the decision to adopt CEP in year *t* by an eligible school district. Once a school district adopts CEP, it drops out of the data set for the remaining years. The different model specifications include ten covariates: identified student percentage, representing the policy characteristic; federal revenue for child nutrition programs per student; state revenue for school meal programs per student; local school meal revenue per student; food service spending per student; district administrative staff per student; a district's student enrollment, representing the internal determinants; the state's direct certification rate; the state's average CEP adoption rate; and the county's political ideology, representing the external determinants (see Table 1.1). We measure the effects of the covariates on CEP adoption using the Cox model described above.

The estimated value $exp(\beta_i)$ for each coefficient β_i represents the hazard ratio (HR) of covariate *i* and can be interpreted in a similar manner to the odds ratio in a logistic regression. The HR measures the instantaneous change in the hazard function for a unit change in the i^{th} covariate when the covariate is a numerical variable. For categorical variables, $exp(\beta_i)$ represents the HR of a given category with respect to the reference category. It tests the null hypothesis whether the covariate is related to survival, and is statistically significant when the confidence interval of the estimate excludes 1 at the given level. Assuming that the Cox model is correctly specified, the estimated HR does not have a causal interpretation due to the issue of selection and unmodelled heterogeneity (Aalen, Cook, and Røysland 2015; Martinussen 2022), considering that school districts opting into CEP is not randomized.

An HR greater than 1 (i.e., $\beta_i > 0$) implies that the i^{th} covariate increases the likelihood of the hazard (i.e., adoption of CEP), which corresponds to a lower survival time. Conversely, an HR less than 1 (i.e., $\beta_i < 0$) implies a decrease in the likelihood of CEP adoption. An HR equal to 1 (i.e., $\beta_i \approx 0$) implies that the i^{th} covariate has no effect on the hazard function or the survival time. For example, an HR of 1.3 indicates that a unit change in the i^{th} covariate would increase the likelihood of CEP adoption by 30%. Thus, we are interested in the covariates that have a statistically significant β value greater than zero.

We used the "survival" package in R to estimate the Cox proportional hazards regression model.[5] We estimated four model specifications to test the associations of the covariates with CEP adoption. In Model 1, we estimated whether a school district's ISP and the state's direct certification rate are associated with CEP adoption, without controlling for the other covariates. In Models 2, 3, and 4, we varied how we defined the ISP variable and included all covariates that represented the internal and external policy determinants for CEP. We defined ISP as a continuous variable in Model 2, whereas the ISP is divided into the categories "under 50%" and "above 50%" in Model 3, and the categories "under 62.5%" and "above 62.5%" in Model 4.

The "under 50% ISP" category in Model 3 represents the relatively lower ISP category of eligible school districts, whereas the "above 62.5% ISP" category in Model 4 represents those districts that receive reimbursement for 100% of the meals served. While Models 1 and 2 allow us to test the relationship between a school district's ISP and the likelihood of CEP adoption, Models 3 and 4 provide insight into

[5] See https://cran.r-project.org/web/packages/survival/survival.pdf for more information.

differences, if any, between school districts in different ISP categories. In each of the four models, we controlled for student enrollment in the school district and included time fixed effects (year).

1.6. Results

The empirical results of all four models, which are presented in Table 1.3, demonstrate that CEP adoption is influenced by various factors, including some policy characteristics, internal determinants, and external determinants. Model 1 shows that higher ISPs for school districts (HR=141.518) and the state's direct certification rate (1.005) increase the likelihood of CEP adoption. The associations between ISP, direct certification, and CEP adoption estimated in Model 1 hold in Models 2, 3, and 4 that control for other covariates. Model 3 shows that school districts with ISPs under 50% are less likely to adopt CEP than school districts above 50% (HR=0.201). Model 4 shows that school districts with an ISP under 62.5% are less likely to adopt CEP than school districts above 62.5% (HR=0.391).

In each of the Models 2, 3, and 4, we see that the log of federal revenue per student from school nutrition programs for school districts is associated with a higher likelihood of CEP adoption. Conversely, log of state (HR=0.790) and log of local (HR=0.577) revenue per student for school districts is associated with a lower likelihood of CEP adoption. School districts that are in states with a higher average rate of adoption are more likely to adopt CEP across the three specifications. The log of district administrative staff per student is not associated with CEP adoption, whereas the log of food service spending per student (HR=0.810) is negatively associated with CEP adoption in Model 4.

Lastly, the results show that partisan identity in a county does not affect the likelihood of CEP adoption. School districts in counties that identify as supporting Republican or Independent parties, or that are unsure of their support, do not differ significantly in terms of CEP adoption from those that identify as Democrat. Model 2 has the highest concordance (0.888), which represents how well the model predicts adoption. A statistically significant logrank statistic (that is asymptotically equivalent to the likelihood ratio test and the Wald test) implies that the model is globally statistically significant.

Table 1.3. Hazard ratio (exp(β)) for covariates representing association with CEP adoption.

Variables	Model 1	Model 2	Model 3	Model 4
Identified Student Percentage	141.518*** (116.626-171.721)	96.424*** (67.842-137.047)		
Identified Student Percentage under 50% [a]			0.201*** (0.175-0.230)	
Identified Student Percentage under 62.5% [b]				0.391*** (0.343-0.447)
log(federal revenue from child nutrition programs per student)		1.943*** (1.585-2.383)	1.651*** (1.337-2.040)	2.250*** (1.859-2.722)
log(state revenue from school meal programs per student)		0.852*** (0.803-0.903)	0.885*** (0.835-0.939)	0.862*** (0.813-0.914)
log(local school meal revenue per student)		0.673*** (0.643-0.705)	0.680*** (0.648-0.712)	0.643*** (0.615-0.673)
log(food service spending per student)		0.907 (0.720-1.142)	1.026 (0.806-1.306)	0.810** (0.659-0.996)
log(district administrative staff per student)		1.030 (0.963-1.100)	1.033 (0.965-1.106)	1.018 (0.952-1.087)
Student enrollment	1.001*** (1.000-1.001)	1.001*** (1.000-1.001)	1.001*** (1.000-1.001)	1.001*** (1.000-1.001)
Direct certification rate in the state	1.005** (1.001-1.010)	1.013*** (1.004-1.022)	1.010** (1.001-1.020)	1.019*** (1.001-1.028)
Average CEP adoption rate in the state		18.610*** (13.748-25.191)	15.950*** (11.776-21.604)	19.132*** (14.136-25.893)
Partisan identity: Republican [c]		1.036 (0.918-1.170)	0.978 (0.867-1.103)	0.988 (0.876-1.115)
Partisan identity: Independent [c]		0.988 (0.829-1.179)	1.018 (0.854-1.214)	0.982 (0.823-1.172)
Partisan identity: Not sure [c]		0.813 (0.570-1.163)	0.881 (0.617-1.258)	0.942 (0.660-1.346)
Year fixed effect	Yes	Yes	Yes	Yes
N	21,605	13,805	13,805	13,805
Number of events	3,014	1,370	1,370	1,370
Concordance	0.844	0.888	0.886	0.856
Logrank test	3,553***	3,064***	3,043***	2,723***

Note: Model 1 estimates the association between CEP adoption, the school district's ISP, and the state's direct certification rate, without controlling for the other covariates. Model 2 adds additional covariates to Model 1 that represent the internal and external policy determinants. In Model 3, the ISP is divided into the categories "under 50%" and "above 50%." In Model 4 the ISP is divided into the categories "under 62.5%" and "above 62.5%." 95% confidence interval of exp(β) in parentheses. ***, **, and * represent coefficients statistically different from 0 at the 1%, 5%, and 10% significance level, respectively. For a description of variables, see Table 1.1.

[a] Base category: Identified Student Percentage above 50%.

[b] Base category: Identified Student Percentage above 62.5%.

[c] Partisan identity base category: Democrat.

1.7. Discussion and Implications

This research provides the first longitudinal, school district-level analysis of the factors associated with adoption of CEP across the U.S. to explicate the eligibility and associated policy characteristics related to higher rates of participation. Specifically, we sought to understand if the factors that federal and state policymakers determine are related to program adoption at the school district level. This study is particularly timely, given that many states are introducing universal free school meal legislation, which requires school districts to take advantage of the federally funded CEP prior to accessing state funds. We draw upon the literature on policy eligibility and diffusion by explicitly modeling factors at the school district level to study adoption. Our results demonstrate that choices made at the federal and state levels have important relationships with adoption of CEP at the school district level. These findings reinforce those of Hecht, Stuart, and Porter (2022), while establishing that the observed relationships hold over time.

1.7.1. Implications for State Agencies

States make several important decisions related to adoption of the CEP at the school district level. Most notably, they decide how to conduct direct certification, which in turn contributes to a school and school district's ISP. Given the importance of the relationship between direct certification rates and the adoption of CEP, there is a strong argument for states to increase direct certification.

For example, 87% of school-age SNAP participants in California were directly certified in SY 2018-19, which is lower than the national average of 98% (Ranalli, Templin, and Applebaum 2021). In the same year, only 39.1% of the eligible school districts had adopted CEP (FRAC 2019). California passed legislation to adopt universal free school meals starting SY 2022-23, requiring eligible school districts to adopt CEP. Our findings suggest that improving direct certification in a state may aid in increasing uptake of CEP, thus maximizing the federal dollars the state receives in funding the universal school meals program.

In order to increase the number of children directly certified, previous research has recommended including programs in addition to SNAP (Maurice 2018). Both SNAP participation and income limits for eligibility vary across states, making them inefficient measures of poverty for directly certifying students (Billings and Carter 2020). The USDA's Food and Nutrition Service conducted a series of demonstration projects to assess the use of Medicaid data for direct certification, starting with seven states in SY 2016-17. As a result, an additional 2.1% to 8.8% of students were directly certified in these states, demonstrating the advantage of this intervention. These implications underscore the need for increased efforts by state agencies to improve direct certification in their states, thereby supporting school districts in adopting CEP.

1.7.2. Implications for Federal Agencies

Relatedly, a school district's ISP is closely associated with adoption of the CEP. The annual report on CEP implementation by FRAC and the Congressional Research Service report on the CEP from 2020 both highlight low adoption rates in school districts with ISPs under 50%. In weighing the benefits and costs of adopting CEP, school districts in the lower ISP categories are less likely to adopt CEP because it may not be financially feasible for them to cover the costs not covered by the total reimbursement they receive. The result in Model 3 substantiates these observations by showing that school districts with ISPs under 50% are significantly less likely to adopt CEP after controlling for various sources of school food revenue and expenditures. Thus, increasing adoption by school districts with low ISPs would require an increase in the total reimbursement. One way to achieve this could be by increasing the multiplier from the current rate of 1.6.

The Child Nutrition Reauthorization bill, which makes changes in school nutrition programs, is due in Congress. The last time a change was made, establishing the current Healthy, Hunger-Free Kids Act, was 2010. The Child Nutrition Reauthorization bill proposes lowering the eligibility threshold from the current ISP of 40% to 25% to increase the number of schools that become eligible for CEP. These recommendations correspond with those made in the Build Back Better Act to expand coverage under

CEP. Additionally, the Child Nutrition Reauthorization bill proposes to increase the reimbursement multiplier from 1.6 to 2.5. The results of this research suggest that school districts that become newly eligible with an ISP of 25% would be less likely to adopt CEP, as the total reimbursement with the higher multiplier of 2.5 (resulting in 62.5% meals reimbursed at the federal free rate) would still leave out costs that the school district would need to cover using other sources.

However, coupling the reduced ISP with the increased multiplier of 2.5, school districts with an ISP of 40% should be more likely to adopt CEP (as suggested by our findings in Model 4). At the current reimbursement rate of 1.6, school districts with an ISP above 62.5% receive reimbursement that covers the cost of all meals served (1.6 multiplied by 62.5 equals 100), and the result in Model 4 shows that these districts would be more likely to adopt CEP. In SY 2018-19, 53% of all participating schools had an ISP at or greater than 62.5% (Billings and Carter 2020). Thus, our findings imply that any increase in the multiplier rate for reimbursement would increase CEP adoption by school districts with relatively lower ISPs. Additionally, lowering the ISP to increase the number of districts eligible without changing the reimbursement multiplier is unlikely to contribute to a significant increase in uptake of CEP.

In efforts to expand the provision of free school meals, the "School Hunger Elimination Act" of 2019 (S.2752)[6] was introduced in the 116th Congress (2019-20). It proposed amendments to the National School Lunch Act to increase the CEP reimbursement multiplier from 1.6 to 1.8 and expand the use of Medicaid for direct certification to all states. Our findings underscore the significance of ISP and direct certification rates in CEP adoption, thereby supporting the recommendations in the bill if the goal is to increase access to free school meals.

More recently, the "No Hungry Kids in School Act" (H.R.3112)[7] and the "Expanding Access to School Meals Act" (H.R.3113) were introduced in the 118th Congress (2023-24),[8] with the objective of expanding

[6] See https://www.congress.gov/bill/116th-congress/senate-bill/2752/text for more information.
[7] See https://www.congress.gov/bill/118th-congress/house-bill/3112/text?s=1&r=2 for more information.
[8] See https://www.congress.gov/bill/118th-congress/house-bill/3113/text?s=1&r=1 for more information.

access to school meals. H.R.3112 proposes to amend the National School Lunch Act to establish an option for states to utilize a statewide CEP that would benefit states that plan to utilize state funds for universal free school meals. The Act proposes to reduce the ISP for CEP to zero, while keeping the multiplier at 1.6 and calculating the ISP for all schools in the state instead of being limited to schools with a relatively high proportion of low-income students. As a result, all schools in the state with ISPs greater than zero would be able to claim federal reimbursement by participating in CEP, with the remaining cost for the school funded by the state. Thus, by improving direct certification rates, states will be able to maximize federal funding in supporting statewide universal free school meals, as our findings emphasize.

H.R.3113 proposes to eliminate reduced-price meals and raise the income threshold in determining eligibility for free meals to 200% of the poverty level (compared to the current 130%). The implication of these changes for CEP would be an increase in the ISPs for school districts, as children who were previously in the reduced-price category would now be counted for provision of free meals. Additionally, the Act also proposes increasing the CEP reimbursement multiplier to 2.5 (from the current 1.6). Our findings suggest that both these changes are highly likely to increase CEP adoption.

1.8. Conclusion

In the last decade, a combination of federal and state policies, grants, and reimbursement programs have pushed for nutrition assistance through school meals. Indeed, the NSLP is the second largest federally assisted meal program in the U.S. Focus on the federally funded CEP is increasing, as a growing number of states in the U.S. are passing legislation to adopt universal free school meals to combat child food insecurity. For example, a policy in Colorado goes into effect starting SY 2023-24, and like other states that have adopted universal school meals, it requires eligible school districts to adopt CEP to maximize the federal dollars to fund school meals. However, only 28.4% of the eligible school districts in Colorado had adopted CEP in SY 2018-19, whereas the rate was 53.8% for the U.S. The findings from this study are thus of particular interest to policymakers and institutions seeking to increase adoption of CEP in their state and reduce state expenditures associated with adoption of universal free school meals.

Using a policy diffusion approach to categorize our study variables and a Cox regression model to examine the determinants of CEP adoption, we find that a school district's ISP and the state's direct certification rate are related to higher adoption. Being the first longitudinal study to examine factors associated with CEP adoption, these findings inform state and federal agencies, policymakers, and other stakeholders of strategies and levers likely to increase program uptake. Our results suggest that the likelihood of adoption is significantly higher for school districts that receive reimbursement at the free rate for all meals served. Efforts by states to improve direct certification may make more school districts eligible for CEP and increase the ISP. Any increase in participation in CEP will not only benefit the state finances, but it will also improve nutrition and food security outcomes for students, as well as schools.

However, there remains the issue about the tradeoffs associated with publicly funded universal free school meals. Providing free school meals to all students can be expensive for the government as the cost includes not only the food itself but also the infrastructure, staff, and administrative expenses associated with managing such a program. While such programs do stimulate the economy through supporting the food industries, and improving nutrition outcomes among children, it is important to consider the opportunity cost associated with funding the programs. While universal free school meal programs ensure that no child goes hungry regardless of their family's financial situation, it may not be the most targeted approach to addressing food insecurity, and one could argue that resources could be better allocated by targeting assistance to low-income families specifically.

The findings from our empirical specifications do not represent causal relationships between the covariates and CEP adoption due to non-random selection of school districts into the program. The results represent correlation, and the effect size could be affected by endogeneity in the model. Another potential limitation is the use of school district revenue and expenditure in the same year of CEP adoption as covariates in the model. While these represent the change in a school district's meal budget that informs the feasibility of CEP adoption, the recorded changes are due to CEP adoption in the first place. However, since we only claim correlation, and not causality with the results obtained, we continue to work with this caveat. Our empirical results are also limited by the quality of data available. Due to a lack of common identifiers between the school district data sets, we use approximate string-matching techniques that do not produce perfect matches, and as a result, we lose some observations. These limitations motivate several opportunities for further research.

Considering the opportunity cost associated with public funding of universal free school meals, an important area of future research could be to investigate an 'optimal' ISP for program participation. This would lend insight into program expenditures related to total meal reimbursement and inform policymakers about the efficacy of the program. Such research could also be valuable for strengthening CEP independently of a universal free school meals program if provision of free meals cannot be expanded indefinitely. The findings from this study emphasize the need for future research that further examines the direct certification process at the school district level. This will give further insight into the factors affecting direct certification that are nested within each state. With the USDA's Food and Nutrition Service introducing demonstration projects for direct certification with Medicaid in an additional 14 states in SY 2023-24, future studies could examine its impact on CEP adoption. Since our study uses data up to SY 2018-19, future research could extend the study period and consider the impacts of COVID-19, provision of free school meals during the pandemic, and various state legislation adopting universal free school meals. An area of future research could be to investigate whether there is a correlation between CEP participation in a state and the likelihood of adopting a statewide universal free school meal program.

Chapter 2

Exploring the Relationships among Stocks of Community Wealth, State Farm to School Policies, and the Intensity of Farm to School Activities

2.1. Introduction[9]

There is growing attention to public food procurement, school meals, and "canteen" programs around the world, with particular interest in promoting local procurement initiatives to both increase healthy food in schools and create new or expanded market opportunities for farmers. For example, countries in the European Union are permitted to encourage local, shortened supply chains in their use of the €250 million available per school year as part of the fresh fruit, vegetable, and milk scheme (European Commission 2021). In Brazil, the School Feeding Law mandates that at least 30% of the food for the school feeding program must be procured directly from family farms and family rural entrepreneurs (da Silva, Pedrozo, and da Silva 2022).

Farm to School (FTS) is a widely implemented local foods program in the United States (U.S.) (Botkins and Roe 2018), supported in part by the federal government, with 67,369 schools and 42.8 million students participating in the program in the school year 2018-19 (USDA FNS 2021a). FTS programming aims to promote community development by supporting farm viability, food and agricultural literacy, and nutrition security. Federal support for FTS is available to all states through the U.S. Department of Agriculture (USDA) Food and Nutrition Service's FTS grant program, as well as through at least four

[9] This chapter has been published as a peer-reviewed article in the journal Food Policy. The article was published in January 2024 and can be accessed here: https://doi.org/10.1016/j.foodpol.2023.102570.

other USDA agencies (USDA FNS n.d.). Additionally, many states have passed FTS legislation, often with significant funding, to augment federal support (NFSN and CAFS 2021).

Previous research finds the impact of state FTS policies is inconclusive; it is unclear if state policies increase FTS participation (e.g., Lyson 2016; McCarthy, Steiner, and Houser 2017). However, potential community advantages – as seen through local endowments of assets – are often ignored when pursuing blanket policies for community development (Schmit et al. 2021). Pender, Marré, and Reeder (2012) describe a community's endowment of wealth as all assets net of liabilities that can contribute to well-being, including many forms of capital that are both tangible (e.g., natural, built) and intangible (e.g., social, cultural). Together, these assets form a community's stock of wealth and can be thought of as a foundation to guide bottom-up development decisions.

In an effort to support policymakers and community economic developers considering implementing FTS policies and programs, we examine the relationship between stocks of community wealth, the type of state-level FTS policy, and FTS program adoption and intensity. Our analysis addresses three research questions. First, is there a relationship between certain local assets and FTS adoption and intensity? Second, given the stocks of local wealth, is the type of state-level FTS legislation (procurement or education) related to program participation? Third, are there spatial effects of a neighboring school food authority's (SFA[10]) decision to adopt FTS programming?

Using the Heckman selection model, we find that components of cultural capital, social capital, and human capital have significant associations with both the probability and intensity of FTS participation. Further, results show that while state-level FTS policies that support procurement are positively correlated with FTS participation and intensity, policies supporting agricultural education activities are negatively correlated. Lastly, we find a small but positive spatial effect of FTS intensity on the probability of participation in FTS.

[10] A School Food Authority (SFA) is the entity responsible for the administration of school food service operations. It may or may not be the same as the corresponding school district (USDA FNS 2021a).

This research makes two primary contributions to literature. First, it is the first national-level research to quantitatively analyze the relationship between community assets and FTS. Recognizing a community's endowment of wealth as a form of advantage and using an asset-based approach to development may support policymakers in identifying endowment-specific investment related to the success of food systems-led policy investments (Pender, Marré, and Reeder 2012; Pender and Ratner 2014; Ratner 2019; Ratner and Allen 2013; Ratner and Markley 2014). Second, as previous research finds inconsistent results from state-level FTS legislation, we develop the first disaggregated, state-level FTS policy database, leveraging research conducted by the National Farm to School Network and the Vermont Law School. This enables us to conduct the first national-level research on the relationship between the type of FTS policy and FTS intensity, controlling for several factors. In this way, we do not treat FTS legislation as homogeneous, better reflecting nuances of the types of policies that states are passing. This has implications for not just FTS in the U.S., but for policymakers globally who provide state support for public food procurement and school meal programs.

2.2. Background and Literature

Community development is a complex and challenging process, so researchers have developed many frameworks to prioritize and evaluate the appropriateness of different policies and programs (e.g., Ife 2013; Kenny 2016). Much of this literature – including the community capitals framework (e.g., Flora, Flora, and Gasteyer 2018), asset-based community development (McKnight and Kretzmann 1993), the capitals and capabilities framework (Bebbington 1999), and rural wealth creation (e.g., Pender, Marre, and Reader 2012; Ratner 2019) – argues for asset-based approaches that leverage existing local assets and stakeholder networks as starting points to determine development approaches.

Pender, Marré, and Reeder (2012) define a community's endowment of 'wealth' as the stock of all assets, net of liabilities. Their conceptual framework of 'wealth creation' draws from the rural development literature (Carney 1998; Castle 1998; Flora, Flora, and Gasteyer 2018; Green and Haines 2016;

Kretzmann and McKnight 1993; Sen 1994) and includes physical, financial, natural, human, intellectual, social, cultural, and political assets, all referred to as capital.

Built capital, also called physical capital, includes infrastructure that supports the community (e.g., roads, telecommunication networks), as well as outputs produced by firms (Pender and Ratner 2014). Financial capital includes money and other liquid financial assets (net of liabilities), like stocks and bonds that are available to invest in the community and accumulate wealth for future development (Pender, Marré, and Reeder 2012). Natural capital includes both renewable and nonrenewable natural resources, such as ecosystems and fossil fuels, respectively (Costanza and Daly 1992). Human capital includes components like level of education and health, representing the skills and knowledge embedded in people (Pender and Ratner 2014). Social capital refers to the trust, relationships, and networks in the community that facilitate collective actions through the formation of associations and groups (Pender and Ratner 2014). Political capital can be viewed as a form of social capital when it is defined in this manner. Finally, cultural capital consists of those tangible and intangible practices that reflect the values and identities of a place or its people, and it can take the form of museums, heritage buildings, beliefs, traditions, and ethnicities (Pender and Ratner 2014; Throsby 1999). Note that the names of the different types of capital vary across the literature, but the substance of what is included remains consistent.

Several studies have proposed methods to empirically measure one or multiple types of capital using publicly available data and employing data-driven tools to inform policy that creates and sustains wealth (e.g., Arrow et al. 2012; Green, Worstell, and Canarios 2017; Johnson, Raines, and Pender 2014; Pender, Marré, and Reeder 2012; Schmit et al. 2017; Schmit et al. 2021). Local food systems inherently impact and are impacted by local endowment of assets; for example, natural capital impacts the viability of local agriculture, while built capital impacts the ability of farmers to add value to products and access different markets.

Despite the challenges in quantifying measures of wealth and modeling the complex relationship between different types of local assets, some research on food systems-led community development has looked at these relationships, including direct-to-consumer markets (Jablonski 2014; Schmit et al. 2021), food security (Crowe and Smith 2012; Herrington and Mix 2020), and food value chains (Lyons and Wyckoff 2014; Rahe and Hause 2020). As an example of the relationship that exists between food systems-led community development and community capital, Connelly and Beckie (2016) find that in addition to the focus on securing physical infrastructure, investing in social capital plays a critical role in scaling up local food initiatives.

Collectively, this research has found relationships between local assets and various community economic development programs. However, we could not identify any empirical analysis of the relationship between community capital assets and FTS. Unlike other local food promotion programs like farmers markets and food hubs that focus on marketing strategies for local produce, FTS presents a unique and more complex case. It focuses on supporting direct and intermediate food markets, as well as educating students on agriculture and nutrition, and is supported by multiple state legislation.

Passed by the U.S. Congress in 2010, the Healthy, Hunger-Free Kids Act (HHFKA) included the authorization of the first federal program exclusively dedicated to FTS (Billings 2021). The objectives of the FTS grant program include improving nutritional outcomes of school children, supporting local farmers and rural communities, and providing education activities related to food and agriculture (Feenstra and Ohmart 2012; NFSN n.d.; Taylor and Johnson 2013). The most recent data (2018-19 school year) estimates that 65% of SFAs participate in FTS, and these SFAs spent $1.26 billion on purchasing local foods as part of the National School Lunch Program (USDA FNS 2021a).

FTS is intended to foster community development by promoting healthy eating behaviors, strengthening the local food systems, and integrating agricultural education into the school curriculum, promoting ‘kids win’, ‘farmers win’, ‘communities win’ outcomes (NFSN n.d.). Overall, research on the impacts of FTS programs and activities is limited and mostly focuses on ‘kids win’ impacts like food-related knowledge and fruit and vegetable consumption, and finds that program outcomes (e.g., improved child nutrition outcomes) are mixed (Bonanno and Mendis 2021; Prescott et al. 2020).

Research on economic spillovers of FTS finds a weak association between FTS and regional economic growth (Brown et al. 2014; Deller et al. 2014; Stickel and Deller 2020), while other research shows small but positive local economic impacts (Austin 2019; Becot et al. 2017; Christensen et al. 2017, 2019; Gunter and Thilmany 2012; Haynes 2010; Roche et al. 2016). There is little research that quantitatively assesses the impacts of FTS on farms, and what does exist includes very small samples of producers (Bobronnikov et al. 2021). Lee et al. (2019) assesses a range of indicators associated with community readiness and capacity for adoption of FTS activities, identifying school capacity, networks and relationships, organizational and practitioner capacity, and community resources and motivations as important themes.

There has been growing support for FTS at the federal and state levels. In 2019, the USDA Food and Nutrition Service awarded $9 million in FTS grants, reaching 3.2 million students in 5,400 schools (NFSN 2021). The USDA Food and Nutrition Service announced the availability of $12 million for the fiscal year 2022 (USDA FNS 2021b). At the state level, a total of 546 bills and resolutions supporting FTS activities were introduced in forty-six states, the District of Columbia, and one US territory between January 1, 2002, and December 31, 2020 (NFSN and CAFS 2021). These state policies provide significantly more funding for some participating states than federal dollars. For example, the Oregon Legislature approved $10.2 million in 2021 to fund the state's FTS grant program (Oregon Farm to School and School Garden Network 2021), while Michigan's budget for their program (10 Cents a Meal) has more than doubled, from $4.5 million in 2022 to $9.3 million for 2023 (Slootmaker 2022).

Results from several studies that examine the relationship between state FTS policies and uptake of FTS activities are inconclusive and only suggest modest outcomes. Some studies found a positive association between state FTS policies and frequency of serving local foods at schools (McCarthy, Steiner, and Houser 2017; Ralston et al. 2017). On the other hand, Lyson (2016) found no correlation between state FTS policies and proportion of districts in a state participating in FTS, and Avuwadah and Kropp (2022) found no change in the number of meals served at lunch or type of meals served at schools in a Florida school district after the introduction of FTS. Bonanno and Mendis (2021) found mixed results regarding the association between state-level policies and a school district's probability and continuation in FTS.

The bills and resolutions passed in states support FTS in various ways, such as through reimbursement programs, school gardens, and forming working groups (NFSN and CAFS 2021). Previous literature does not evaluate state FTS policies based on any categorization of the type of policy, i.e., there is no explicit distinction between a policy that supports local procurement and one that supports school gardens. Yet, one can imagine very different types of impacts occurring as a result of different types of FTS policies. For example, a local procurement policy may directly create new market opportunities for farmers and ranchers, but does not inherently change student knowledge about healthy eating unless an educational program accompanies the procurement decision. On the other hand, a school garden likely provides direct educational opportunities to students without impacting (or potentially indirectly negatively impacting) school markets for locally grown products. Accordingly, it is problematic that policies in previous research measure the presence of a state-level FTS policy either as binary variables, indicating the existence of the policy, or as number of policies (e.g., Avuwadah and Kropp 2022; Lyson 2016; McCarthy, Steiner, and Houser 2017; Ralston et al. 2017).

Despite the support of federal and state grants (NFSN 2016), adoption and implementation of FTS activities vary within and across states (Lyson 2016; USDA FNS 2021a). These disparities in adoption and intensity of participation make it challenging for policymakers and local economic development officials to understand where, when, and how to incentivize FTS. Unlike other local food promotion programs like farmers' markets that focus on direct marketing strategies for local products, FTS has multiple goals and directly-impacted stakeholders (e.g., local procurement aspires to create new or expand markets for producers, the education elements focus on improving student health outcomes). Accordingly, FTS is complex and exploring the relationships between community assets, FTS, and different types of state policies remains a key area of research.

2.3. Conceptual Framework

We use the conceptual framework of wealth creation to understand how differences in participation in FTS are affected by the distribution of stocks of wealth and the supporting policy environment, while taking into account the growing national interest in local food systems development. We adapt the framework of Pender, Marré, and Reeder (2012) to contextualize our research questions (see Figure 2.1). The framework incorporates stocks of assets within a local community that are owned or controlled by local actors. The local economic, institutional, and policy contexts affect local decisions, but they are controlled by external actors and are not considered local assets. Together, they inform a community's local endowment and policy context, which affect the decisions made by the local actors. These decisions and outcomes can then directly or indirectly affect the capital stocks, and they may also affect the policy context over a period of time, as explained by the circular nature of the framework.

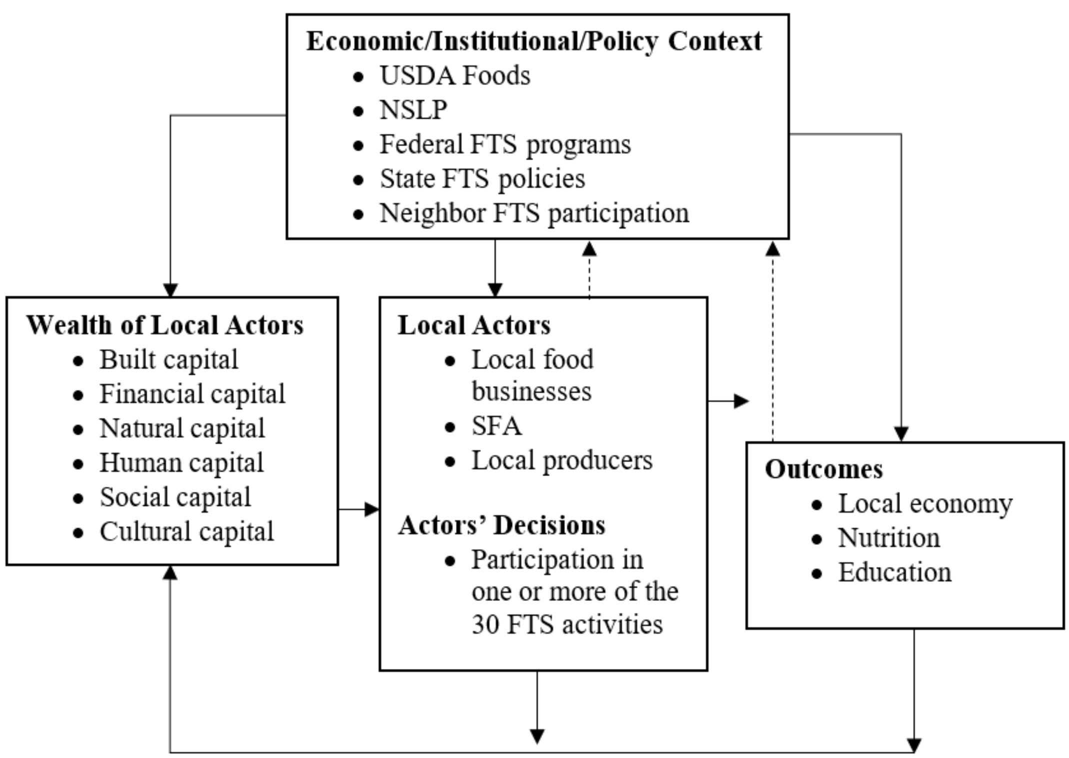


Figure 2.1. Wealth-decisions-outcomes framework for conceptualizing factors affecting Farm to School (FTS) intensity. Adapted from Pender, Marré, and Reeder (2012).

These capitals are reported as stocks of existing wealth, not as flow measures, which is an important distinction within the framework. Measures of household income or GDP are examples of flow measures, while net worth (tangible assets net of existing liabilities) is a stock measure (Schmit et al. 2021). Tradeoffs may be ignored in flow variables like GDP, since they may only reflect benefits in the short term (e.g., from activities like mining), but they may have adverse effects in the long term. In setting up the framework, the authors were careful to argue that wealth creation must not be pursued in a vacuum but must be considered within the broader development in the region.

We use the framework to guide the model of the decision of SFAs to participate in FTS, as well as the intensity of their participation. The local actors consist of local producers and food businesses selling to schools, as well as SFAs in the county. In addition to the local assets, we consider the federal FTS grant program and state legislation, procurement support for SFAs, federal nutrition requirements, and participation in FTS by neighbor SFAs to form the local economic, institutional, and policy contexts for program adoption.

Given the policy context, we would expect local wealth endowments to play a role in enabling or hindering local actors in adopting different FTS activities. Assets like built capital (e.g., local food processing infrastructure), human capital (e.g., food service staff), social capital (e.g., formal, and informal social organizations), and others are expected to aid schools in adopting FTS activities.

Furthermore, social, and cultural relationships both within the community and with the local authorities are likely equally important in understanding the intensity of program adoption. From our review of literature, we expect wealth endowments like stocks of social, cultural, and human capital to be positively associated with higher probability of participation in FTS and support higher intensity within the participants.

2.4. Data

2.4.1. FTS Intensity

The USDA Food and Nutrition Service (FNS) conducts the FTS Census periodically to evaluate the state of FTS activities across the U.S. The Census was conducted most recently in the fall of 2019, with responses measuring FTS participation in school year (SY) 2018-19. The Census included self-reported responses from 12,634 SFAs from all fifty states and Washington, DC, representing a 67% response rate (USDA FNS 2021b). The survey asked SFAs whether they had participated in any of the 30 FTS activities. SFAs that confirmed participating in at least one activity received additional questions about local food purchasing, expenditures, staffing, gardens, and management. SFAs that did not acknowledge participating in any of the activities received only a limited set of follow-up questions like challenges to participation in FTS.

Using the responses in the 2019 FTS Census, we create measures of FTS intensity, designed to show where a particular SFA falls on a scale ranging from lesser to higher degree of FTS participation. The overall FTS intensity variable is an index of FTS activities and other program characteristics, which allows us to compare intensity of program adoption across SFAs in the U.S. SFAs that do not confirm participation in any of the thirty FTS activities listed in the survey represent an intensity value of zero. SFAs that participate in at least one FTS activity receive an intensity value based on the number of activities adopted, frequency of some activities, annual expenditures on local foods, and dedicated program staffing. Figure 2.2 illustrates the distribution of FTS intensity (0-16) of SFAs, providing a visual representation of participation across the country.

To investigate the relationship more carefully between FTS intensity, local assets, and policy, we created three categories of FTS activities: procurement, education, and staffing. Within the two broad categories of procurement and education, we created sub-categories that group activities that are similar and/ or related. Since the Census data on the thirty FTS activities only tells us whether an SFA participates in the activity or not, and not the intensity of each activity, we believe that creating these categories and sub-categories of the activities are an appropriate way to understand the overall intensity of participation based on the objectives of the program.

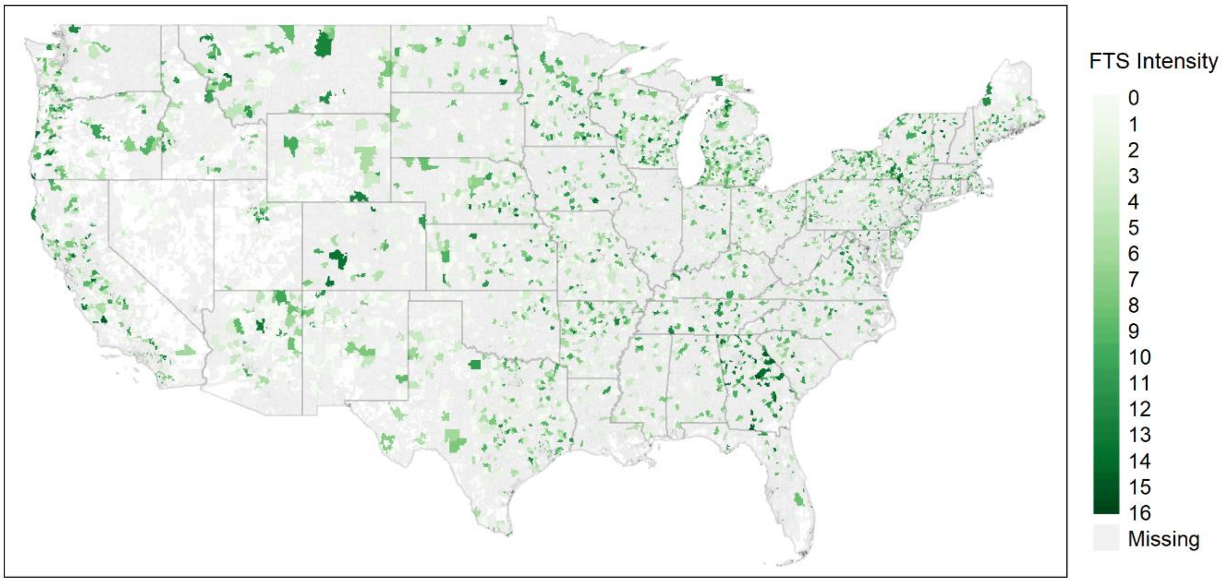


Figure 2.2. Map of Farm to School (FTS) intensity, representing the extent of program participation (0-16) for school food authorities in the U.S.

Decisions about the three categories and sorting of the activities into the categories and further sub-categories were made following the 2019 FTS Census Report (USDA FNS 2021a), the core objectives of FTS as articulated by the National Farm to School Network (NFSN n.d.), the categorization by Bonanno and Mendis (2021), and in consultation with an Advisory Committee for this USDA-funded project that included members from the National Farm to School Network, State Departments of Agriculture and Education, the USDA Food and Nutrition Service, and nonprofits.

Procurement intensity includes the following five categories of activities from the Census: (i) activities involving procuring and serving local foods in the school cafeteria, (ii) whether local foods are also being sourced from USDA Department of Defense Fresh[11], (iii) frequency of serving local foods, including

[11] Schools can use USDA Foods entitlement dollars to buy fresh produce from the USDA Department of Defense Fresh Fruit and Vegetable Program that is operated by the Defense Logistics Agency at the Department of Defense.

fruits, vegetables, protein, and grains, weighted by the expenditure on local foods as a proportion of total food expenditure, (iv) education and promotion activities directly related to such procurement activities as taste tests and Harvest of the Month, and (v) strategic activities to facilitate and assist in procurement of local foods. Following previous literature, we exclude local expenditures on fluid milk[12] (Bonanno and Mendis 2021; Botkins and Roe 2018).

Education intensity includes the following four categories of activities from the Census: (i) garden-based activities in schools, (ii) food, nutrition, and agricultural education in the classroom, (iii) community awareness programs, like student field trips to farms and celebrating National Farm to School Month, and (iv) the proportion of schools in the SFA with school gardens.

Finally, we create a staffing intensity index from two Census responses: (i) availability of staff dedicated to managing FTS activities and (ii) whether training is provided to the school food service staff on procurement- or school garden-related activities. Dedicated full-time or part-time staff and training of staff reflects a relatively higher effort by SFAs to carry out FTS activities and is expected to lead to more intensive programming. The activities and other survey responses used from the 2019 FTS Census to construct procurement intensity, education intensity, and staffing intensity are presented in Appendix A.

We weight the procurement intensity by the proportion of schools within the SFA that served local foods and education intensity by the proportion of schools within the SFA that provided agricultural education. We calculate the FTS intensity variable by aggregating the weighted procurement intensity, weighted education intensity, and staffing measures at the SFA level as shown in Equation (1).

$$FTS\ intensity = Procurement\ intensity\ \left(\frac{number\ of\ schools\ serving\ local\ foods}{total\ number\ of\ schools\ in\ the\ SFA}\right) + $$

$$Education\ intensity\ \left(\frac{number\ of\ schools\ providing\ agriultural\ eduction}{total\ number\ of\ schools\ in\ the\ SFA}\right) + Staffing\ support \qquad (1)$$

[12] Milk served in schools is often a 'local food', irrespective of their participation in Farm to School.

The summary statistics are given in Table 2.1, showing that values of FTS intensity for SFAs participating in FTS range from 0.014 to 15.174, with a maximum possible value of 16. The mean intensity value is 3.929 for all SFAs, whereas it is 5.803 for SFAs participating in FTS.[13]

Table 2.1. Summary statistics for FTS participation and intensity (n=8,162).

Variable	Description	Mean	S.D.	Min	Max
FTS	Binary variable = 1 if SFA participates in FTS in SY 2018-19; 0 otherwise	0.677	0.468	0	1
FTS intensity	Index of participation calculated using weighted measures of adoption of procurement activities, education activities, and staffing by the SFA	3.929	3.961	0.000	15.174
FTS intensity (FTS = 1)	FTS intensity for those SFAs that participated in FTS in SY 2018-19 (n=6,161)	5.803	3.506	0.014	15.174

Source: U.S. Department of Agriculture's Food and Nutrition Service's 2019 Farm to School Census.

A relatively higher intensity value represents more engagement in FTS, which could be driven by greater participation in one or more areas of procurement activities, education activities, or staffing activities. However, our approach to measuring intensity does not take into account the extent of participation within a type of activity for most activities or the number of students in the SFA participating in those activities. We proceed, recognizing this is a limitation with the measures. More detail on the construction of procurement intensity, education intensity, and the overall FTS intensity is presented in Appendix A.

2.4.2. Stocks of Community Wealth

We use a database of the stock of local wealth created by Schmit et al. (2021). The data are at the county-level and include indicators associated with six types of capital: built, cultural, financial, human, natural, and social. They use Principal Component Analysis (PCA) to create indices for each capital, arguing that

[13] We drop the observations that reported the total number of schools in the SFA to be zero. We keep the states in the contiguous U.S. and drop observations for Hawaii, Alaska, Puerto Rico, the Virgin Islands, American Samoa, Guam, and the Northern Mariana Islands. We drop Nassau BOCES SFA in NY, which manages 56 school districts consisting of 2434 schools, making it a major outlier. Finally, we aggregate the total number of students reported by SFAs at the county level and compare it with the total number of students in a county, as reported by the Common Core of Data. If the number reported in the Census is below 50% of the number of students reported by the Common Core of Data, then we drop the SFAs in that county. The Common Core of Data is the Department of Education's national database of all public-school districts in the United States.

this is appropriate for making comparisons across capital sets and for econometric analyses. PCA is a technique to reduce large multivariate datasets into fewer dimensions, while minimizing loss of information in the process. The indices are scaled from zero to 100, which implies that a community with a cultural capital value of 8.575 for example, has a relatively larger endowment of the asset as compared to a community with a value of 6.463. Data is not available for the District of Columbia, so it is dropped from our analysis.

The Schmit et al. (2021) database includes two principle components for built capital, one reflecting manufacturing activities (food and beverage, as well as other manufacturing) and the second reflecting access to infrastructure (interstate highways and broadband); two components for cultural capital, one reflecting the concentration of art and educational institutions, as well as racial diversity (access to museums and public libraries and racial diversity), and the second reflecting concentration of creative industries (museums, film, architecture, and advertising industries); one component for financial capital, reflecting both public and private finance (local public spending, personal bank deposits, and housing ownership); two components for human capital, one reflecting health and education (health outcome and health factor z-scores from the Robert Wood Johnson health rankings, as well as educational attainment) and the second reflecting food security and access to medical services (food security, share of population with health insurance, and access to primary health care); two components for natural capital, one reflecting natural amenities and conservation (general natural amenities, forestland, and land under conservation easement) and the second reflecting concentration of farmland; and finally, two components for social capital, one reflecting number of private nonprofit and social establishments and the second reflecting public voice and participation (voter turnout and participation in the census). The description of variables included in the PCA is presented in Appendix B. The summary statistics of all capital stocks are given in Table 2.2.

Table 2.2. Summary statistics for county-level stocks of community wealth (n=8,162).

Variable	Description	Mean	S.D.	Min	Max
Built capital – manufacturing	The component of built capital reflecting manufacturing activities	1.011	0.943	0.000	34.033
Built capital - infrastructure	The component of built capital reflecting access to infrastructure	22.384	10.624	0.611	59.446
Cultural capital – arts and diversity	The component of cultural capital reflecting the concentration of art and educational institutions and racial diversity	7.141	3.726	0.000	100.000
Cultural capital – creative industries	The component of cultural capital reflecting the concentration of creative industries	21.317	7.882	0.000	58.688
Financial capital – finance	The component of financial capital reflecting public and private finance	75.889	1.725	0.000	91.930
Human capital – health and education	The component of human capital reflecting health and education	41.410	12.899	0.000	100.000
Human capital – food security and medical services	The component of human capital reflecting food security and access to medical services	40.938	11.933	0.184	95.999
Natural capital – natural amenities and conservation	The component of natural capital reflecting natural amenities and conservation	44.837	12.479	0.000	100.000
Natural capital - farmland	The component of natural capital reflecting concentration of farmland	9.719	1.630	0.000	55.972
Social capital – nonprofit and social establishments	The component of social capital reflecting number of private nonprofit and social establishments	9.780	2.706	1.522	30.375
Social capital – public voice and participation	The component of social capital reflecting public voice and participation	67.208	10.549	11.974	100.000

Source: Schmit, Todd M., Becca BR Jablonski, Alessandro Bonanno, and Thomas G. Johnson. "Measuring stocks of community wealth and their association with food systems efforts in rural and urban places." Food Policy 102 (2021): 102119.

2.4.3. FTS Policy Environment

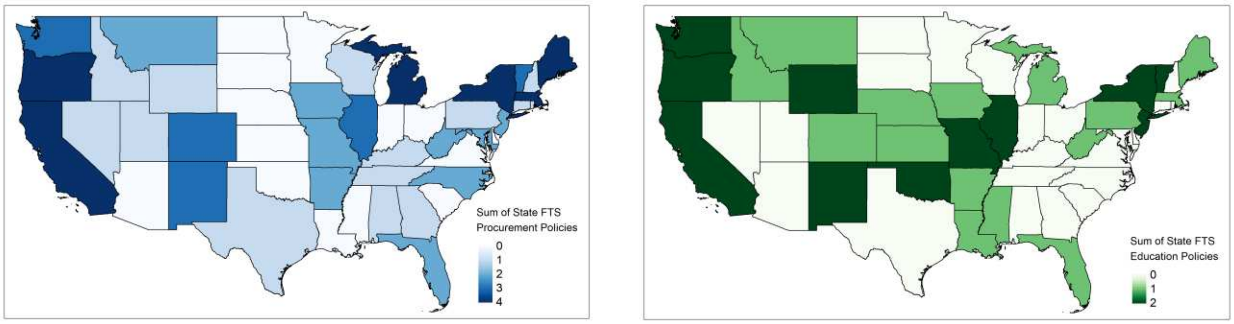
One innovation of this research is its use of a disaggregated dataset of state FTS policies. To do this, we create variables for the FTS policy environment in each state by using the 'State FTS Policy Handbook (2002-2020) developed by the National Farm to School Network and the Center for Agriculture and Food Systems at Vermont Law School. The Handbook summarizes FTS legislation between 2002 and 2020 from the 50 states, the District of Columbia, and U.S. territories, including whether they were enacted, defeated, or are still pending (NFSN and CAFS 2021). It only includes bills and resolutions introduced by state legislatures, not funding or policies approved only through state budget processes or Tribal laws and policies.

We leverage the Handbook to create a unique database of FTS policies grouped into three types of objectives: (i) policies that support local procurement of foods (e.g., reimbursement structures and local preference laws), (ii) policies that support education and school garden activities (e.g., grant or program support for school gardens), and (iii) policies that provide additional logistical support, promotion programs, or infrastructure support (e.g., establishment of state FTS coordinator positions, task forces, and statewide promotional programs). We only include legislation that was enacted, dropping any that are either dead or still pending in 2018, the year when the FTS Census was conducted. Together, these describe the state policy environment that supports FTS activities.

For each of the three categories of the state policies, we aggregate the active legislation to obtain category-specific aggregate measures. The Handbook organizes the legislation under various topics. We obtain the measure ‘procurement policies’ by aggregating legislation under the topics ‘appropriations and other revenue streams’, ‘grant programs’, ‘reimbursement and incentive programs’, and ‘local preference’. We obtain ‘education policies’ by aggregating legislation under the topics ‘food and agricultural education’ and ‘school gardens’. We obtain ‘other policies’ by aggregating legislation under the topics ‘statewide farm to school programs’, ‘farm to school coordinator’, ‘state databases or directories’, ‘pilot programs’, ‘task forces, councils, and working groups’, ‘promotional programs or events’, ‘resolutions’, ‘food hubs’, ‘economic development, food security, and health policies’, and ‘economic, health, and racial equity’.

The summary statistics of the three categories of policies are presented in Table 2.3, and Figure 2.3 a and 2.3 b shows the number of ‘procurement policies’ and ‘education policies’ in each state, respectively. With each category now being a sum of related legislation in each state, we are assuming that a larger sum represents relatively greater or more robust policy support. However, this may not necessarily be true given that we have no measure of the "robustness" of a particular policy. We proceed, recognizing this is a limitation of our work.

(a) State FTS Procurement Policies (b) State FTS Education Policies



Figures 2.3a and 2.3b. Map of the sum of policies supporting local food procurement (a) and education activities (b) Farm to School activities, by state, 2002-2018.

2.4.4. Challenges in Participating in FTS

All SFAs that responded to the 2019 FTS Census, whether they participated in FTS or not, reported challenges they faced in conducting FTS activities. The Census characterized the challenges into three categories: (i) vendors (accounting for availability of local foods and producers), (ii) price and purchasing (describing whether the local foods are cost prohibitive and if the SFAs faced procedural challenges in procurement), and (iii) staff and kitchen (describing the infrastructure available to prepare the foods available). We use these challenges to characterize the food environment for the SFAs, as they describe the local support for FTS.

There are 12 challenges listed under the 'vendors' category, five under 'price and purchasing' category, and four under 'staff and kitchen' category. More than half of the responses in each category are coded as zero, which means that the SFAs do not report facing any challenges in that category. These zeros are valid responses, but they can skew the data and bias the regression estimates, not meeting the assumptions of the standard linear regression. Accordingly, we sum the challenges reported by an SFA under each category and recode the responses using a four-point Likert scale. SFAs are classified as having reported vendor challenges that are "not a challenge" (zero vendor challenges reported), "somewhat challenging" (one to four vendor challenges reported), "moderately challenging" (five to eight vendor challenges reported), and "extremely challenging" (nine to 12 vendor challenges reported). We follow the same approach for price and purchasing challenges (categories 0, 1, 2-3, and 4-5), and staff and kitchen challenges (categories 0, 1, 2, and 3-4). Summary statistics for the three categories of challenges are presented in Table 2.3.

Table 2.3. Summary statistics for state farm to school policies and challenges reported by SFAs in participating in farm to school activities (n=8,162).

Variable	Description	Mean	S.D.	Min	Max
Policies					
Procurement	Sum of state policies that support local procurement of foods	1.789	1.527	0	4
Education	Sum of state policies that support education and school garden activities	0.934	0.833	0	2
Other	Sum of state policies that provide additional logistical support, promotion programs, and infrastructure	3.368	2.091	0	8
Challenges					
Vendor	Vendor-related challenges in procurement of local foods by SFAs reported on a four-point Likert scale	1.531	0.772	1	4
Price and purchase	Price- and purchasing-related challenges in procurement of local foods by SFAs reported on a four-point Likert scale	1.378	0.712	1	4
Staff and kitchen	Kitchen- and food service-staff related challenges in processing and preparing local foods by SFAs reported on a four-point Likert scale	1.367	0.779	1	4

Note: State farm to school policies are obtained from the 'State Farm to School Policy Handbook (2002-2020)' developed by the National Farm to School Network and the Center for Agriculture and Food Systems at Vermont Law School. The challenges to participation are obtained from the U.S. Department of Agriculture's Food and Nutrition Service's 2019 Farm to School Census.

2.4.5. Participation in the Fresh Fruit and Vegetable Program

The Fresh Fruit and Vegetable Program, which is administered at the federal level by the USDA's FNS, is a competitive grants program that supports the provision of fresh fruits and vegetables to children at elementary schools during the school day (but not during lunch). Schools must participate in the National School Lunch Program to be eligible for the program and receive \$50 to \$75 per student for the school year (USDA FNS 2022a). The Fresh Fruit and Vegetable Program shares some common objectives with

FTS, as both programs encourage procurement of fresh local foods and the provision of nutrition education. We use participation in the Fresh Fruit and Vegetable Program as an instrumental variable to identify our econometric model. We discuss its validity as an exclusion restriction in Section 2.5.3. Summary statistics of participation in Fresh Fruit and Vegetable Program are presented in Table 2.4.

2.4.6. Other Control Variables

To control for SFA characteristics that could influence FTS adoption, we include the percentage of students eligible for free and reduced-price meals in the SFA. All students are eligible to receive meals at schools if the school participates in the National School Lunch Program, and students from low-income families are eligible for free or reduced-price meals (FRAC n.d.). Additionally, we include the SFA size, measured by the total number of students, sourcing both variables from the 2019 FTS Census.

To control for any unobservable effects of population density and urbanicity of communities, we also include the 2013 USDA Rural Urban Continuum Codes (RUCCs), which classify the counties into three metropolitan and six nonmetropolitan categories. Summary statistics of the control variables are presented in Table 2.4.

Table 2.4. Summary statistics for participation in the Fresh Fruit and Vegetable Program, school food authority (SFA) characteristics, and urbanicity (n=8,162).

Variable	Description	Mean	S.D.	Min	Max
Fresh Fruit and Vegetable Program	Binary variable = 1 if SFA participates in the program in SY 2018-19; 0 otherwise	0.261	0.439	0	1
SFA size	The total number of students in the SFA	3,740.702	13,068.630	4	517,651
Free and reduced-price meals	Free/reduced-price lunch status for SFA; 1 (31% or fewer students eligible), 2 (31% - 51% students eligible), 3 (51% - 86% students available), and 4 (more than 86% students eligible)	2.500	1.089	1	4
RUCC	Indicator variables for 2013 USDA Rural Urban Continuum Codes (RUCC)	-	-	1	9

2.5. Empirical Model

2.5.1. Heckman Selection Model

While all SFAs that responded to the USDA's FTS Census indicated whether they participated in FTS or not, we are able to measure the intensity of participation only for the subset of SFAs that reported participating in at least one FTS activity. The nonrandom missing data are likely to lead to incorrect estimates by creating a selection bias if we use OLS to estimate the relationship between FTS intensity and the model covariates. The Heckman (1979) two-stage selection model is a useful modeling method in this case, as it accounts for the anticipated selection bias in FTS participation and allows us to estimate unbiased parameter estimates (Greene 2008).

We chose a selection model instead of a censored or a double hurdle model based on the specific characteristics of the data and the research objectives. Even though a Tobit model deals with the presence of zeros in the dependent variable, it is limited by its assumption that the decision to participate is irrelevant and instead it is identical to the intensity of participation. Alternatively, the double hurdle model would have been the preferred choice if the research argument was centered around participation in the activity rather than the intensity, which is not the case in this research.

Accordingly, we use the Heckman two-stage selection model. We model the SFA's decision to participate in FTS as the first stage, where the dependent variable is binary (*yes* they participate, *no* they do not participate). The dependent variable in the second stage is the intensity of participation, and the sample in this specification only includes the subset of SFAs with the outcome *yes* in the first stage. The equations for the Heckman model, FTS_i (selection) and INT_i (outcome) for the i-th SFA, are as follows in (2.1) and (2.2) and form the first specification we estimate.

$$FTS_i = \alpha^S + \mu FFVP_i + \sum_{k=1}^{11} \beta_k^S K_{ik} + \sum_{n=1}^{3} \theta_n^S P_{in} + \sum_{j=1}^{3} \delta_j^S C_{ij} + \sum_{m=1}^{2} \pi_m S_{im} + \sum_{r=1}^{9} \gamma_r^S RUCC_{ir} + u_i \qquad (2.1)$$

$$INT_i = \alpha^T + \sum_{k=1}^{11} \beta_k^T K_{ik} + \sum_{n=1}^{3} \theta_n^T P_{in} + \sum_{j=1}^{3} \delta_j^T C_{ij} + \sum_{m=1}^{2} \pi_m S_{im} + \sum_{r=1}^{9} \gamma_r^T RUCC_{ir} + \rho\sigma IMR_i + v_i \qquad (2.2)$$

FTS_i is a binary variable for participation in SY 2018-19 for the i-th SFA. Both (2.1) and (2.2) include the county-level community capital indices (K_{ik}, k = 1 to 11), state-level FTS policy variables (P_{in}, n = 1 to 3), and challenges in FTS participation (C_{ij}, j = 1 to 3) as covariates. We include SFA characteristics (S_{im}, m = 1 to 2) and the RUCCs for each county ($RUCC_{ir}$, r = 1 to 9) as additional control variables. $FFVP_i$ is a binary variable for participation in the Fresh Fruit and Vegetable Program in SY 2018-19, and its inclusion in the selection equation serves as the exclusion restriction in the model. We map each SFA to a county using a ZIP code crosswalk since the 2019 FTS Census data provides ZIP codes for each SFA. If an SFA lies in more than one county (by virtue of their ZIP code) then it is matched to that county in which it has a higher population.

The error terms u and v are jointly distributed as bivariate normal. The variance of u is constrained to equal 1, whereas the variance of v is allowed to vary for estimation purposes (Greene 2008). We assume their individual distributions as follows:

$u \sim N(0,1)$, $v \sim N(0, \sigma^2)$, and $\text{corr}(u,v) = \rho$

The model is estimated in two stages, with the following steps for estimation: the probit regression is used to model binary participation in the first stage and to construct the inverse Mills ratio (IMR). The IMR is the ratio of the standard normal density function to the complementary standard normal distribution function of the first stage model. Heckman (1979) proposed the IMR to control for selection bias by adding it as an independent variable in the second stage of the OLS model.

It is reasonable to be concerned about the presence of collinearity between local assets like social capital and state FTS policies. Multicollinearity in the model would decrease the precision of the coefficient estimates, making it difficult to determine which variables are actually statistically significant. Accordingly, we test for multicollinearity among the independent variables in the model by calculating the variance inflation factor (VIF) that identifies the correlation and the strength of that correlation between variables. The VIF of the independent variables are under 4 implying that multicollinearity is not an issue in our empirical model.

2.5.2. Modeling Spatial Dependence in FTS

The Heckman model assumes homogeneity and the absence of any spatial correlation between the observations. It is possible that nearby SFAs can influence each other in their participation in FTS activities (i.e., the presence of a spatial relationship). If such a relationship exists, then the observations in the data are not independent of each other. Ignoring the spatial dependence in the observations results in omitted variable bias and coefficient estimates that underestimate geographic clustering.

To identify whether there is any spatial variation in our data, we conduct a global Moran's I test. To calculate Moran's I, we generate a matrix of inverse distance weights (W) using the coordinates of each SFA (identified by their ZIP codes). The non-diagonal elements of W equal $1/distance_{ij}$, where $distance_{ij}$ is the Euclidean distance between SFA i and SFA j. We refrain from using geographical boundaries to define neighbors since there is no single definition for 'local' for FTS procurement (rather SFAs or states make these decisions on a program-by-program basis).

For FTS intensity, we obtain a Moran's I value of 0.0345, with a p-value below the one percent level. A statistically significant value of Moran's I confirms the presence of spatial autocorrelation in the data and points towards the tendency of similar intensity values to cluster together geographically, but it does not tell us the type of spatial dependence that is present. We test for spatial autocorrelation of the residuals from equation (2.2) in our first specification. A statistically significant Moran's I value of 0.012, though of small magnitude, suggests global spatial autocorrelation in the model residuals. This is often interpreted as an issue of relevant omitted variables or underlying spatial processes that are missing from the model. This spatial autocorrelation could therefore arise out of various situations: measurement error, model misspecification, and/ or spatial processes like spillovers. Along with the limitations of the

Heckman model in dealing with spatial issues, the presence of spatial dependence in the model motivates the use of spatial econometric modeling.

To address the presence of spatial dependence in FTS participation, we add a spatially lagged FTS intensity variable to the Heckman model to incorporate an omitted variable that may explain some of the spatial variation in the data. In our second specification, we modify our two-stage econometric model to control for and estimate the extent to which FTS intensity by neighbor SFAs affects outcomes of an SFA. In equations (3.1) and (3.2), we add the spatially lagged variable of FTS intensity, weighted using the matrix of inverse distance weights (W), in both stages of the model.

The parameter of interest here is τ, the coefficient associated with the spatial lag. However, the interpretation of the coefficients now includes a direct and an indirect effect, considering that adding the spatial lag makes this a global spatial model. All neighbors in the network now have a feedback effect from changes in any covariate affecting the outcome of interest. The IMR that gets added (3.2) now accounts for the spatial dependence in FTS intensity, in addition to the selection bias.

$$FTS_i = \alpha^S + \tau^S W_i \, INT + \mu FFVP_i + \sum_{k=1}^{11} \beta_k^S K_{ik} + \sum_{n=1}^{3} \theta_n^S P_{in} + \sum_{j=1}^{3} \delta_j^S C_{ij} + \sum_{m=1}^{2} \pi_m S_{im} + \sum_{r=1}^{9} \gamma_r^S RUCC_{ir} + u_i \quad (3.1)$$

$$INT_i = \alpha^T + \tau^T W_i \, INT + \sum_{k=1}^{11} \beta_k^T K_{ik} + \sum_{n=1}^{3} \theta_n^T P_{in} + \sum_{j=1}^{3} \delta_j^T C_{ij} + \sum_{m=1}^{2} \pi_m S_{im} + \sum_{r=1}^{9} \gamma_r^T RUCC_{ir} + \rho\sigma IMR_i + v_i \quad (3.2)$$

2.5.3. Identification Strategy and Concerns of Endogeneity

For identifying our econometric model, we assume that participation in the USDA's Fresh Fruit and Vegetable Program ($FFVP_i$) affects only the SFA's decision to participate in FTS (selection), not the intensity of participation (outcome). The variable $FFVP_i$ is an instrumental variable that we expect to have a positive association with the SFA's probability of participating in FTS, considering the shared objectives of the two programs. The Fresh Fruit and Vegetable Program is a federally supported, grant-based program that is separate from FTS. Participation in the program affects INT_i in the model only through FTS_i and has no direct effect on INT_i, conditional on the other covariates.

We are able to make this distinction by exploiting a major difference in program guidelines. While both FTS and the Fresh Fruit and Vegetable Program require that schools participate in the National School Lunch Program, schools participating in the Fresh Fruit and Vegetable Program cannot use funds from the program to serve fruits and vegetables as part of breakfast, lunch, or any other federal child nutrition program; Fresh Fruit and Vegetable Program funds can only be used for a snack outside of regular meal times. Variables from the USDA's 2019 FTS Census that are included in calculating INT_i are local foods served during meals and expenditures separate from the Fresh Fruit and Vegetable Program.

We believe that participating in the Fresh Fruit and Vegetable Program helps SFAs in familiarizing themselves with federal programs supporting the purchase of fresh produce, thus positively affecting their probability of participating in programs like FTS. However, owing to the differences in the structures of the two programs, participation in the Fresh Fruit and Vegetable Program would not affect their intensity of participation in the other programs. $FFVP_i$ therefore serves as an exclusion restriction, as it is only included in the first stage equation, and our identification strategy is based on its validity. While the exclusion restriction is an assumption within the Heckman model to identify the model parameters it is not a necessary condition (Greene 2008). Owing to similarities in program objectives, it is likely that $FFVP_i$ is not completely independent of INT_i, and this is a potential weakness of our instrument. However, through careful consideration, $FFVP_i$ stands out as a suitable choice despite its inherent limitations.

Among considerations of endogeneity in our model, one concern is reverse causality, wherein the capital stocks are affected by the adoption and intensity of FTS activities. The nature of the data addresses this issue. More than half of the SFAs (57%) in the sample reported participating in FTS for less than three years (USDA FNS 2021a). The FTS Census data were collected for the 2018-19 school year, whereas Schmit et al. (2021) use data from 2010 to 2018 to create the capital stock indices. We believe that using capitals data from the years prior to the Census addresses some concerns of reverse causality.

Endogeneity in our model could also result from the capital stocks, state FTS policies, or participation in FTS responding to unmeasured factors, leading to omitted variable bias. While the use of participation in the Fresh Fruit and Vegetable Program as an instrument in the Heckman model accounts for the selection bias in the data, it does not completely address the issue of endogeneity, especially if we are dealing with omitted variables. However, using only the active (instead of those pending approval) state FTS legislation in the years preceding the 2019 FTS Census and addressing spatial dependency in the data resolves some endogeneity concerns. However, our independent variables may still be correlated with the error term in our econometric specifications. We proceed with this caveat and are careful to talk about associations and not causality in our results.

2.6. Results and Discussion

We used the Heckman selection model to empirically analyze the relationship between local assets, state FTS policies and FTS intensity, while controlling for the school's food environment. We estimate the Heckman selection models in R using the 'sampleSelection' package[14] and report the results in Table 2.5 and Table 2.6. We discuss the average marginal effects (AME) for the binary FTS participation and coefficients from the outcome equation that represent partial effects for FTS intensity. The AME represents the average probability predictions in the model. The results suggest that both probability of participation and intensity of FTS are influenced by various factors, which are discussed subsequently.

A statistically significant IMR indicates the presence of sample selection bias and justifies the use of the Heckman model to correct for this bias. Additionally, the VIF of the independent variables in the model are well under 4, which implies that the level of multicollinearity is minor and does not require corrective measures. Multicollinearity is not a problem in estimating the model if VIF of the variables in the model are below 10 (Gujarati 2004).

[14] See https://cran.r-project.org/web/packages/sampleSelection/index.html.

2.6.1. Stocks of Community Wealth

Results are presented in Table 2.5 and Appendix C.[15] Although the capital stocks are comparable quantitatively as an index on the same scale, it does not imply that the indices of capital have similar magnitude. The marginal cost of investment in two capital stocks may differ substantially, for example investing in a local meat processing facility as compared to establishing a local nonprofit. Thus, while the standardization of the capital stocks allows us to compare within capital indices, we cannot claim that similar numeric values imply similar magnitude across indices.

Both cultural capital components (concentration of creative industries, concentration of art and educational institutions, and racial diversity) and social capital (public voice and participation) have positive and statistically significant associations with participation in FTS, with 0.3, 0.5, and 0.2 percentage points AME, respectively. Of these, one component of cultural capital (concentration of creative industries) has a positive statistically significant association with intensity of FTS. The other component of social capital (private nonprofit and social establishments) has a negative association with participation (AME of 0.6 percentage point), but a positive association with intensity of FTS, statistically significant at the 5% and 1% levels, respectively.

Our results are consistent with other studies that find evidence of the importance of the creative class in supporting efforts in community economic development (Duxbury 2021; Wojan and Nichols 2018). Promotional activities in FTS, in school cafeterias and classrooms (e.g., developing creative signage), and within the community (e.g., media coverage and themed events) have been found to promote both local foods and agricultural education. Positive associations with the component of cultural capital that reflects racial diversity highlights the importance of culturally responsive school meals and agricultural education

[15] The results presented in Table 2.5 are robust to the specification that includes the SFA Nassau BOCES that we had dropped for being an outlier. Regression coefficients from the alternate specification is presented in Appendix C.

in successful adoption of programs like FTS, which is in line with Stapleton and Cole's (2018) research that school food plays an important role in sustaining and validating students' cultural foods.

Table 2.5. Regression results of association between Farm to School (FTS) intensity, stocks of community wealth and state FTS policies, given the school food environment.

Variables	FTS Participation		FTS Intensity
	Estimated Coefficient	Average Marginal Effects	Partial Effects
Stocks of Community Wealth			
Built capital – manufacturing	0.009 (0.016)	0.003 (0.005)	0.051 (0.064)
Built capital - infrastructure	-0.003 (0.002)	-0.001 (0.001)	-0.002 (0.008)
Cultural capital – arts and diversity	0.017^{**} (0.007)	0.005^{**} (0.002)	-0.016 (0.024)
Cultural capital – creative industries	0.009^{***} (0.003)	0.003^{***} (0.001)	0.032^{**} (0.012)
Financial capital – finance	-0.006 (0.013)	-0.002 (0.004)	-0.032 (0.041)
Human capital – health and education	-0.002 (0.002)	-0.001 (0.001)	0.010 (0.006)
Human capital – food security and medical services	0.006^{***} (0.002)	0.002^{***} (0.001)	-0.003 (0.008)
Natural capital – natural amenities and conservation	0.000 (0.002)	0.000 (0.001)	0.006 (0.006)
Natural capital - farmland	0.030^{***} (0.011)	0.010^{***} (0.003)	-0.022 (0.036)
Social capital – nonprofit and social establishments	-0.020^{**} (0.008)	-0.006^{**} (0.002)	0.086^{***} (0.032)
Social capital – public voice and participation	0.005^{***} (0.002)	0.002^{***} (0.001)	-0.011 (0.008)
State FTS Policies			
Procurement policies	0.092^{***} (0.017)	0.030^{***} (0.005)	0.124^{*} (0.064)
Education policies	-0.088^{***}(0.027)	-0.029^{***}(0.008)	-0.292^{***}(0.102)
Other policies	0.016 (0.012)	0.005 (0.003)	0.041 (0.041)
Challenges in FTS			
Vendor challenges	-0.067^{**} (0.027)	-0.022^{**} (0.008)	0.149 (0.102)
Price and purchase challenges	0.130^{***} (0.029)	0.042^{***} (0.009)	0.020 (0.113)
Kitchen challenges	-0.174^{***}(0.023)	-0.057^{***} 0.007)	0.293^{***} (0.100)
Fresh Fruit and Vegetable Program [a]	0.418^{***} (0.037)	0.131^{***} (0.011)	
R^2			0.087
Inverse Mills Ratio			-4.051^{***} (0.590)

Note: N = 8,162 (2,631 censored and 5,531 observed). ***, **, and * represent coefficients statistically different from 0 at the 1%, 5%, and 10% significance level, respectively. Standard errors in parentheses. Standard errors in the outcome equation have been corrected for selection bias. The inverse Mills ratio is defined as a ratio of the standard normal density function and the standard normal distribution function of the first stage model. Constant, RUCCs, and SFA variables are excluded for brevity. The table of complete result is presented in Appendix C.
[a] Participation in the Fresh Fruit and Vegetable Program is used as an exclusion restriction.

While one component of social capital (private nonprofit and social establishments) may not have a positive relationship with the probability of participation in FTS, it is associated with higher FTS intensity. Higher program intensity is reflected through their support for various activities by means of various forms of collaboration, which could take the form of management of school gardens, logistical support of shared kitchens, training for school teachers and food service staff, and promotional content for schools. Our results indicate that these partnerships with nonprofits and social establishments drive FTS intensity conditional on program participation.

Our findings are consistent with studies that found that farmers sold to schools with the objective of contributing to social benefits in addition to diversifying their markets (Izumi, Wright, and Hamm 2010; Lehnerd et al. 2018) and that it is not uncommon for schools in rural and agriculture-based communities to receive donations and philanthropic funding to support food purchasing, gardens, and other activities (Williams 2016). Conner et al. (2011) map a network of FTS activities and institutions, emphasizing the relevance of networks between individuals and institutions for higher program participation. It is thus reasonable to expect an association between communities with higher levels of cultural and social capital and greater adoption rates of FTS, a program that focuses on supporting local producers and imparting agricultural education.

Components of human capital (food security and access to medical services) and natural capital (concentration of farmland) have positive and statistically significant associations with participation in FTS, with 0.2 and 1 percentage points AME, respectively. Additionally, the component of human capital (health and education) is positively associated with FTS intensity. Our results suggest that SFAs that are in a relatively food secure environment are more likely to participate in FTS. A higher concentration of farmland in a region suggests higher probability of both local procurement and education activities like farm visits.

One potential weakness of our approach is the implicit assumption that more capital is always better. Schmit et al. (2021) identify this as a caveat in their exercise of developing indices for community capitals. For example, higher levels of social capital are not a priori good. Consider the inclusion of a racial diversity index in one of the cultural capital indices. Putnam (2000) uses diversity to explain how it could lead to exclusion in the community rather than an increase in overall wealth. He discusses how greater diversity may result in withdrawal from collective life and distrust among neighbors, both of which could lead to increased bonding capital but lower bridging capital. Taking this empirical issue into consideration, we have discussed how higher or lower stocks of capital may be associated with participation in FTS, our outcome of interest.

2.6.2. FTS Policy Environment

Given the stocks of capital, the policy environment in the state plays a supporting role in program adoption and intensity. We find that an additional state policy supporting FTS procurement activities is positively associated with both participation (AME of 3 percentage points) and intensity of FTS, statistically significant at the 1% and 10% levels, respectively. Our results show that access to financial resources supporting FTS activities and targeted support to procure local foods (e.g., grants and reimbursements) are positively associated with the success of the program.

However, the same cannot be said for state legislation focused on education activities. We find that an additional state policy supporting FTS education activities is negatively associated with participation (AME of 2.9 percentage points) and intensity of FTS, both statistically significant at the 1% level. One possible explanation for the negative association could be the lack of additional time available for school teachers and students during school hours. Additional curriculum and management of school gardens may not make the cut in schools despite policy support due to requirements for out-of-school time engagement (e.g., watering the garden on weekends or over the summer), and the relatively greater focus on academic curriculum that contributes to school testing requirements. Our study is the first to disaggregate the legislation into separate categories, thus presenting a more nuanced finding.

2.6.3. School Food Environment

Both Bonanno and Mendis (2021) and Botkins and Roe (2018) found that the local food environment affects participation of SFAs in FTS. In our study, challenges in participating in FTS reflect the local and school food environment. While higher vendor-related and kitchen-related challenges are both associated with lower probability of participation (AME of 2.2 and 5.7 percentage points, respectively), only kitchen-related challenges have a positive and statistically significant association with intensity of FTS. Greater reported challenges of price and purchasing are positively associated with probability of participation, with an AME of 4.2 percentage points.

Our results show that staff- and kitchen-related challenges, such as lack of kitchen equipment and lack of staff trained to prepare fresh local foods, may be critical in enabling schools to participate in FTS, since it is associated with both probability of participation and FTS intensity. Even after schools begin participating in FTS, they continue to face these challenges. This could be due to seasonality and types of produce, which may not always match the skills of the staff. The staff may not have enough time or adequate equipment to process local foods for preparation or serving. They may have difficulty with tasks like slicing locally procured apples, chopping local potatoes, or preparing salad using fresh lettuce and other unprocessed produce. Policy and funding support has not been directed towards meeting these challenges in the same way that procurement itself has been supported, which continues to adversely affect adoption of FTS.

2.6.4. Spatial Dependence

We find a positive association between intensity of FTS in neighboring SFAs and the probability of participation in FTS of an SFA, though the magnitude of the spatial effect is extremely small (Table 2.6). There could be various factors that determine the spatial variation in participation in FTS. For example, we see that participation in FTS grew from 42% in 2013 to 72% in 2019 (USDA FNS 2021b). On one hand, greater participation could be associated with learning effects between SFAs, resulting in positive spatial effects. On the other hand, it could also lead to competition between SFAs to access local foods if the local food market in a region has not grown as fast to meet the higher demand. We could also be observing the spatial clustering in FTS intensity due to other characteristics that we do not control for in our analysis.

Table 2.6. Regression results of association between Farm to School (FTS) intensity and stocks of community wealth and state FTS policies, given the school food environment, Heckman selection model with spatial lag.

Variables	FTS Participation		FTS Intensity
	Estimated Coefficient	Average Marginal Effects	Partial Effects
Spatial Lag			
FTS intensity	0.00005*** (0.00001)	0.00002*** (0.000005)	0.00003 (0.00006)
Stocks of Community Wealth			
Built capital – manufacturing	0.008 (0.016)	0.002 (0.005)	0.050 (0.064)
Built capital – infrastructure	-0.004* (0.002)	-0.001* (0.001)	-0.002 (0.008)
Cultural capital – arts and diversity	0.017** (0.007)	0.006** (0.002)	-0.015 (0.024)
Cultural capital – creative industries	0.009*** (0.003)	0.003*** (0.001)	0.031*** (0.012)
Financial capital – finance	-0.009 (0.014)	-0.003 (0.005)	-0.034 (0.041)
Human capital – health and education	-0.001 (0.002)	0.000 (0.001)	0.010* (0.006)
Human capital – food security and medical services	0.004* (0.002)	0.001 (0.001)	-0.005 (0.008)
Natural capital – natural amenities and conservation	0.002 (0.002)	0.001 (0.001)	0.008 (0.006)
Natural capital – farmland	0.021* (0.011)	0.007* (0.003)	-0.024 (0.036)
Social capital – nonprofit and social establishments	-0.015* (0.009)	-0.005* (0.003)	0.089*** (0.032)
Social capital – public voice and participation	0.006*** (0.002)	0.002*** (0.001)	-0.011 (0.008)
State FTS Policies			
Procurement policies	0.091*** (0.017)	0.030*** (0.005)	0.127** (0.063)
Education policies	-0.084*** (0.027)	-0.027*** (0.009)	-0.289*** (0.101)
Other policies	0.012 (0.012)	0.004 (0.004)	0.037 (0.042)
Challenges in FTS			
Vendor challenges	-0.067** (0.027)	-0.022** (0.009)	0.146 (0.101)
Price and purchase challenges	0.128*** (0.029)	0.042*** (0.010)	0.021 (0.112)
Kitchen challenges	-0.173*** (0.023)	-0.056*** (0.007)	0.292*** (0.100)
FFVP [a]	0.426*** (0.037)	0.133*** (0.011)	
R^2			0.088
Inverse Mills ratio			-4.030*** (0.581)

Note: N = 8,162 (2,631 censored and 5,531 observed). ***, **, and * represent coefficients statistically different from 0 at the 1%, 5%, and 10% significance level, respectively. Standard errors in parentheses. Standard errors in the outcome equation have been corrected for selection bias. Constant, RUCCs, and SFA variables are excluded for brevity. The inverse Mills ratio is defined as a ratio of the standard normal density function and the standard normal distribution function of the first stage model.
[a] Participation in the Fresh Fruit and Vegetable Program as exclusion restriction.

Botkins and Roe (2018) estimate a positive and significant spatial spillover in FTS participation using USDA's 2013 FTS Census. They define spatial spillover as the impact that a neighbor school district's participation has on another school district's probability of participation in FTS. Their results suggest that school districts in areas that have a relatively high participation rate in FTS are more likely to participate in FTS themselves.

Our findings could also be sensitive to the differences in program implementation between states. Consider the example of the National School Lunch Program in Oregon, in which all participating SFAs are eligible for meal reimbursement when participating in FTS and must choose to opt out of the program if they do not wish to participate. Conversely, reimbursements are made available to different regions in the state of Michigan in different years, and SFAs must opt into the program. Heterogenous spatial factors like these are likely to affect the spatial dependence in FTS intensity that we capture in our estimates.

2.7. Conclusions and Implications

Our research takes an asset-based approach to understanding local assets and policy factors related to an SFA's participation in FTS and its level of intensity. We create disaggregated measures of state policies supporting FTS and leverage two novel datasets, a comprehensive dataset of stocks of wealth and USDA FNS's 2019 FTS Census, to examine the relationship between stocks of community wealth, state FTS policies, and intensity of FTS participation. The analysis has four overarching findings that lend important perspectives to food-systems-led community development.

First, we find statistically significant relationships between participation in FTS and multiple stocks of community wealth. As in previous research, our results suggest that the success of food system policies like FTS may be strongly associated with the stocks of community assets, and particularly intangible assets, thereby emphasizing their consideration for planners of community development. Cultural and social assets are challenging to understand and quantify, and they are not easy to create or change (Taras, Rowney, and Steel 2009; Throsby 1999), making it difficult to think about the impacts for policy. The associations with components of cultural and social capital were in line with our initial hypotheses, with the exception of the component of social capital (nonprofit and social establishments) being negatively associated with probability of FTS participation.

Second, we find evidence that different types of FTS policies are associated with different performance outcomes. While greater support through state legislation focused on procurement of local foods positively affects an SFA's probability of participation and intensity of FTS, the association is reversed in the case of legislation supporting education activities in FTS. This may have important policy implications for future legislation supporting different components of FTS. It may be that human and financial resource constraints make it difficult to accommodate additional school garden activities and agricultural education in the school curriculum, despite the existence of state level policies to support these efforts. While meal-reimbursement programs and funding to buy local foods are relatively more easily adopted, components of agricultural education may require additional support for schools. The empirical result for the association with 'education policies' diverged from our initial hypothesis, revealing issues that warrant further research.

Third, we find that kitchen- and staff-related challenges had the largest negative association with probability of participation in FTS, among the different categories of challenges. With fresh and local foods, school food service staff are often required to perform additional food-processing tasks before serving it, and a lack of necessary equipment or training is likely to adversely affect participation. Policy and funding support has not been directed towards meeting these challenges in the same way that subsidizing the costs of local procurement has been supported. These challenges could be addressed by future state legislation that support FTS by focusing on meeting local needs for fresh-foods processing and kitchen equipment; this may be a particularly novel consideration given that most current funding programs do not support capital investments.

Finally, while we find a positive and statistically significant spatial effect in intensity of FTS associated with the probability of participation in FTS, the magnitude of the effect is small. The result may be driven by counteracting factors, like positive learning and networks, as well as increasing competition for local produce as more SFAs participate in FTS. Our results may be sensitive to our estimation strategy, choice of weights matrix, and other unobservable spatial factors.

While our study provides comprehensive analyses of factors associated with participation in FTS, it is not without its limitations. We use data from the 2019 FTS Census to develop the measure of FTS intensity, but because it is survey data, with self-reported activities and expenditures, it is likely to have errors. Despite education activities being a major component of FTS, the Census survey does not ask SFAs to report any challenges faced in adopting them. Including state-level policies may add issues of reverse causality in our model and lead to biased results. Despite these limitations, our study provides novel insights into the importance of various community assets in program adoption and the role played by the supporting policy environment in community food systems development.

Chapter 3

Measuring Changes in Pork Demand, Welfare Effects, and the Role of Information Sources in the Event of an African Swine Fever Outbreak in the United States

3.1. Introduction

African swine fever (ASF) is a highly contagious viral disease in pigs with close to 100 percent fatality (USDA APHIS, n.d.). It has been spreading across continents, with a growing number of outbreaks being reported in China, Southeast Asia, and countries in the European Union, raising the concern of it becoming a global pandemic in the domestic and feral swine population (WOAH, n.d.). High mortality rates, transmission, and lack of vaccines make ASF a serious threat to global well-being (Khanna, 2022), considering that pork is the largest consumed meat in the world after poultry (Shahbandeh, 2022a). These outbreaks, along with the report of ASF in domestic swine farms in the Dominican Republic in July 2021 (Gonzales et al., 2021) and Haiti in September 2021 (USDA APHIS, 2021) have heightened the risk that the disease could spread to otherwise disease-free countries in the world, including the United States (U.S.).

The U.S. is the largest pork exporting country by volume and value globally, exporting close to a third of pork and pork products produced in the country (Shahbandeh, 2022d). As ASF is listed as 'notifiable' by the World Organisation for Animal Health (OIE), it is expected that exports of all pork products from the country will decline drastically and almost immediately in the event of an ASF outbreak, severely affecting producers (Berthe, 2020; Carriquiry et. al., 2020; Costard et al., 2009; Halasa et al., 2016). Excess supply in the domestic market in the short run would push down domestic prices in order to clear the market for pork. Such an outcome would be in sharp contrast to the larger outbreaks in China and other Southeast Asian countries where the outbreak led to a shortage in the domestic pork supply, sharp increases in the price of pork, and increases in the price and demand for substitute commodities (Mason-D'Croz et al., 2020; You et al., 2021).

Despite being fatal for the swine population, ASF is non-zoonotic, poses no known threat to human health, and is not a food safety concern (USDA APHIS, n.d.). In addition to the loss of the export market and death of infected hogs, losses in the U.S. pork industry would be amplified if there is a simultaneous decline in domestic demand for pork. There is limited research on consumer awareness of ASF in the U.S. as well as the extent to which an outbreak might affect demand. Any downward (or inward) shift in demand resulting from consumers abstaining from consuming pork will impact welfare outcomes for the pork industry. In a partial equilibrium setup, pork consumers abstaining from consuming pork and a simultaneous reduction in price and quantity demanded for pork products is likely to result in welfare losses for both the consumers and producers.

In this study, we examine U.S. pork consumers' perception of ASF vis-à-vis concerns of food safety, purchase decisions of pork products in the case of an outbreak of ASF, and the role played by different sources of information in informing purchase decisions. We then consider the welfare implications associated with a downward shift in demand resulting from the outbreak. More specifically, our study addresses three related research questions. First, to what extent does demand for pork shift downward following an ASF outbreak? Second, in the event of an ASF outbreak, is demand for pork affected differently by different news sources that inform consumers about ASF? Third, what are the welfare implications for pork consumers and producers following an outbreak of ASF?

We conduct an online survey experiment to examine perceptions of U.S. pork consumers towards food safety, frequency of consumption of pork products, and prior knowledge of ASF. We use the survey-based one-and-one-half-bound dichotomous choice contingent valuation approach, a stated preference methodology, to estimate changes in the consumers' mean willingness to pay in case of an outbreak of

ASF in the U.S., separately for unprocessed and processed pork categories. By randomly exposing the respondents to information about ASF from different news sources, we examine its impact on purchase decisions following an announcement of the outbreak. Finally, we discuss the welfare implications resulting from changes in consumer demand for the different pork products.

We find that only about a fourth of the respondents are aware of ASF and believe that consuming pork following an outbreak is safe for human health. About 23% of all respondents were unwilling to consume pork in the event of an ASF outbreak, irrespective of the price at which it is offered. We also find that consumers who receive information about ASF from a government institution, as opposed to the news media or producers, are less likely to stop consumption of pork in case of an ASF outbreak.

Results from the contingent valuation model show that consumers who are uninformed about ASF, perceive it to be a risk to human health, and are infrequent pork consumers, have a relatively larger reduction in willingness to pay for pork following an ASF outbreak. When we account for the reported frequency of consumption of pork and consumers who are unwilling to purchase pork at any price, the resulting downward shift in demand is approximately 32% (30%) for unprocessed pork (processed pork). This results in a welfare loss of $24.11 billion for pork consumers and $31.35 billion for the producers in the pork market.

The findings from this study build on the work by Lee et al. (2023) and provide further insights into changes in preferences of U.S. pork consumers following an outbreak of ASF, a disease that to date has never been found in the U.S. Additionally, understanding if demand outcomes differ after being exposed to information about ASF from different news sources will be critical in approaching awareness strategies for an animal disease that is not a threat to food safety. Consumer awareness about ASF in the U.S. is limited, and proper communication prior to and during an outbreak could be critical in minimizing the economic losses in the pork sector. The findings will also provide further insights into overall impacts on the pork producers as well as the associated sectors by informing about partial equilibrium outcomes in the pork market.

3.2. Background and Review of Literature

China, the world's largest producer, importer, and consumer of pork, suffered a devastating outbreak of ASF in 2018. Unofficial estimates suggest that about 150-225 million pigs either died or were culled due to the outbreak, representing about 25% of the global pig population (Khanna, 2022; Mason-D'Croz et al., 2020; You et al., 2021). Using an input-output model to assess the economic impact of ASF in China, You et al. (2021) estimated direct financial losses to the swine industry, and total economic losses in the economy to range from $9.1 billion to $20.6 billion, and $89.5 billion to $196.2 billion respectively.

The U.S. on the other hand is the largest pork exporting country by volume as well as value globally (Shahbandeh, 2022c). In 2019, approximately 27.6 billion pounds of pork were produced in the US (Shahbandeh, 2022d), whereas domestic consumption was estimated to be about 17.2 billion pounds (Shahbandeh, 2022b). Export of pork from the U.S. to China almost doubled in 2020, from 2019, due to the decrease in domestic production from the ASF outbreak, making it the largest market for U.S. produced pork products (USDA FAS, 2020). ASF is foreign to the U.S. and has never been reported in the country to date. Niederwerder et al. (2020) describe ASF as being the most significant global threat to the pork industry today.

Carriquiry et al. (2020) assess the impact of an outbreak of ASF on U.S. agriculture, anticipating definite downsizing in production and losses in employment in the industry, and almost complete loss of the export market for pork. They model two scenarios; one in which the U.S. exports of pork resume after two years following the outbreak, and a second after a period of 10 years, where the disease spreads to feral swine and takes longer to control. Their study focuses on industry losses and estimates that the domestic price of pork declines by 40-50% to clear the market which now has excess supply of pork. For the analysis, they assume that consumer preferences remain unchanged and changes in equilibrium consumption are represented by movements along the demand curve. They estimate a loss of about $50 billion for their scenario of 10 years for the entire pork industry. An outbreak in the U.S. can therefore be devastating for the pork industry, and further impact the global pork market.

The Centers for Disease Control and Prevention estimates that pork consumption results in 525,000 illnesses, 2,900 hospitalizations, and 82 deaths every year. Food safety concerns, food recalls, and outbreak of diseases directly affect consumer demand, and there is a large body of literature that has extensively studied this relationship (e.g., Marsh et al., 2004; Piggot and Marsh, 2004; Yim and Katare, 2023). While ASF is highly contagious and fatal for the swine population, there is no evidence that it is a food safety concern (USDA APHIS, n.d.).

The incidence of food-borne illnesses continues to increase in the U.S. (Tack et al., 2020). Studies have shown that the psychological perception of risk rather than the factual risk itself is likely to affect consumer behavior (Ferrer and Klein, 2015; Liao, Luo, and Zhu, 2020; Taylor, 1974). Animal diseases have been shown to be an important factor affecting meat demand, both in the US and globally (Wang and de Beville, 2017). Research has also shown that people tend to respond in a uniform manner to different types of uncertainty concerning food safety, leading them to often overestimate risk when the actual risk may be low (Miles and Frewer, 2003; Miles et al., 2004). Lee et al. (2023) finds that 46% of pork consumers would not purchase pork if there was an ASF outbreak in the U.S. despite it not being a food safety concern. Utilizing survey data, Schroeder et al. (2007) find that risk perceptions affect consumption decisions more than risk attitudes, making dissemination of health information by trusted institutions critical.

Media tools can play a major role in educating consumers about food safety and lead to behavioral changes that affect consumption decisions (Bolek, 2020). Attavanich et al. (2011) examined the market impact of media coverage of swine flu on the pork industry and estimated a sharp immediate decline in pork consumption in the US even after the WHO announced that pork was safe to eat. On the other hand, Mazzocchi et al. (2008) studied behavioral determinants of chicken consumption under the risk of salmonella in five European countries and found that their results differ significantly across the five countries. They hypothesized that cultural differences, social networks, media communications, and trust in institutions play important roles in determining consumption.

Studies have estimated adverse welfare impacts from outbreaks of livestock-related diseases (e.g., ASF outbreak in China by You et al. (2021) and Food and Mouth Disease (FMD) outbreak in the U.S. by Paarlberg et al. (2003)). Large production losses from the ASF outbreak in China affected consumer welfare largely through higher prices (You et al., 2021), but the dynamics following an outbreak in the U.S. are likely going to be very different. While the loss of export market and infected animals will lower producer welfare, the resulting lower prices would translate into higher consumer welfare in the short run, other factors held constant. A downward shift in the demand would take the domestic market to a new equilibrium, with adverse impacts on both consumer and producer welfare.

Lee et al. (2023) use survey data from 2020 and contingent valuation methods to analyze whether consumers' perceptions of ASF and how the news about ASF is framed affects their purchase decisions for pork if an ASF outbreak occurs in the U.S. The willingness to pay estimates they obtain suggest that prior knowledge of the disease influences purchase decisions, and the nature of information framing (i.e., the connotation associated with the headline) has a greater effect on those who are less informed.

Our research takes a similar approach to Lee et al. (2023) to estimate changes in the willingness to pay for pork during an ASF outbreak in the U.S. Building on this research and prior studies on food safety issues and consumer behavior, we contribute to the literature by using the willingness to pay estimates to determine changes in pork demand in the domestic market and the resulting welfare outcomes. We obtain these results for disaggregated pork categories: unprocessed and processed pork, thereby exploiting the variation between the two markets. Additionally, we examine whether informing consumers about ASF using different news sources is associated with their purchase decisions in the event of an ASF outbreak.

3.3. Analytical Framework

We use an economic model of domestic and global demand and supply for pork produced in the U.S. to present different scenarios of an ASF outbreak in the U.S. We draw on the model presented by Paarlberg et al. (2003) that measures welfare impacts from an outbreak of FMD in the U.S. We begin with modeling the demand and supply of pork as a single commodity. Figure 3.1(a) illustrates the domestic demand (D_0) and supply (S_0) of pork prior to an ASF outbreak in the U.S. Figure 3.1(b) illustrates the demand and supply for pork produced in the U.S. in the global market, represented by D_x and S_x respectively, which determine the domestic price along with D_0 and S_0. Consumers in the U.S. purchase Q_D quantity of pork at price P_0, while a total of Q_T pork is produced. We work with the scenario discussed by Carriquiry et al. (2020) who model the economic impacts of an outbreak of ASF in the U.S. where they consider a closure of international markets to pork produced in the U.S. and as a result of that, assume excess supply in the domestic market. Figure 3.1(c) illustrates this change in domestic supply of pork as marked by a shift of the supply curve from S_0 to S_1. For the domestic market to clear, the price will fall to P_1. As a short-run outcome, we assume that the entire quantity for export is now available in the domestic market, making Q_T the total pork available in the U.S. when the outbreak occurs.

While Carriquiry et al. (2020) assumes that the demand curve does not shift, Lee et al. (2023) finds that 46% of pork consumers may avoid consuming pork during an outbreak. The extent of a downward (or inward) shift in demand is not clearly known and some prior literature has dealt with this by making assumptions. For example, in analyzing the potential outbreak of classical swine fever in the U.S., Paarlberg et al. (2009) assumes a fall in demand for pork by just 1%, much lower than what the findings of Lee et al. (2023) suggest. Figure 3.1(d) illustrates a downward shift in demand, from D_0 to D_1, representing a reduction in the willingness to pay for pork during an ASF outbreak, further pushing down the equilibrium price to P_2. We use this framework to estimate the reduction in demand resulting from the ASF outbreak and the associated welfare implication.

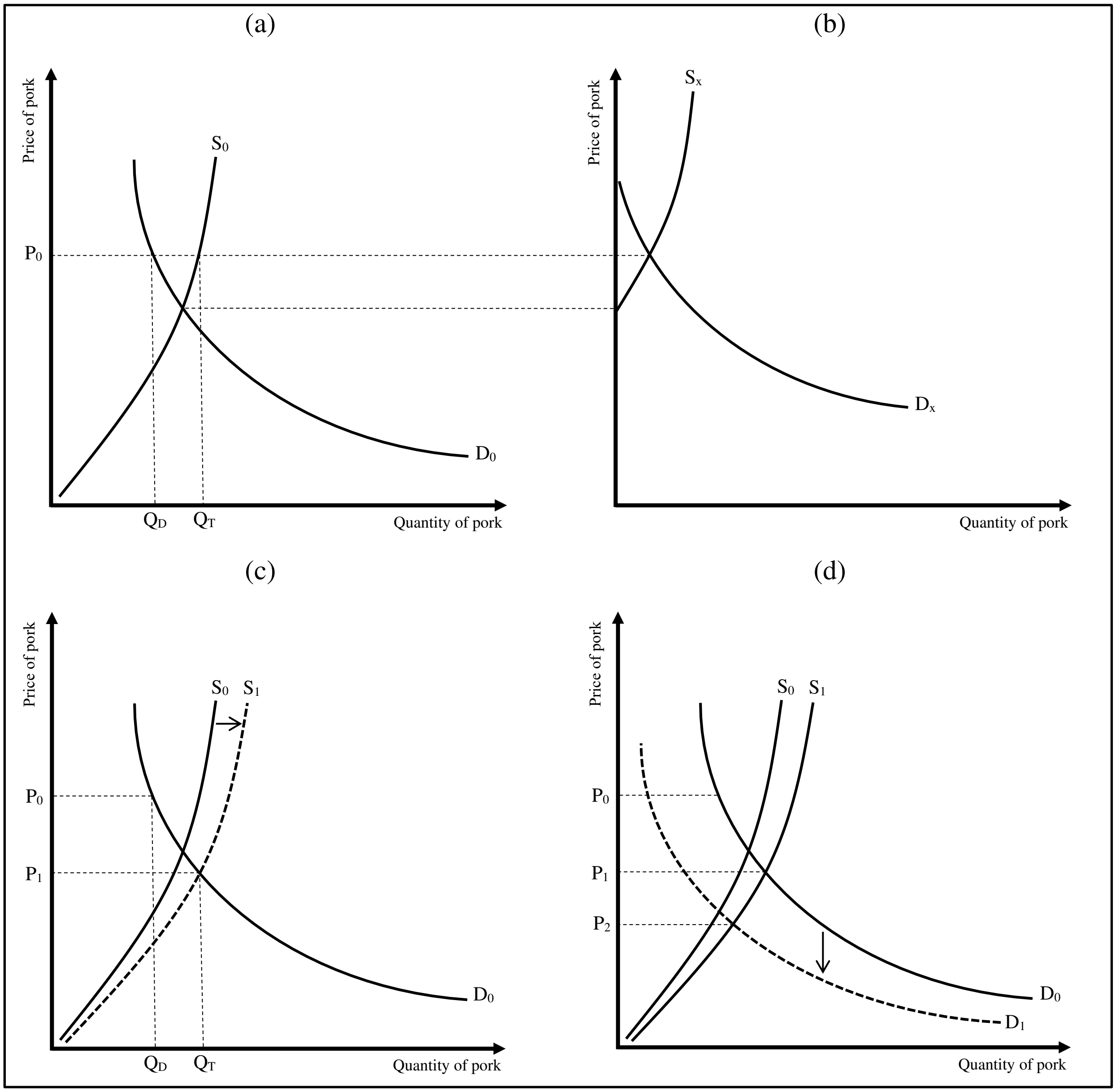


Figure 3.1. Modeling the market effects of ASF outbreak in the U.S. pork market.

3.4. Survey Design

We conduct a survey experiment to examine perceptions of U.S. pork consumers towards food safety, changes in their consumption behavior of pork after a hypothetical outbreak of ASF in the country, and whether different sources of information affect how consumers respond. We use a stated preference methodology to elicit responses from consumers for a hypothetical situation, which can only be done in a controlled environment. This allows us to use different sources of information as our treatment to inform consumers about the outbreak, something we cannot otherwise control in the respondents' real lives.

3.4.1. Survey and Data Collection

We developed an online survey to collect responses from pork consumers in the U.S. We programmed our survey on Qualtrics and used their panel of consumers to distribute the survey. We conducted a pre-test of the survey by collecting 50 responses through Qualtrics, following which we conducted the survey from January 25, 2023, to January 31, 2023. The survey included a screening question to identify pork consumers. The incidence rate of the survey was 80.23%, i.e., close to 20% of the participants who initiated the survey were screened out because they did not consume pork. We collected 1,519 complete responses and this sample was balanced for gender, age, race, and region, closely following the U.S. Census of 2020. The survey is presented in Appendix D.

Responses to the survey included frequency of consumption for both unprocessed pork products (e.g., chops, loin, and ribs) and processed pork products (e.g., bacon, ham, and sausages). Disaggregating 'pork' into the two broad categories allowed us to consider the difference in own-price elasticities between the two categories and therefore evaluate changes in demand with more precision. The respondents were asked about their tradeoffs between food cost and food safety on a scale of 1 to 3, where 1 represented greater importance for food prices, and 3 represented a greater importance to food safety. Responses were also recorded for the occurrence of any food-borne illnesses within the last two years of taking the survey.

Next, to understand changes in pork consumption behavior during an outbreak of ASF, respondents were presented with a news article related to ASF. To investigate whether being informed about ASF from different news sources had any effect on consumers' pork consumption behavior after being told about the ASF outbreak, the respondents were randomly assigned the news from one of three sources. The three sources were: (i) U.S. Department of Agriculture's Animal and Plant Health inspection Service (USDA APHIS), (ii) National Pork Producers Council (NPCC), and (iii) National Public Radio (NPR), representing the government, pork producer, and media respectively. One news source was randomly presented to each survey participant.

The news announcements, that were between 100 and 125 words, contained similar information, each telling the respondents about the disease, its fatality in pigs, lack of any evidence of threat to food safety, and that it had not been reported in the U.S. to date. The information used in these announcements were exact words taken from the respective sources to resemble the language the respondent could expect to see from that source. Each news announcement cited the source and contained a link to the respective website for the respondents to verify and read the complete article if they wished to do so.

Following the news announcement, respondents were informed about a hypothetical outbreak of ASF in the U.S. The announcement was as follows:

> Consider the following **hypothetical situation**:
>
> Suppose there is a widespread outbreak of African Swine Fever (ASF) in the United States. Hog farms where the outbreak occurs report the death of their pigs and confirm the outbreak. The pork supply chain is likely to include meat from hogs that were infected with the virus.

The respondents were then asked about their willingness to pay for the two categories of pork products during the period of the outbreak of ASF. They are also asked whether they would substitute away from consuming pork, and if so, then what products would they purchase more of. We also obtained responses of their understanding of personal health risk associated with ASF and whether they had any knowledge of ASF prior to the survey.

Next, the respondents were presented with different sources of news from where they might receive information about food safety and diseases. The news sources included: television and radio news, social media, print media, Centers for Disease Control and Prevention, meat producers, academic sources, and word of mouth. For each source, they were asked about their perception of trustworthiness using a five-point Likert Scale. The survey concluded with questions on socio-demographic characteristics including gender, age, education, race, household income, number of household members, and whether there were children and/ or older adults in the household.

3.4.2. The Contingent Valuation Method

We utilize the one-and-one-half-bound (OOHB) dichotomous choice contingent valuation (CV) approach to analyze the survey responses and estimate the consumers' WTP for unprocessed and processed pork products. The OOHB CV model was proposed by Cooper et al. (2002) as a method with potentially lower response bias than the double-bounded models and more efficient estimates than the single-bound models. Contingent valuation methods are utility-based, stated preference models that have been extensively used to study consumer preferences for different food attributes and technologies. These include assessment of WTP for genetically modified foods (e.g., Delmond et al., 2018; McCluskey et al., 2003), issues related to animal welfare (e.g., Bennett and Blaney, 2005; Tonsor and Wolf, 2011), and food safety (Buzby, Skees, and Ready, 2019; Neill and Holcomb, 2019).

In this study, we take an approach that is similar to the one used in Delmond et al. (2018) which employed a modified OOHB model to estimate consumers' WTP for genetically modified bread in Russia. After the respondents were presented with the news announcement related to ASF and informed about a hypothetical outbreak in the U.S., they were asked whether they would be willing to purchase pork at the same price as before the outbreak. If they answered "yes", then they did not receive a follow-up question on pricing. If they answered "no", they received a follow-up question that asked whether they were willing to buy the same pork product at a discounted price. We used three discount levels: 25%, 50%, and 75%. The respondents were presented with a discount that was chosen randomly and each discount was presented to one-third of the survey respondents. This set of questions was presented twice, once to elicit responses for unprocessed pork and once for processed pork. We disaggregated pork into two categories and estimate changes in demand separately for both as prior research has shown the two categories to have different own-price elasticity estimates (Tonsor and Lusk, 2021).

Despite being informed that ASF is not a food safety issue, we expect consumers to regard it as a credence attribute that reflects negatively on the quality of pork. Due to such an association, we do not expect consumers to be willing to pay a higher price for pork in the case of an outbreak of ASF. This justifies our choice of using the OOHB dichotomous choice method instead of a double-bound method. As a result, we did not ask a follow-up question to determine a price premium when the respondent answered "yes" to whether they were willing to purchase pork at the same price as prior to the outbreak. Additionally, since we did not provide any initial retail price of pork to the respondents and instead asked whether they were willing to purchase pork "at the same price as before the ASF outbreak", we avoid having a starting point bias in the survey (Veronesi, Alberini, and Cooper, 2011).

Following the setup in Delmond et al. (2018), let B_i^1=1 represent the initial bid offered to individual i (i.e., "the same price as prior to the ASF outbreak"). Since we do not specify any prices, the initial bid is normalized to 1 and the follow-up discounted prices are with respect to this normalized price of pork. Let B_i^2= {0.75, 0.5, 0.25} represent the follow-up prices that are equivalent to receiving a discount of 25%, 50%, or 75% respectively, conditional on the respondent answering "no" to the initial bid. Let C_i represent individual i's true willingness to pay, a value that is unobserved by the researcher. This setup of the modified OOHB model is illustrated in Figure 3.2.

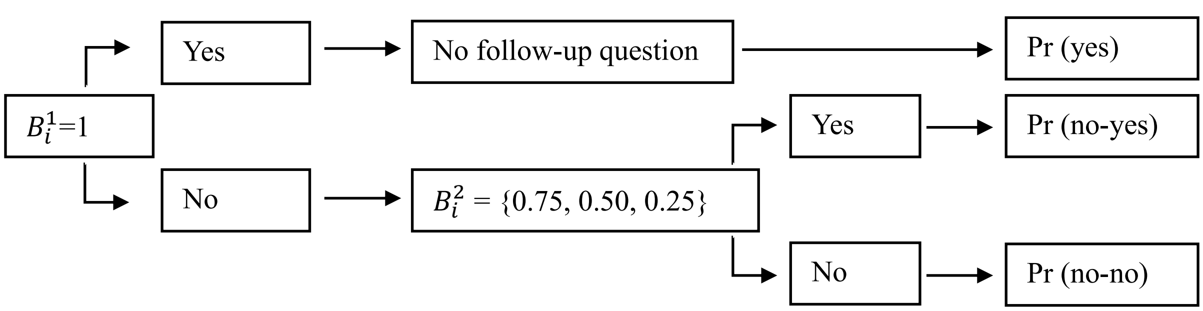


Figure 3.2. Method of presenting bids and the possible response probabilities in the one-and-one-half-bound dichotomous choice contingent valuation model.

The responses to these close-ended CV questions therefore produce three possible discrete outcomes. First, the respondent is willing to purchase the pork at the initial price, and is not offered a discounted price (i.e., “yes”). Second, the respondent is unwilling to purchase pork at the initial price but is willing to purchase at the discounted price (i.e., “no-yes”). Third, the respondent is not willing to purchase pork at the initial price and is neither willing to purchase at the discounted price (i.e., “no-no"). According to the random utility framework, C_i is a random variable and its cumulative distribution function can be specified as $G(C_i;\theta)$, where θ represents the parameters of the distribution. Thus, under the OOHB approach, we can write the response probabilities π_i^y, π_i^{ny}, and π_i^{nn} for “yes”, “no-yes”, and “no-no” respectively as:

$$\pi_i^y\left(B_i^1\right) = \Pr\left(B_i^1 \leq C_i\right) = 1 - G(B_i^1;\theta) \tag{1}$$

$$\pi_i^{ny}\left(B_i^1, B_i^2\right) = \Pr\left(B_i^1 \geq C_i \geq B_i^2\right) = G\left(B_i^1;\theta\right) - G(B_i^2;\theta) \tag{2}$$

$$\pi_i^{nn}\left(B_i^1, B_i^2\right) = \Pr\left(B_i^1 > C_i \cap B_i^2 > C_i\right) = G(B_i^2;\theta) \tag{3}$$

Then the corresponding log-likelihood function can be expressed as:

$$lnL^{OOHB}(\theta) = \sum_{i=1}^{N}\{d_i^y ln\, \pi_i^y\left(B_i^1\right) + d_i^{ny} ln\, \pi_i^{ny}\left(B_i^1, B_i^2\right) + d_i^{nn} ln\, \pi_i^{nn}\left(B_i^1, B_i^2\right) \tag{4}$$

where d_i^y, d_i^{ny}, and d_i^{nn} are dummy variables equal to 1 when the responses are “yes”, “no-yes”, and “no-no” respectively, and 0 otherwise.

The model assumes a logistic cumulative distribution function for $G(C_i;\theta)$, and given the bids, this is specified as:

$$G(B) = [1 + e^{\alpha-\rho B}]^{-1} \tag{5}$$

where $\theta = \{\alpha, \rho\}$ are the parameters of the logistic function and B represents the bids. The maximum likelihood estimation method is used to obtain consistent and asymptotically efficient estimates, $\hat{\alpha}$ and $\hat{\rho}$, as functions of the bids. Using these estimates, we can obtain the mean and median relative WTP for pork, that are both given by $-\alpha/\rho$, in a model without any additional covariates. To estimate the relative WTP in a model with additional covariates, X, the standard logistic cumulative distribution function with mean zero and variance $\sigma^2/3$ is used, i.e., $G(B;X) = \left[1 + e^{\alpha-\rho B+\beta X}\right]^{-1}$. The mean relative WTP is now given by $\left(-1/\hat{\rho}\right)(\hat{\alpha} + \hat{\beta}\,\bar{X})$.

However, this WTP formulation is not constrained to be a non-negative random variable and the estimated area below the fitted function lies between negative and positive infinity. This creates a possibility for the estimated mean WTP to be negative, which in our case would imply a discount that exceeds 100%. Hanemann (1989) discusses that the choice of employing CV models with the possibility of negative WTP values must depend on whether they are meaningful in the study context and provides a formulation to estimate the mean WTP that is constrained to be non-negative and bound at a maximum positive bid amount. The mean relative WTP, constrained to be between zero and the maximum bid B^{max} is given by:

$$E[WTP] = (-1/\hat{\rho})\, ln\left(\frac{1+e^{\hat{\alpha}}}{1+e^{\hat{\alpha}-\hat{\rho}B^{max}}}\right) \tag{6}$$

We estimate and report the WTP estimates obtained using equation (6) since we are interested in obtaining a non-negative WTP for purchasing pork (i.e., a discount that does not exceed 100%) and relative to the original bid of unity that we start with. We interpret the relative WTP as the discount that the mean consumer must receive to be willing to consume pork during an outbreak of ASF. For example, an estimate of 0.65 would mean that the mean consumer is willing to purchase pork after being offered a discount of 35% (i.e., 1 minus 0.65) during the ASF outbreak. Further, we estimate the influence of different information treatments on the choice responses, as well as the associations with the different covariates of interest in the model.

In addition to the response outcomes obtained to set up the OOHB model, the respondents who chose "no" for the first bid were also asked whether they would prefer not to purchase pork at any price. Spike models have been used in the literature to modify the log likelihood function with a spike at zero to incorporate this outcome (e.g., Lee et al., 2023). However, given the manner in which our model is set up, we do not use the spike model since we observe a spike in the data at two points; one for the set of respondent unwilling to buy at any price (i.e., equivalent to the response outcome “no-no” at a discount of 100%), and second for the respondents who are willing to purchase at the price prior to the outbreak (i.e., equivalent to the response outcome “yes” or receiving a 0% discount).

In estimating the mean WTP for the two categories of pork using the OOHB model described above, the response outcome “no-no” includes the respondents who are unwilling to purchase pork at any price. This is likely to bias the WTP estimates by underestimating the discount for the mean respondent. We account for this bias in estimating the resulting downward shift in demand for pork by separately weighting the respondents who are unwilling to consume pork at any price during the ASF outbreak, as discussed in the next subsection. Additionally, we analyze the characteristics of these respondents separately and determine whether the decision to stop purchasing pork is affected by the source of information describing ASF.

3.4.3. Estimating Shift in Demand

Consumers who are unwilling to purchase pork at any price represent a true zero WTP, i.e., they would choose “no-no” even when offered a discount of 100%, considering the non-negative WTP formulation in equation (6). When we estimate the mean relative WTP for the whole sample, it gives us the most conservative estimate of the change in WTP given that it ignores the fact that some individuals in the sample have a zero WTP. To account for this additional information, we obtain a modified estimate for the mean relative WTP in two steps. First, we estimate the WTP as a discount from the original price using equation (6) for the sub-sample of respondents that excludes those who have a zero WTP for pork following the ASF outbreak. Next, we assign a discount of 100% (equivalent to a WTP of zero) to the respondents who indicated that they were unwilling to purchase pork at any price following the ASF outbreak. Finally, we obtain the weighted average WTP for the complete sample using these two estimates which now accounts explicitly for the case of zero WTP.

Furthermore, respondents who consume pork more frequently have a greater potential to influence changes in market demand, making the mean relative WTP for the pork market sensitive to frequency of consumption. Thus, to estimate changes in market demand for pork following an ASF outbreak, we use the survey responses of frequency of consumption to calculate weighted measures of changes in WTP. We aggregate the survey responses 'at least once a day' and 'at least once a week' to represent a 'high' frequency of consumption. Similarly, we aggregate the responses 'about once a month' and 'less than once a month' to represent a 'low' frequency of consumption. We estimate the mean relative WTP separately for the sub-samples of 'high' and 'low' consumption frequency respondents to obtain WTP_{high} and WTP_{low} respectively.

To obtain an aggregate weighted estimate for mean WTP, we generate weights for WTP_{high} and WTP_{low}. We create a numeric scale for the four categories of frequency of consumption by assigning each with a number that approximately represents 'times consumed in a month (four weeks)'. Accordingly, the weights assigned for 'less than once a month' is '0.5', 'about once a month' is '1', 'at least once a week' is '4', and 'at least once a day' is '28'. These weights are informed estimates and can be varied to test the sensitivity of the WTP estimates.

Using the relative proportions of consumption within 'high' and 'low' frequencies (see Table 3.2), and the numeric scale for the four responses of frequency, we obtain weights represented by $freq_i$ where $i = \{unprocessed, processed\}$. $freq_{unprocessed}$ is 6.4 and $freq_{processed}$ is 14.6 for those reporting 'high' frequency of consumption relative to the weight of '1' assigned to 'low' frequency of consumption. We assign WTP_{high} and WTP_{low} to the respective respondents and aggregate the estimates using weights for 'high' and 'low' to obtain WTP_{con_i}, the weighted estimate for mean relative WTP based on the reported frequency of consumption represented by equation (7). The number of respondents reporting high and low frequencies of consumption are represented by n_{high} and n_{low} respectively.

$$WTP_{con_i} = \frac{freq_i\,(n_{high})(WTP_{high}) + (n_{low})(WTP_{low})}{freq_i(n_{high}) + (n_{low})} \quad (7)$$

Lastly, we combine the reported frequency of consumption with zero WTP to obtain estimates for the shift in demand. As discussed above, we first estimate $WTP_{high}^{non-zero}$ and $WTP_{low}^{non-zero}$ for the respective sub sample of respondents who report a positive WTP following the ASF outbreak. We modify equation (7) by adding WTP_{zero} (equivalent to a discount of 100%) to both the 'high' and 'low' categories. We estimate equation (8) to obtain WTP_i that represent the extent of the downward shift in demand for the respective pork categories resulting from the ASF outbreak. The number of respondents who report a non-zero WTP for pork, and high and low frequencies of consumption are represented by $n_{high}^{non-zero}$ and $n_{low}^{non-zero}$ respectively. The number of respondents who report a zero WTP for pork, and high and low frequencies of consumption are represented by n_{high}^{zero} and n_{low}^{zero} respectively.

$$WTP_i = \frac{freq_i\,[\left(n_{high}^{non-zero}\right)\left(WTP_{high}^{non-zero}\right)+\left(n_{high}^{zero}\right)(100\%)\,]+[\left(n_{low}^{non-zero}\right)\left(WTP_{low}^{non-zero}\right)+\left(n_{low}^{zero}\right)(100\%)\,]}{freq_i\left(n_{high}^{non-zero}+n_{high}^{zero}\right)+\left(n_{low}^{non-zero}+n_{low}^{zero}\right)} \tag{8}$$

It is important to note that each of the WTP estimates in equations (7) and (8) are in the form of discounts that the mean consumer will be offered to purchase pork during the ASF outbreak. For example, $WTP_{high}^{non-zero}$ and $WTP_{low}^{non-zero}$ could be discounts of 18% and 25% respectively, whereas the discount of 100% represents WTP_{zero}.

3.5. Survey Data and Descriptive Statistics

Among the 1,519 respondents to the survey, 51.61% were female, the mean annual household income was about $63 thousand, and had a mean household size of 2.7. The mean age was about 47 years, which lies in the median range of age in the data (45-54 years), and about 46% of the respondents lived in households that did not contain children (under 18 years of age) or older adults (over 65 years of age). About 34% of the respondents had a bachelor's degree or higher, and while about 60% of the respondents were "White", 18.5% were "Black", and 15.2% were "Hispanic or Latino".

See Table 3.1 for a description of the socio-demographic data, complete summary statistics, and comparison with the U.S. Census of 2020 where available. While the socio-demographics of U.S. pork consumers may differ from larger population statistics, our sample is representative of the U.S. population in terms of gender, income, and household size.

Table 3.1. Summary statistics for respondents' socio-demographic variables (N=1,519)

Variable	Categories	Statistics		U.S. Census 2020
Gender	Female		51.61%	50.5%
	Male		48.39%	49.5%
Education (highest completed)	Some high school or less		3.22%	
	High school		25.74%	
	Some college		24.09%	
	Associates or technical degree		13.17%	
	Bachelor's degree		23.51%	
	Graduate or professional degree		10.27%	
Race	White		60.17%	75.8%
	Black		18.50%	13.6%
	Asian		3.49%	6.1%
	Hispanic or Latino		15.21%	18.9%
	Other		2.63%	
Children and/ or old adults in the household	Only children		28.24%	
	Only older adults		22.38%	
	Children and older adults		3.36%	
	Neither children nor older adults		46.02%	
Annual household income ($)		Mean	63,028	69,021
		S.D.	41,258	
Age		Mean	47.23	38.5 (median)
		S.D.	17.97	
Household size		Mean	2.69	2.6 (median)
		S.D.	1.48	

Table 3.2 presents the summary statistics for respondents' consumption preferences, prior awareness of ASF, and perceived impact of ASF on personal health. While less than 10% of the respondents reported consuming pork daily (4.61% for unprocessed pork and 9.28% for processed pork), the majority of them report consuming pork at least once a week (40.82% for unprocessed pork and 53.20% for processed pork). When it comes to choosing between food price and food safety, 58.2% respondents weigh them equally while purchasing food, whereas 32.06% consider food safety as a more important parameter, and

9.74% consider food price as being more important. Most of the respondents (82.49%) did not report any incident of sickness from food-borne diseases in the last two years.

Table 3.2. Description and summary statistics for respondents' consumption preferences, prior awareness of ASF, perceived impact of ASF on personal health, and substitutes for pork.

Variable	Categories	Statistics
Frequency of consumption of unprocessed pork	At least once a day	4.61%
	At least once a week	40.82%
	About once a month	36.73%
	Less than once a month	17.84%
Frequency of consumption of processed pork	At least once a day	9.28%
	At least once a week	53.20%
	About once a month	26.92%
	Less than once a month	10.60%
Price vs. food safety	Lower food price is most important	9.74%
	Food price and safety equally important	58.20%
	Food safety is most important	32.06%
Food-borne illness in past two years	Yes	12.78%
	No	82.49%
	Cannot say	4.73%
Understanding of personal health risk associated with ASF	High risk	15.73%
	Some risk	35.55%
	No risk	26.27%
	Uncertain	22.45%
Knowledge of ASF prior to the survey	Very knowledgeable	8.30%
	Moderately knowledgeable	19.42%
	Limited knowledge	33.57%
	Not informed	38.71%
Substitute for pork following ASF outbreak	Beef	44.50%
	Poultry	45.82%
	Lamb	9.74%
	Seafood	36.21%
	Non-meat food product	19.03%
	Not purchase more of anything	18.89%
	Other	3.16%

Close to three-quarters of the respondents (72.28%) were uninformed or had a very limited knowledge about ASF prior to the survey. Despite the news announcement in the survey containing information about food safety, only 26.27% of the respondents perceived ASF as not being a risk to personal health, whereas the others perceived some amount of risk or were uncertain. Lee et al. (2023) had found that even fewer respondents (16%) were aware of ASF and did not believe that it was a threat to human health. The majority of respondents would substitute pork with beef and poultry during the ASF outbreak, in line with the findings of Tonsor and Lusk (2021), followed by seafood and non-meat food products.

Table 3.3 shows a summary of the three response outcomes from the survey, as well as respondents who are not willing to purchase pork at any price after an ASF outbreak. To purchase unprocessed pork, about a third of all respondents (33.71%) were willing to pay the same price as they did before the ASF outbreak. Only 7.24% of respondents were willing to purchase pork at the discounted price. The majority (59.05%) of the respondents were unwilling to purchase pork even though some were being offered a discount of up to 75%. Additionally, close to 23% of all respondents (or 34% of those who chose "no-no") did not want to continue purchasing unprocessed pork, irrespective of the price.

Table 3.3. Percent of respondents for the three response outcomes and those who are not willing to purchase pork at any price following the ASF outbreak.

Response to bids	Percent respondents	
	Unprocessed pork	Processed pork
yes	33.71	42.86
no-yes	7.24	7.37
no-no	59.05	49.77
Total	100	100
Do not purchase at any price	22.71	22.58

Note: The response outcome "no-no" includes those who responded as not willing to purchase at any price.

On the other hand, to purchase processed pork, a relatively higher number of respondents (42.86%) were willing to pay the same price as they did before the ASF outbreak. Another 7.37% were willing to purchase pork when offered a discount and the remaining 49.77% declined to purchase pork even after being offered a discount. Similar to the case of unprocessed pork, 22.58% of all respondents were not willing to purchase processed pork at any price in case of an ASF outbreak. The proportion of consumers unwilling to purchase pork at any price in our survey is considerably smaller than the figure of 46% reported by Lee et al. (2023) from their survey in May 2020.

We evaluate the three response outcomes “yes”, “no-yes”, and “no-no” based on categories of news sources, prior knowledge of ASF, perceived health risk from ASF, and frequency of consumption of pork. These are presented in Figure 3.3, with the cases for unprocessed pork in the left panel and for processed pork in the right. After the announcement of the hypothetical ASF outbreak, 36.5% of the respondents who received the news from the government were willing to purchase unprocessed pork at the same price as before the outbreak (i.e., the outcome “yes”), higher than the same outcome for media (33.2%) and producer (31.4%). This trend is similar for processed pork consumers with 44.7% of the respondents who received the news of ASF from the government were willing to purchase pork at the market price, greater than media (43.9%) and producer (39.9%), as illustrated in Figure 3.3 (a) and (e).

On the other hand, while 55.7% of the respondents receiving the information about ASF from the government chose “no-no” for unprocessed pork, it was lower than the media (58.8%) and producer (62.7%). Again, the trend was similar for processed pork consumers with 46.7% respondents who learned about ASF from the government chose “no-no”, less than those learning about it from media (46.8%) and producer (53.8%). In assessing the change in willingness to pay for pork, we evaluate whether learning about ASF from these three different news sources had any effect on the responses following an outbreak and discuss the implications for communication about the disease.

When considering the responses based on their knowledge of ASF prior to the survey, as illustrated in Figure 3.3 (b) and (f), the respondents choosing “no-no” were highest when they were least informed about ASF (64.1% and 55.4% for unprocessed and processed pork respectively). This proportion decreased with an increase in the reported knowledge of ASF for both categories of pork. Conversely, the proportion of respondents choosing “yes” was the highest among those who reported being ‘very knowledgeable’ about ASF (59.6% and 61.9% for unprocessed and processed pork respectively). This proportion declined with the decreasing knowledge of ASF, for both categories of pork, and was the lowest among those who were uninformed about ASF.

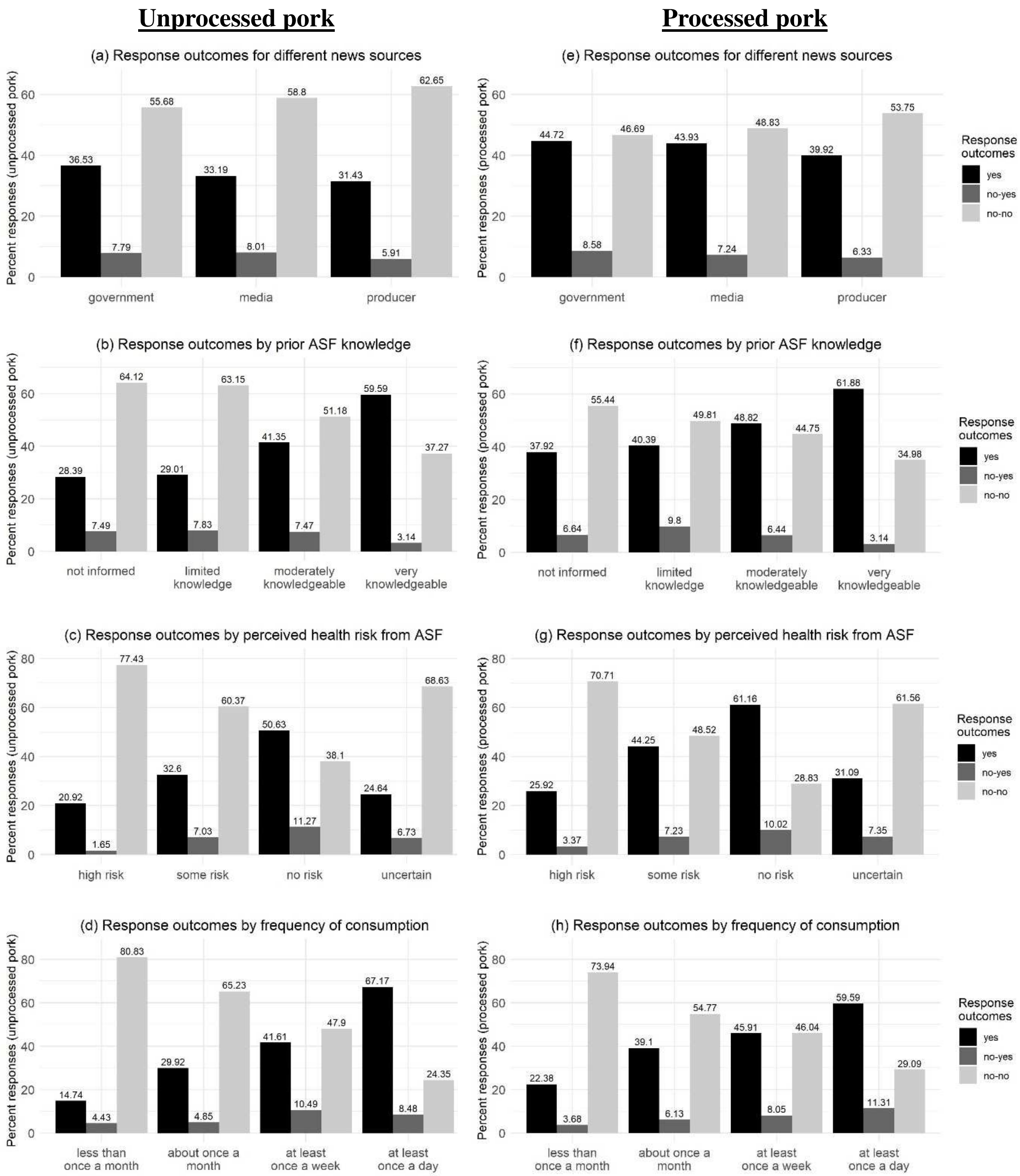


Figure 3.3. Response outcomes for unprocessed and processed pork, categorized by different survey responses.

In Figure 3.3 (c) and (g), we see that among the respondents who did not perceive ASF as a risk to their personal health, the proportion choosing "yes" was the highest (50.6% and 61.2% for unprocessed and processed pork respectively) when compared to those who believed otherwise, and the proportion choosing "no-no" was the lowest. The respondents who considered ASF to be of high risk to their personal health, the proportion choosing "no-no" was the highest (77.4% and 70.7% for unprocessed and processed pork respectively). We test whether prior knowledge of ASF and its perceived health risk affects the change in willingness to pay for pork since this will inform the need for communication about the disease before and during the outbreak. In assessing the response outcomes based on the reported frequencies of consumption, as illustrated in Figure 3.3 (d) and (h), we see that the proportion of respondents who chose "yes" was highest among those who reported consuming pork at least once every day (67.2% and 59.6% for unprocessed and processed pork respectively). This proportion declined with the decrease in reported frequency of consumption. Those choosing "no-no" were the highest in proportion among the respondents who consumed the least amount of pork (less than once a month), for both unprocessed (80.8%) and processed pork (73.9%). This proportion declined with the increase in reported consumption. This distribution is likely to have an impact on changes in market demand since it tells us the characteristics of those who might lower or stop their consumption of pork during the outbreak. We consider the differences in frequency of consumption and the respective choice outcomes in estimating the change in willingness to pay for both unprocessed and processed pork.

Next, we evaluated differences across news sources, awareness of ASF, and frequency of consumption of pork of the respondents who were unwilling to purchase pork at any price in case of an ASF outbreak. Figure 3.4 illustrates these cases for both unprocessed and processed pork, in the left and right panels respectively. Among the consumers of unprocessed pork (processed pork) who received information about ASF from the government, 18.96% (19.96%) were unwilling to purchase pork at any price, lower than the proportion of respondents receiving the news from the media and producer, as shown in Figure 3.4 (a) and (e).

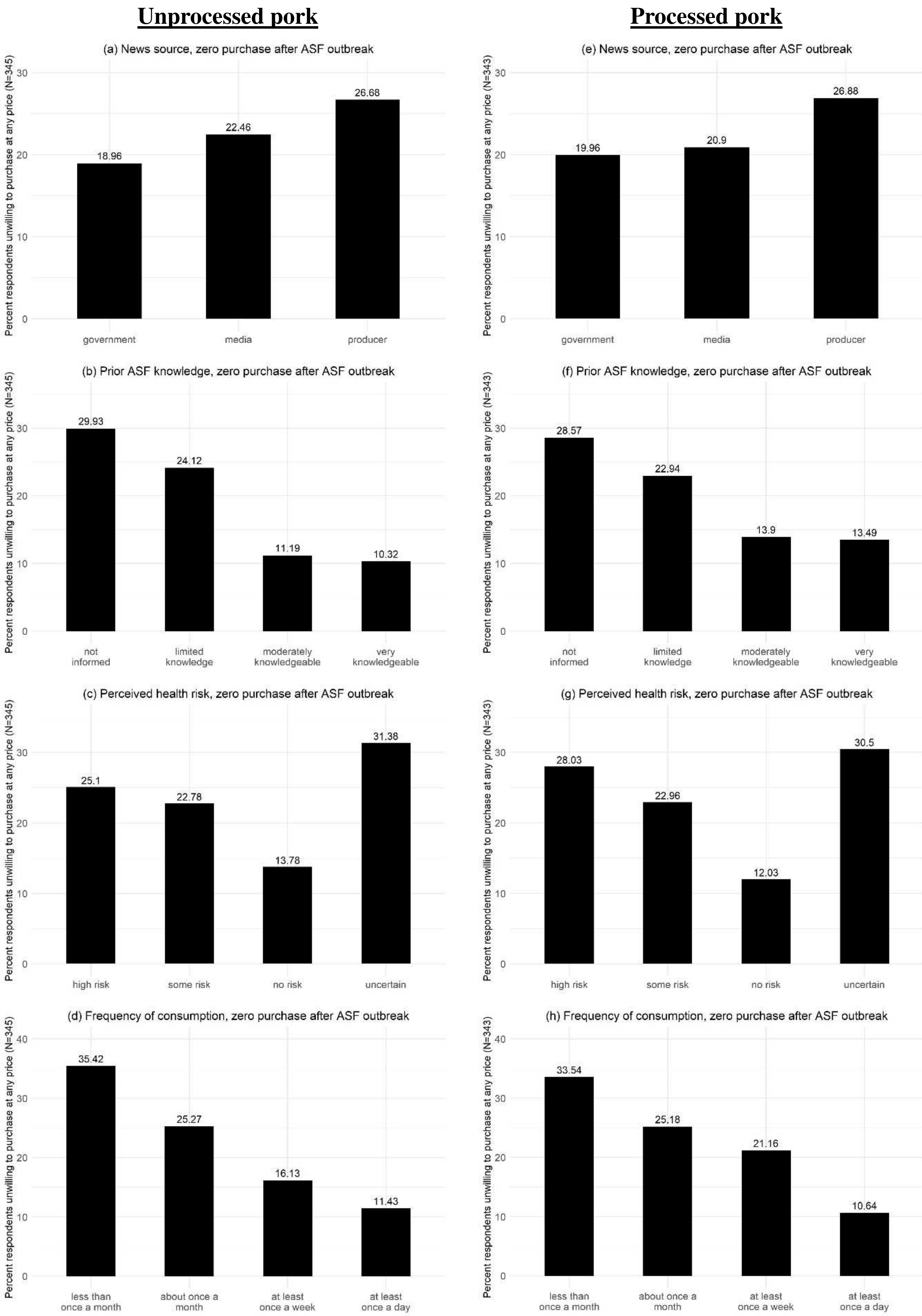


Figure 3.4. Respondents unwilling to purchase unprocessed and processed pork at any price, categorized by different survey responses.

Figure 3.4 (b) and (f) show that the consumers who were the least informed about ASF were most likely to stop purchasing pork during an outbreak. Among the respondents who reported being uninformed about ASF prior to the survey, 29.93% (28.57%) were unwilling to purchase unprocessed pork (processed pork) at any price. On the other hand, among those that reported being highly knowledgeable, 10.32% (13.49%) were unwilling to purchase unprocessed pork (processed pork) at any price.

Figure 3.4 (c) and (f) show that after being presented with the information about ASF in the survey, consumers who were uncertain about personal health risk associated with ASF or perceived ASF to be of some risk, were more likely to stop purchasing pork during the outbreak. Among respondents who perceived ASF to be of high risk to them, 25.10% (28.03%) were unwilling to purchase unprocessed pork (processed pork) at any price, higher than the proportion of respondents who did not perceive ASF to be of any risk: 13.78% (12.03%). Figure 3.4 (d) and (h) show that the majority of those willing to stop purchasing pork during the outbreak of ASF did not consume pork very frequently. 35.42% (33.54%) of the respondents who reported consuming pork less than once a month were unwilling to purchase unprocessed pork (processed pork) at any price. This was higher than the proportion of respondents who reported consuming pork at least once a day: 11.43% (10.64%).

3.6. Results and Discussion

First, we discuss whether learning about ASF from different news sources affects consumption of pork in an outbreak. Next, we present the coefficient estimates from the OOHB contingent valuation analysis and the estimated mean relative WTP for unprocessed and processed pork. Finally, we factor in the frequency of consumption and the respondents unwilling to pay to purchase pork following an ASF outbreak to estimate the shift in demand and the resulting welfare implications.

3.6.1. Impact of News Sources

We use a probit model to test whether receiving information about ASF from different news sources has a significant effect on consumers' decision to continue purchasing pork at the same price as well as their decision to stop purchasing pork during an ASF outbreak. We regress the binary choice of "yes" (i.e., continue to purchase pork at the same price) on the three news sources, one of which was randomly assigned to each respondent in the survey. We repeat the exercise with the binary choice of "not purchase at any price".

Results in Table 3.4 (a) show that consumers are 5.1% less likely to continue purchasing unprocessed pork at the same price during the ASF outbreak if they hear about the disease from producers as opposed to from the government, statistically significant at the 10% level. The marginal effects for both media and producer provided information are negative for processed pork, but not statistically significant. Results in Table 3.4 (b) show that consumers of unprocessed pork (processed pork) are 7.7% (6.9%) more likely to stop purchase of pork if they receive the information about ASF from producers as opposed to from the government, statistically significant at the 1% level. While the marginal effects for the information from the news media source are also positive, neither is statistically significant.

Table 3.4. Marginal effects of news sources on purchase decision of pork following an ASF outbreak.

News Sources	Unprocessed Pork	Processed Pork
(a) Binary choice of purchasing pork at the same price		
Media	-0.033	-0.008
	(-0.092, 0.025)	(-0.069, 0.053)
Producer	-0.051*	-0.048
	(-0.109, 0.007)	(-0.109, 0.013)
Government (reference category)		
(b) Binary choice of not purchasing pork at any price		
Media	0.035	0.009
	(-0.015, 0.085)	(-0.040, 0.059)
Producer	0.077***	0.069***
	(0.026, 0.129)	(0.017, 0.121)
Government (reference category)		
Observations [a]	1,519 (345)	1,519 (343)

Note: *** and * represent coefficients statistically different from 0 at the 1% and 10% significance level respectively. Confidence intervals for the marginal effects in parentheses.
[a] Total observations, and the number of respondents who chose 'not purchase at any price' in parentheses.

While the reduction in WTP for pork underscores the need for efforts to grow awareness of ASF and messages of food safety, results in Table 3.4 provide insights into the efficacy of different news sources in doing so. If the pork market fails to consider awareness of ASF, something that can be considered a public good, then considering the resulting market failure and the associated welfare loss, the government has incentives to intervene and provide the necessary knowledge. Summary statistics in Table 3.2 showed that close to 73% of all respondents were either uninformed or had limited knowledge about ASF, and these respondents were the most likely to stop purchasing pork in the event of an ASF outbreak (Figure 3.4).

Similar to the modeling approach for news sources, we also tested whether prior knowledge of ASF was associated with the probability of purchasing pork at the same price as before the ASF outbreak or not purchasing at all. Results from the probit regression show that consumers who were slightly, moderately, or highly knowledgeable about ASF were more likely to purchase pork at the same price and less likely to stop pork consumption following an ASF outbreak when compared to consumers who were uninformed about ASF. Any public intervention would need to be designed accordingly, considering a large proportion of the population being uninformed about ASF. Further, we assess the impact that prior knowledge has on the change in willingness to pay for pork in the event of an ASF outbreak in the following section.

Our results show that knowledge sharing by the public sector is likely to benefit the pork market and minimize losses for the producers. In the survey, we had asked the respondents to indicate their trustworthiness for various news sources for information about food safety and food diseases. The responses are presented in Figure 3.5 and show that compared to other news sources like television news and social media, the respondents trust the Centers for Disease Control and Prevention (CDC) with news about food safety and food diseases. The findings make the case for public sector institutions like the CDC to strengthen collaborations with pork producers as well as other news sources to garner the trust of consumers, tackle the mistrust, and prevent the spread of misinformation.

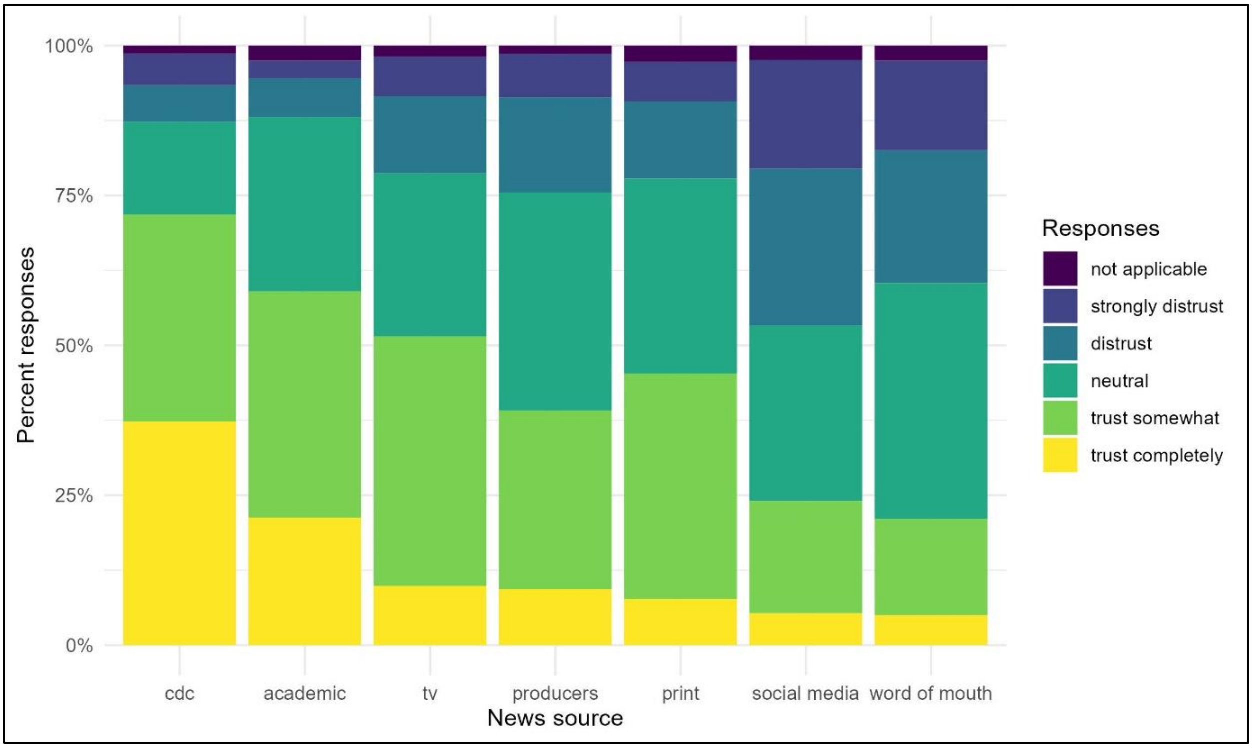


Figure 3.5. Responses for trustworthiness of various news sources for information about food safety.

3.6.2. Change in Willingness to Pay

We estimate two model specifications for each pork category. We estimate Models 1 and 3 by including the three randomly assigned news sources as explanatory variables in addition to the bids. We estimate Models 2 and 4 by including variables representing consumption behavior and awareness of ASF in addition to the news sources and bids. In all four specifications, we use the complete sample of 1,519 respondents. The results are presented in Table 3.5.

Consistent across all model specifications, the bid is negatively associated with WTP and statistically significant at the one percent level. Thus, as the discount offered to consumers increases (i.e., the relative price of pork decreases), the likelihood of a consumer purchasing pork following the ASF outbreak increases. The estimated mean relative WTP in Model 1 (3) is 0.4560 (0.5257), i.e., the mean respondent must receive a discount of 54.40% (47.43%) relative to the price of unprocessed pork (processed pork) products before the outbreak of ASF to be willing to consume pork in case of an outbreak.

The additional covariates in Models 2 and 4 account for the observable (stated) differences across the respondents that include having experienced food-borne illnesses in the past, perceived personal health risk from ASF, knowledge of ASF prior to the survey, frequency of consumption of pork, and preference between price of food and food safety. The estimated mean relative WTP for pork in Model 2 (4) is 0.6642 (0.7402), i.e., the mean respondent must receive a discount of 33.58% (25.98%) relative to the price of unprocessed pork (processed pork) products before the outbreak of ASF.

We interpret the sign (direction) of the estimated coefficients of the covariates in Models 2 and 4 as these are not marginal effects and cannot be interpreted directly. A positive sign implies that the variable has a positive correlation with the likelihood of answering ‘yes’ to the given bid, i.e., it is associated with a higher WTP for pork during the ASF outbreak relative to the price of pork prior to the outbreak.

Coefficient estimates for news sources in Models 1 and 3 show that receiving the information about ASF from the media or from a producer is associated with a lower mean relative WTP as compared to receiving news from the government, although the coefficients are not statistically different from zero. Coefficient estimates in Models 2 and 4 show that consumers who have experienced food-borne illness within the two years preceding the survey or are unsure of it do not have an effect that is significantly different from those who did not experience any such illness. Relative to consumers who do not perceive ASF to be a health risk, those that consider it to be of high risk, or having some amount of risk, or are uncertain about their belief of the risk are likely to have a significantly lower WTP for pork during the outbreak.

Consumers who are highly or moderately knowledgeable about ASF are likely to pay a relatively higher price for pork compared to consumers who are uninformed about the disease. Additionally, we see that those who report a higher frequency of consumption of pork products are more likely to pay a higher price for pork during the ASF outbreak as compared to those who report infrequent consumption. Lastly, consumers who prioritize food safety over price are willing to pay a lower price for pork during the outbreak.

Table 3.5. Coefficient estimates of the explanatory variables on mean relative willingness to pay for unprocessed and processed pork from the one-and-one-half bound model.

Variables	Unprocessed Pork Model 1	 Model 2	Processed Pork Model 3	 Model 4
Constant	-1.608*** (0.241)	-0.343 (0.335)	-1.219*** (0.202)	-0.026 (0.320)
Bid	-2.807*** (0.275)	-2.178*** (0.244)	-2.675*** (0.235)	-2.365*** (0.230)
News source				
Media	-0.163 (0.146)	-0.165 (0.148)	-0.032 (0.138)	-0.038 (0.142)
Producer	-0.105 (0.148)	-0.050 (0.150)	-0.126 (0.139)	-0.024 (0.145)
Government (reference category)				
Prior food-borne illness				
Yes		0.213 (0.183)		0.179 (0.181)
No (reference category)				
Unsure		0.060 (0.291)		0.014 (0.274)
Perceived health risk				
High risk		-1.488*** (0.227)		-1.590*** (0.212)
Some risk		-0.677*** (0.156)		-0.705*** (0.152)
No risk (reference category)				
Uncertain		-0.763*** (0.175)		-0.980*** (0.171)
Prior ASF knowledge				
Very knowledgeable		1.437*** (0.258)		1.250*** (0.251)
Moderately knowledgeable		0.590*** (0.179)		0.501*** (0.172)
Limited knowledge		0.065 (0.151)		0.115 (0.143)
Not informed (reference category)				
Frequency of consumption				
High		0.536*** (0.123)		0.325*** (0.122)
Low (reference category)				
Price vs safety [a]		-0.326*** (0.101)		-0.331*** (0.098)
Mean relative willingness to pay [b]	0.4560	0.6642	0.5257	0.7402
Observations	1,519	1,519	1,519	1,519

Note: ***, **, and * represent coefficients statistically different from 0 at the 1%, 5%, and 10% significance level, respectively. Standard errors in parentheses. For the description and summary statistics of the variables, see Table 3.2.
[a] Continuous variable, increasing in preference for food safety over price of food.
[b] Estimates obtained using equation (6).

These findings have important implications for pork consumers and producers, based on the assumption that our survey data is representative of the U.S. population. In the event of an outbreak of ASF in the U.S., the average pork consumer would only purchase pork when it is offered at a discounted price despite ASF not being a threat to food safety. The findings are in line with Lee et al. (2023) but contrary to the consumer response discussed by Carriquiry et al. (2020). In the short term, an outbreak of ASF in the U.S. could be highly damaging for pork producers if they lose their export market and possibly animals in their herd. Their situation would worsen with a reduction in the domestic demand for pork, which could be driven to some extent by the lack of awareness of ASF and perceived concerns of food safety.

The majority of respondents in our survey had little or no knowledge about ASF despite there being a global outbreak, findings mirrored by Lee et al. (2023) and the KSU Meat Demand Monitor[16]. Additionally, the majority of pork consumers also perceive ASF to be a risk to personal health, reaffirming the lack of awareness about the disease. Both low awareness and perceived health risk of ASF adversely affect pork demand and would hurt producers in the case of an outbreak in the U.S. However, both these issues can be mitigated to a large extent through strategic information campaigns. These findings provide an insight into consumer beliefs and responses pertaining to ASF and can aid in developing measures to inform consumers about the disease, both prior to and during the outbreak. Policy that supports communication efforts about food safety will be key in minimizing adverse impacts of ASF in the U.S. pork sector.

From the socio-demographic variables, only gender has a statistically significant effect on WTP. For both the unprocessed and processed pork categories, female consumers have a larger decrease in WTP than male consumers in case of an ASF outbreak. The other demographic variables include log(income), age, education, household size, and whether the household has either children, older adults, both or neither.

[16] See https://www.agmanager.info/livestock-meat/meat-demand/monthly-meat-demand-monitor-survey-data

The estimates suggest that these variables do not have a statistically significant effect on the mean relative WTP for pork. Complete results for both unprocessed and processed pork are presented in Appendix E.

Empirical results from the OOHB models for both unprocessed and processed pork show that a certain proportion of consumers would be willing to purchase pork only when offered at discounted prices, while some are willing to purchase at the same price as they did before the outbreak or not purchase at all. Overall, this will result in a downward shift of the demand curve in the domestic pork market when there is an outbreak of ASF. Next, we discuss the sensitivity of the extent of the demand shift followed by the resulting changes in welfare.

3.6.3. Estimates for the Shift in Demand

In order to obtain WTP estimates that reflect the consumption pattern of the consumers, we estimate the mean relative WTP for both unprocessed and processed pork for sub-samples divided by the reported frequencies of consumption. Findings from the OOHB models in Table 3.5 show that respondents with a relatively higher frequency of consumption of pork are willing to pay a higher price following the outbreak. While the WTP estimates in Table 3.5 represent unweighted mean changes, we argued in Section 3.4.3 that consumers with a relatively higher frequency of pork consumption would have a greater impact on changes in market demand.

Table 3.6 presents the mean relative WTP for both pork categories for respondents reporting non-zero WTP, and high and low frequencies of consumption, as well as for the complete sample. For unprocessed pork, while the change in WTP is a 33.58% discount for the full sample, it is 15.51% and 31.90% for respondents with high and low frequencies of consumption respectively. For processed pork, the mean WTP during an outbreak is a 25.98% discount for the full sample, and 12.69% and 23.40% for respondents with high and low frequencies of consumption respectively. WTP_{zero} is equivalent to a discount of 100%.

Table 3.6. Estimates of mean willingness to pay (in percentage discount from initial price) by sub-samples based on frequency of consumption.

Category	Mean Relative Willingness to Pay (Observations)	
	Unprocessed pork	Processed pork
(a) WTP	33.58% discount (1,519)	25.98% discount (1,519)
(b) $WTP_{high}^{non-zero}$	15.51% discount (582)	12.69% discount (763)
(c) $WTP_{low}^{non-zero}$	31.90% discount (592)	23.40% discount (413)
(d) WTP_{zero}	100% discount (345)	100% discount (343)

Note: WTP estimates for (a) are obtained from Model 2 and Model 4 respectively, presented in Table 3.5. Coefficient estimates from the one-and-one-half bound models for (b) and (c) are presented in Appendix E.

Coefficient estimates from the models used to obtain estimates for respondents with high (b) and low (c) frequency of consumption are presented in Appendix E. While we controlled for the reported frequency of consumption in Models 2 and 4, we do not do so in estimating $WTP_{high}^{non-zero}$ and $WTP_{low}^{non-zero}$ since we are dividing the sample itself by the respective frequencies.

Table 3.7 shows the extent of reduction in demand for both categories of pork for two scenarios. The reduction in demand is analogous to a downward shift in demand resulting from a decrease in the WTP for pork products. The first scenario reflects the unweighted WTP estimates which do not consider the differences in frequency of consumption across consumers, or the fact that some consumers would be unwilling to purchase pork at any price in the event of an outbreak and are likely either over- or under-estimating the extent of the shift. The second scenario reflects the reduction in demand that explicitly accounts for consumers who drop out of the pork market following the ASF outbreak. The resulting downward shift in demand, estimated using equation (8) is 32.31% (30.38%) for unprocessed (processed) pork.

Table 3.7. Estimates of mean reduction in market demand for pork following an outbreak of ASF.

	Scenario	Unprocessed pork	Processed pork
i.	Reduction along price, unweighted	33.58%	25.98%
ii.	Reduction along price; weighted and explicitly accounting for respondents unwilling to consume at any price [a]	32.31%	30.38%

[a] Estimates obtained using equation (8).

When we include weights for the frequency of consumption, the mean discount for processed pork increases compared to the first scenario. We observe this change because among those who are willing to purchase pork at a relatively higher discount (or not willing to consume at all), the reported frequency of consumption is relatively higher for processed pork consumers. As a result, the reduction in demand for processed pork is amplified when we account for frequency of consumption. We do not see as much of a change in the case of unprocessed pork.

3.6.4. Welfare Implications

In this section, we evaluate the changes in economic welfare outcomes for consumers and producers of pork associated with the outbreak of ASF in the U.S. using the single-sector partial equilibrium model set up in Figure 3.1. We have estimated that at any given price, the demand for pork shifts downward, which is in addition to an increase in domestic supply of pork. Consumers stand to gain from the resulting reduction in price, thus experiencing an increase in welfare, whereas producers experience a loss in welfare. These represent changes in consumer and producer surplus respectively, and their net aggregate represents the total welfare effect. While our welfare analysis does not capture the economic effects associated with the ASF outbreak on the pork sector and associated sectors fully, it provides insights into the potential welfare implications for pork consumers and producers resulting from shifts in supply and demand for pork.

We represent the welfare effects resulting from changes in the pork market equilibrium in Figure 3.6. First consider the scenario where the domestic supply of pork increases from S_0 to S_1 following the ASF outbreak but the demand remains unchanged at D_0, like the case discussed in Figure 3.1(c). The change in consumer surplus is given by $\Delta CS = CS_1 - CS_0 = A + B + C + D$. The respective change in producer surplus is given by $\Delta PS = PS_1 - PS_0 = H + I + K + L - R - A - B - C$. The change in total surplus is given by $\Delta TS_1 = \Delta CS + \Delta PS = D + H + I + K + L - R$.

Consider next, the simultaneous reduction in demand for pork and its implications on welfare outcomes. The change in consumer surplus resulting from the ASF outbreak is now given by $\Delta CS = I + E + A - N$, whereas the change in producer surplus in now $\Delta PS = K + L - R - A - B - C - E - F - G$. The change in total surplus is $\Delta TS_2 = \Delta CS + \Delta PS = I + K + L - R - B - C - F - G - N$. Accounting for a reduction in demand for pork results in an outcome ΔTS_2 that can represent a net welfare loss in the pork market, an outcome significantly different from ΔTS_1.

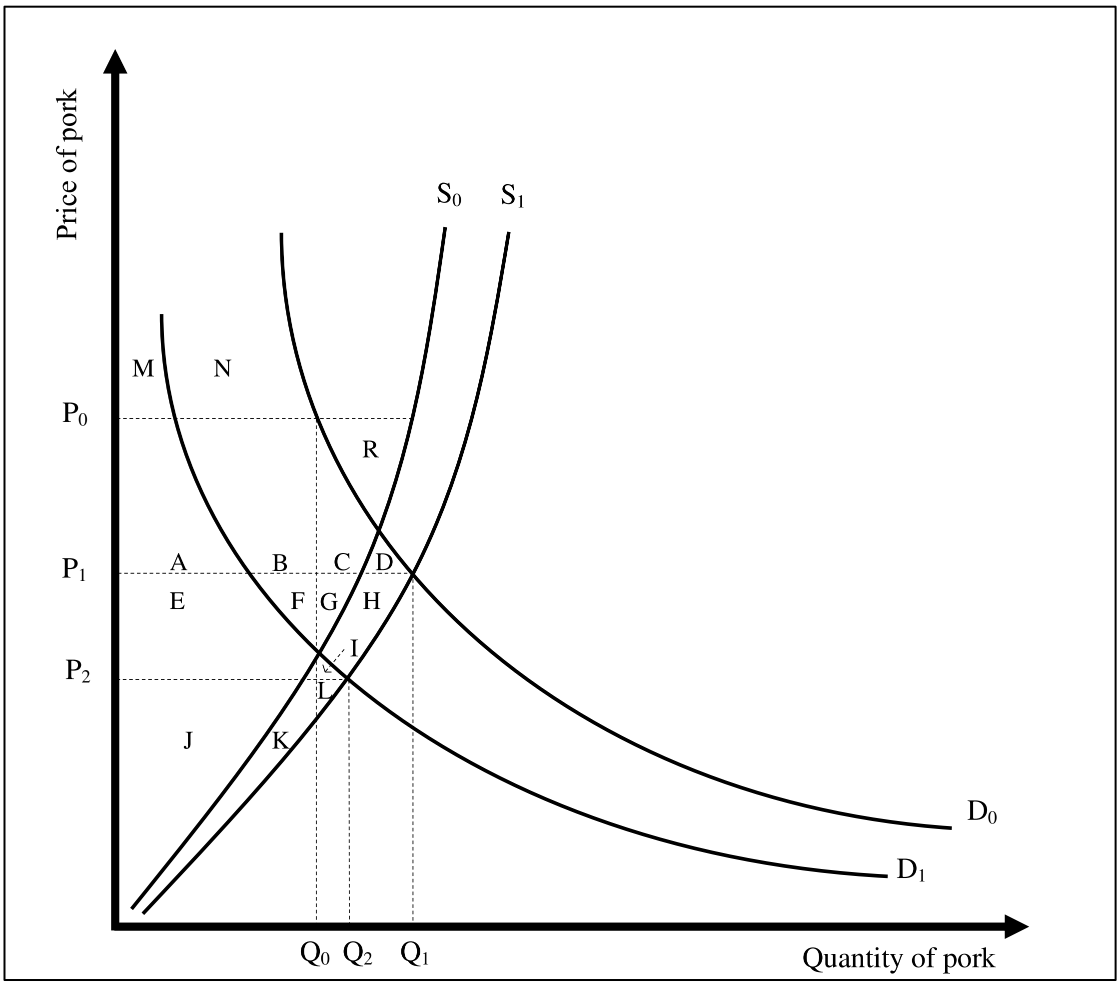


Figure 3.6. Welfare implications associated with an increase in supply and reduction in demand for pork following an outbreak of ASF in the U.S.

To estimate welfare changes resulting from a downward shift in the demand curve, we compute the demand and supply functions for pork. We obtain own-price demand elasticity and supply elasticity of pork from the literature. The elasticity estimates will determine the share of welfare loss between the consumers and producers of pork. We use a demand elasticity (η_d) of -1.2, that we obtain by taking the mean of the estimates of Okrent, and Alston (2012), Rahman, Amin, and Palash (2019), and Tonsor and Lusk (2021) and a supply elasticity (η_s) of 0.165, that we obtain by taking the mean of the estimates of Suh and Moss (2017) and Kaiser (2022) to compute the demand and supply functions respectively and to perform the welfare analysis (see Table 3.8). We assume constant elasticity demand and supply curves, with the functional forms $Q = a_d P^{\eta_d}$ and $Q = a_s P^{\eta_s}$ respectively.

Table 3.8. Estimates of own-price demand and supply elasticities from literature.

Own-price demand elasticity	Source
-0.341	Kaiser, 2022
-1.26	Okrent, and Alston, 2012
-1.03	Rahman, Amin, and Palash, 2019
-1.315	Tonsor and Lusk, 2021
Own-price supply elasticity	
0.15	Suh and Moss, 2017
0.182	Kaiser, 2022

We use data for average pork sale price and volume to calibrate the values of a_d and a_s, which are 110.55 (for D_0) and 18.29 (for S_0) respectively. At the time of the survey (January 2023), the composite retail price of pork was $4.76 per pound (NPCC, 2023). In 2022, the per capita consumption of pork in the U.S. stood at about 51 pounds per year (Shahbandeh, 2023), equivalent to a total of approximately 17 billion pounds per year. About 25% of the U.S. pork production was exported in 2021 (Cool and Schulz, 2022), representing approximately 6.6 billion pounds of the pork produced in 2022. We use this data to calculate the demand and supply functions, as well as the prices and quantities that would be realized if there is an ASF outbreak.

In the previous section, we estimate that following an ASF outbreak, the demand for unprocessed pork (processed pork) would shift downward along the price axis by 32.31% (30.38%), as shown in Table 3.7. For estimating welfare implications for the composite pork market, we use a reduction in demand of 31.35%, an average of the two estimates. In calculating the shift in the demand and supply curves, we assume that the elasticity estimates remain unchanged, and that as an immediate impact of the outbreak, the entire quantity that was being exported is now available in the domestic market. This allows us to calculate the change in consumer, producer, and total surplus resulting from an ASF outbreak. We estimate the consumer surplus as $\int_{P_i}^{\infty} D(P)dP$ and the producer surplus as $\int_{0}^{P_i} S(P)dP$ for each price point and use these to obtain the changes in consumer and producer surplus. The estimates of the welfare implications associated with an increase in supply and reduction in demand for pork following an ASF outbreak is presented in Table 3.9.

In the first scenario, where the domestic supply of pork increases following an ASF outbreak and demand remains unchanged, consumer surplus increases by $23.01 billion and producer surplus decreases by $23.37 billion. Therefore, the total surplus decreases by $0.36 billion. In the second scenario, where the demand for pork decreases in addition to the increase in the domestic supply of pork, consumer surplus decreases by $24.11 billion and producer surplus decreases by $31.35 billion. Therefore, the total surplus decreases by $55.46 billion. Although there is a decrease in total surplus in both scenarios, it is significantly larger in the scenario that accounts for a reduction in demand.

Table 3.9. Estimates of welfare implications for the pork market associated with an outbreak of ASF.

	Scenario	Price ($/lb)	ΔCS	ΔPS	ΔTS
(1)	$S_0 \rightarrow S_1$ $D_0\ unchanged$	$P_0 = 4.76$ $P_1 = 3.61$	23.01	-23.37	-0.36
(2)	$S_0 \rightarrow S_1$ $D_0 \rightarrow D_1$	$P_0 = 4.76$ $P_2 = 3.27$	-24.11	-31.35	-55.46

Note: ΔCS, ΔPS, and ΔTS are reported in billion dollars.

Though the welfare loss for pork consumers is large in the second scenario, this can be considered as the gross welfare effect limited to the pork market since this is a partial equilibrium analysis. Pork consumers can be expected to substitute to other markets like beef and poultry which will attenuate their overall loss. Nonetheless, the large decline in consumer welfare draws attention to the limited awareness of ASF in the U.S. and its consequences for the pork industry. It may be likely that consumer welfare impacts may be even greater if changes in demand are driven by misinformation. The welfare outcomes reiterate policy implications for information dissemination to pork consumers as well as for consideration of spillover effects into substitute markets like beef and poultry. However, the public intervention programs themselves may result in different welfare outcomes in the pork market considering the misperception of risks by consumers (Salanié and Treich 2009). Findings from Salanié and Treich (2009) would imply that risk misperceptions regarding ASF would justify increased prevention efforts for consumers which might reduce their ability to adequately respond to the actual risk associated with the outbreak, thereby creating ambiguity in social welfare outcomes.

At the same time, welfare loss for pork producers increases in the second scenario as compared to the first, exacerbating the losses they stand to face due to the outbreak. Producers might have to manage unsold herds of swine in addition to other preventive measures like improved biosecurity, thus confronting losses even if their herd is not infected with ASF. Welfare loss for the producers would be even greater if their herd gets infected because of which the pigs die or are culled, an outcome that we do not consider in this study. Such an outcome is likely to make the recovery of the pork sector even more challenging. Particular regions in the U.S. may be more adversely impacted since pork production is concentrated within few states like Iowa, Minnesota, and North Carolina (USDA NASS 2023). The number of hog operations continues to decline over the last two decades alongside an increase in the farm size (Schulz 2023) with over 90% of all hogs being raised on farms with 2000 or more hogs (NPCC n.d.). This could have distributional impacts for producers in terms of the losses associated with an ASF outbreak and negative economic impacts in the counties where production is concentrated, a factor that this study does not consider.

The welfare loss that we estimate is based on the assumption that the entire quantity for export would be available in the domestic market and that both the upward shift in supply and the downward shift in demand would be observed over a one-year period. But both the extent and duration of the drop in U.S. pork meat exports after an ASF outbreak are subject to uncertainty. During the 2014–2019 period, ASF was introduced into several member states in the European Union, including the Baltic states and Poland

(2014), Czech Republic and Romania (2017), Belgium, Bulgaria, and Hungary (2018), and Slovakia (2019). Niemi (2020) estimated that ASF reduced the exports of pig meat by close to 15% on average in these eleven countries.

The first case of another OIE notifiable disease, bovine spongiform encephalopathy (BSE), on May 20, 2003, in Alberta (Canada) had a more drastic impact on the value of exports of beef as they plunged to almost zero in the three months following the ban in May. This drop was only observed for three months as exporters adjusted to pre-ban levels in August 2003 (Boame, Parsons, and Trant, 2009). A similar discovery of a single reported case of BSE on in the United States was confirmed on December 23, 2003. Many governments had imposed import bans on U.S. beef exports, causing a sharp decline of 83 percent from December 2003 to January 2004. But the United States only surpassed the pre-BSE exports levels of beef meat and beef offal for the first time in 2011 (Taha and Hahn, 2014).

It is also important to note that these welfare estimates are sensitive to the parameters of the demand and supply functions as well as the respective elasticities. Research suggests that the own-price demand elasticity estimates vary significantly across pork products. Tonsor and Lusk (2021) find elasticity estimates for bacon (-0.87), breakfast sausage (-3.29), loin (-1.145), and ribs (-2.516), and report that they vary significantly across the states. This suggests that welfare implications for from the ASF outbreak would differ for the unprocessed and processed pork markets as well as across states in the U.S. Our estimates for welfare changes provide a benchmark that incorporates demand changes for both unprocessed and processed pork consumers and is representative of the U.S. population.

3.7. Conclusion

The recent global outbreak of ASF has grown to become the largest animal disease outbreak in the world and have raised the risk of outbreaks in countries like the U.S. which have otherwise been disease-free. An immediate impact of an ASF outbreak in the U.S., the largest pork exporting country globally, would be a reduction of export, thereby increasing domestic pork supply and pushing down prices in the short run. While ASF is almost completely fatal for the swine population, it is not a food safety concern and consumption of pork products following an outbreak is completely safe. However, given consumers' concerns of food safety and limited awareness of ASF in the U.S., in this research we examine whether the ASF outbreak would lead to a downward shift in demand for pork and the welfare implications such a shift may have on the pork market. Additionally, we examine the awareness of ASF in the U.S. pork consumers and whether learning about the disease from different news sources affects their consumption behavior in the event of an outbreak.

We conducted an online survey in January 2023 that was representative of the U.S. population to collect data on pork consumption preferences in the U.S. We observed that about three-quarters of pork consumers were largely uninformed about ASF and believed that it posed a risk to human health. Additionally, about a fourth of the survey respondents would not be willing to purchase pork at any price if there is an ASF outbreak. We find that consumers who receive news about ASF from a government institution (e.g., CDC), as opposed to from the news media or producers, are less likely to stop consumption of pork following an ASF outbreak. Using the one-and-one-half-bound dichotomous choice contingent valuation approach, we find that the ASF outbreak results in a downward shift in demand by 32.31% (30.38%) for unprocessed pork (processed pork) products. The resulting welfare loss is $24.11 billion for pork consumers and $31.35 billion for the producers.

In addition to the potentially larger losses for pork producers, findings from this study have important implications for the pork sector pertaining to awareness about ASF and concerns of food safety. While some prior research has estimated the impacts of an ASF outbreak in the U.S. pork sector that is largely driven by impacts to producers, our results suggest that the estimated economic losses are likely underestimated if the possible reduction in demand is not considered. Considering that the average U.S. pork consumers is likely uninformed about ASF, proper communication about the disease and related messages of food safety would be critical in minimizing concerns of food safety and rumors in consumers as well as losses to the pork sector.

The findings from this study also emphasize the need for future research that examines in more detail the spillover effects of the reduction in pork demand to auxiliary industries like feed, processing, and transportation. Our model does not consider the possibility of an increase in demand for pork by consumers resulting from a decrease in the price, an outcome that can be further examined. Another avenue of further research that would have important implications for the pork sector would be to examine the duration of the reduction in demand and the time it might take for the demand to return to the pre-outbreak level. In estimating the welfare outcomes of an ASF outbreak, we have not considered the scenario where swine herds die and/ or get culled because they get infected. This would result in further welfare losses for the producers and could be examined through an upward shift of the supply curve.

Conclusions

This dissertation examined contemporary and interrelated topics of food systems economics, with particular focus on three issues: the adoption of school nutrition policies, the relationship of community resources and state policies with local foods promotion programs, and the role of food safety information in affecting economic welfare. Several key findings have emerged with implications for public policy, community development, and individual well-being, underscoring the significance of addressing these issues.

The first chapter was an examination of policy factors associated with the adoption of the Community Eligibility Provision (CEP) by eligible school districts in the U.S. The research employed a conceptual framework rooted in the literature on policy adoption and diffusion to identify factors associated with the adoption of CEP at the school district level. Subsequently, a Cox regression model was utilized to derive empirical estimates of these associations. This research is the first to provide a longitudinal, school district-level analysis of the factors associated with CEP adoption and does so by developing a novel dataset on program adoption and associated factors. The empirical analysis revealed that the "identified student percentage" (ISP) of a school district and the state's rate of "direct certification" were positively correlated with increased adoption of CEP by school districts. The ISP serves as an indicator of the poverty level within a school or school district, determining eligibility for the program and the program reimbursement, while direct certification refers to the method of certifying students for free meals based on secondary records.

The findings from this study carry important policy implications for states that are considering implementing universal free school meal legislation, providing insights into federal and state policy levers that may be successful in increasing participation in CEP. The likelihood of CEP adoption was significantly higher for school districts at or above an ISP of 62.5% (which has a multiplier of 1.6, equating to being reimbursed for all meals served), implying that any increase in the reimbursement multiplier would increase CEP adoption. This is important information for advocates and policymakers as the proposed Child Nutrition Reauthorization bill aims to increase the uptake of CEP by making changes to the ISP and the associated reimbursement rate. Recent studies have shown that using Medicaid data for direct certification in states increases the number of students directly certified, and the results from this study demonstrate that such an outcome would likely increase CEP adoption, thereby providing a strong argument in favor of the process. While the findings were robust under different specifications, they did not have causal implications.

The second chapter used the U.S. Department of Agriculture's 2019 Farm to School (FTS) Census, a new disaggregated database on state legislation supporting FTS activities, and a new comprehensive dataset of community assets to assess the relationships between the intensity of participation in FTS, stocks of community wealth, and state FTS policies. The study adapted the conceptual framework of wealth creation developed by Pender, Marré, and Reeder (2012) to contextualize these relationships. A measure of FTS intensity, an index designed to show where a particular School Food Authority (SFA) falls on a scale ranging from lesser to higher degree of FTS participation was created, calculated based on responses that the SFAs provided in the 2019 FTS Census. Using the two-step Heckman selection model, the research included an econometric analysis to test the associations between community wealth and state FTS policies with an SFA's probability and intensity of participation in FTS. Furthermore, the analysis extended the Heckman model to examine whether there are any spatial effects in program participation.

Results show positive associations between components of cultural and social capital and FTS intensity, highlighting nonmarket local assets that are often overlooked in community development programs. Further, results demonstrate that different types of FTS policies were associated with differences in FTS intensity; procurement policies had positive associations and education policies had negative associations. These results provide rationale for more nuanced consideration of the types of FTS policy and local assets by policymakers and community economic developers. Despite the limitations of the empirical model, this research is the first to examine the association of FTS and community assets, and the first to use disaggregated variables for FTS policy to study its impact on program outcomes.

The final chapter used an online survey experiment following the one-and-one-half-bound dichotomous choice contingent valuation approach to estimate changes in demand for pork products in case of an African Swine Fever (ASF) outbreak in the U.S. The survey was conducted in January 2023 and included 1,519 responses that provided information about pork consumption preferences separately for unprocessed and processed pork products, prior awareness about ASF, and sources of information for food safety issues. The respondents were presented with a news article about ASF from one of three news sources selected at random following which they were informed about a hypothetical outbreak of ASF in the U.S. The subsequent willingness to pay responses were used to estimate the extent of shift in demand following the ASF outbreak and the welfare implications associated with it.

The results showed that approximately three-quarters of all pork consumers were uninformed about ASF, and believed that it was a food safety concern, despite being informed otherwise in the survey. Additionally, about a fourth of the survey respondents were unwilling to purchase pork at any discounted price if there was an ASF outbreak. Using an economic model of domestic and global demand and supply for U.S. pork, coupled with the willingness to pay estimates, findings show that demand would shift downward by 32% (30%) for unprocessed (processed) pork products following an ASF outbreak. This resulted in a welfare loss of $24.11 billion for pork consumers and $35.35 billion for the producers. Survey results show that the majority of consumers would substitute pork consumption with beef and poultry which would lessen the overall welfare loss. Lastly, results show that individuals who received information about ASF from government institutions, such as the Centers for Disease Control and Prevention, were less inclined to discontinue pork consumption following an outbreak, compared to those who received information from the news media or producers. While the findings are based on survey responses to a hypothetical outbreak of ASF, this study is a first to provide comprehensive insights into changes in the U.S. pork market outcomes resulting from an ASF outbreak, and effective ways of informing consumers about the disease. Further, it examines changes in consumption behavior separately for unprocessed and processed pork products.

This dissertation examined key aspects within food systems economics, with a specific focus on local foods, school nutrition policies, and consumer behavior. The three chapters also present several opportunities for future research as more states are introducing policies to adopt universal free school meal programs and advance farm to school programming, and as the U.S. braces for a possible outbreak of ASF.

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Appendices

A: Calculating the Farm to School (FTS) Intensity Variable

We organized the Farm to School (FTS) activities listed in the U.S. Department of Agriculture's Food and Nutrition Service's (USDA FNS's) 2019 FTS Census into three broad categories and further subcategories based on the core objectives of FTS, the research goals, and in consultation with the Advisory Committee for this USDA-funded research. The three categories are: (i) procurement and procurement-related activities, (ii) education activities, and (iii) staffing support for FTS activities. From these three categories we obtain estimates of 'procurement intensity', 'education intensity', and 'staffing' respectively, and add them up to obtain the estimate for the overall 'FTS intensity'.

First, we define the procurement intensity (*proc_int*). We start by defining *proc_local*, which aggregates the activities focusing on procuring and serving local foods in school cafeterias and procurement of local foods through DoD Fresh (see Table A1 for a description of the variables used) as well as expenditure on any local foods by the School Food Authority (SFA) and the frequency of serving local foods in the school cafeterias (see Table A2 for a description of the variables used). In considering purchase of local foods, since schools may be limited by the availability of these foods in the region, we count the reported purchase of either fruits, vegetables, protein, or grain towards *proc_local*, and the maximum reported frequency of either local food category.

We include some activities of education and promotion in calculating procurement intensity instead of education intensity since they are closely linked with procurement of local foods. For example, taste tests of local foods will happen in schools if they are procuring local foods. For the education and promotion activities in procurement, if the SFAs are participating in at least one of the activities, they get counted towards *proc_edu*. Similarly, for the strategic activities in procurement, if the SFAs are participating in at least one of the activities, they get counted towards *proc_str*. Finally, we add the four components of procurement and procurement-related activities to obtain procurement intensity. Higher participation in the different categories of activities translates into higher intensity of FTS.

Table A1. Activities from the 2019 FTS Census used for categorizing procurement activities in FTS intensity.

Category	Subcategory	Variable	Description	Value
(i) Procurement and procurement-related activities (14 activities)	Sourcing local foods	Q4_i_6	Source local foods from USDA Department of Defense Fresh	=1 if 'yes' =0 otherwise
	Serving local foods activity	Q4_i_1	Use local foods in any form (e.g., fluid milk, fresh, frozen, or dried products, and more) in the National School Lunch Program	=1 if 'yes' =0 otherwise
		Q4_i_2	Use local foods in any form (e.g., fluid milk, fresh, frozen, or dried products, and more) in the School Breakfast Program	=1 if 'yes' =0 otherwise
		Q4_i_3	Serve local foods as a snack (in the classroom, sold a la carte, at fundraisers, etc.)	=1 if 'yes' =0 otherwise
	Education activity directly related to procurement	Q4_i_11	Hold taste tests/cooking demonstrations of local or garden-grown foods in the cafeteria, classroom, or other school-related setting	=1 if 'yes' =0 otherwise
		Q4_i_13	Implement strategies to encourage student selection and consumption of local foods (e.g., product placement, food prompts, creative signage, etc.)	=1 if 'yes' =0 otherwise
		Q4_i_14	Use cafeteria food coaches to promote the consumption of local foods (e.g., adults or students in the cafeteria encouraging kids to eat local foods)	=1 if 'yes' =0 otherwise
	Promotion activity directly related to procurement	Q4_i_21	Promote local foods through themed or branded promotions (e.g., Harvest of the Month, Local Day, Taste Washington Day, etc.)	=1 if 'yes' =0 otherwise
		Q4_i_22	Promote local foods at school in general (e.g., via cafeteria signs, posters, newsletters, etc.)	=1 if 'yes' =0 otherwise
		Q4_i_23	Generate media coverage of local foods being used in schools	=1 if 'yes' =0 otherwise
	Strategy to facilitate and assist in procurement	Q4_i_12	Work with local food producers to develop specific food products using local foods	=1 if 'yes' =0 otherwise
		Q4_i_27	Seek out sources to procure local food	=1 if 'yes' =0 otherwise
		Q4_i_28	Forecast budgetary needs for local purchases	=1 if 'yes' =0 otherwise
		Q4_i_29	Utilize the geographic preference option to purchase local foods	=1 if 'yes' =0 otherwise

Note: Categories and sub-categories created by authors.
Source: U.S. Department of Agriculture's Food and Nutrition Service's 2019 Farm to School Census.

proc_int = proc_local + proc_edu + proc_prom + proc_str , where:

(i) proc_local = (Q4_i_1 + Q4_i_2 + Q4_i_3) + (Q4_i_6) + [either (fruit, veg, protein, grains) = 1] [$local/$total] + [max(fruitfreq, vegfreq, proteinfreq, grainsfreq)]

(ii) proc_edu = 1 ; if either (Q4_i_11, Q4_i_13, Q4_i_14) = 1

(iii) proc_prom = 1 ; if either (Q4_i_21, Q4_i_22, Q4_i_23) = 1

(iv) proc_str = 1 ; if either (Q4_i_12, Q4_i_27, Q4_i_28, Q4_i_29) = 1

Table A2. Components of local foods served and expenditure on local foods from the 2019 FTS Census.

Variable	Description	Value
Q34_a (fruit)	Fruit: SFA purchased local food or plans to	=1 if ‘yes’ =0 otherwise
Q34_b (veg)	Vegetables: SFA purchased local food or plans to	=1 if ‘yes’ =0 otherwise
Q34_e (protein)	Protein: SFA purchased local food or plans to	=1 if ‘yes’ =0 otherwise
Q34_f (grains)	Grains, including baked goods: SFA purchased local food or plans to	=1 if ‘yes’ =0 otherwise
Q36_a (fruitfreq)	Frequency of including local fruits in meals or snacks	=1 if ‘daily’, =1/2 if ‘a few times per week’, =1/5 if ‘weekly’, =1/10 if ‘a few times per month, =1/20 if ‘monthly’, =1/40 if ‘occasionally’, =0 if ‘never’
Q36_b (vegfreq)	Frequency of including local vegetables in meals or snacks	
Q36_e (proteinfreq)	Frequency of including local protein in meals or snacks	
Q36_f (grainsfreq)	Frequency of including local grains in meals or snacks	
Q37_1 ($total)	SY2018-2019 approximate total food costs	$ amount reported
Q38_1	SY2018-2019 approximate local food costs	$ amount reported
Q39_1	SY2018-2019 approximate local fluid milk costs	$ amount reported
Q38_1 – Q39_1 ($local)	Local food expenditure minus expenditure on local milk	$ amount reported

Note: Variables created using U.S. Department of Agriculture’s Food and Nutrition Service’s 2019 Farm to School Census.

Next, we define the intensity for education activities (*educ_int*), for each subcategory of education activities described in Table A3. This includes four components. First, activities involving participation in the school garden (*educ_garden*), second, participating in any agricultural education activities in the classroom and cafeteria (*educ_kids*), third, participating in any activities involving the community outside of schools (see Table A3 for description of variables), and fourth, density of school gardens in the SFA (*gprop*) (see Table A4 for description of variables). Higher participation in the different categories of activities translates into higher intensity of FTS. Lastly, we add the four components of education activities to obtain education intensity.

educ_int = educ_garden + educ_kids + educ_comm + gprop , where:

(i) educ_garden = [Q4_i_7 + Q4_i_16]

(ii) educ_kids = 1 ; if either (Q4_i_15 / Q4_i_18 / Q4_i_19) = 1

(iii) educ_comm = 1 ; if either (Q4_i_24 / Q4_i_25 / Q4_i_17 / Q4_i_30) = 1

(iv) gprop = Q29_1/ totalschools

Table A3. Activities from the 2019 FTS Census used for categorizing education activities in FTS intensity.

Category	Subcategory	Variable	Description	Value
(ii) Education activities (9 activities)	Garden-based activity	Q4_i_7	Serve products from school-based or district-based gardens/farms in any school meal, including summer and the Child and Adult Care Food Program	=1 if 'yes' =0 otherwise
		Q4_i_16	Conduct educational, edible school garden as part of a school, summer, or afterschool curriculum	=1 if 'yes' =0 otherwise
	Classroom and cafeteria education activities	Q4_i_15	Use USDA Team Nutrition materials (such as *The Great Garden Detective Adventure* or *Dig In!*) as part of taste testing or educational activities	=1 if 'yes' =0 otherwise
		Q4_i_18	Have farmer(s) visit the cafeteria, classroom, or other school-related setting	=1 if 'yes' =0 otherwise
		Q4_i_19	Integrate Farm to School activities (such as gardening and local foods education) into Pre-Kindergarten curriculum	=1 if 'yes' =0 otherwise
	Community awareness/education/ promotion activity	Q4_i_17	Conduct student field trips to farms, farmers' markets, producers, or processors	=1 if 'yes' =0 otherwise
		Q4_i_24	Host Farm to School-related family and community events (e.g., invite parents to lunch, corn shucking contests, farmers' markets at schools, etc.)	=1 if 'yes' =0 otherwise
		Q4_i_25	Celebrate National Farm to School Month (October)	=1 if 'yes' =0 otherwise
		Q4_i_30	Evaluate the impact of Farm to School activities (e.g., measuring changes in food waste, student acceptance of local items, changes in participation rates)	=1 if 'yes' =0 otherwise

Note: Categories and sub-categories created by authors.
Source: U.S. Department of Agriculture's Food and Nutrition Service's 2019 Farm to School Census.

Table A4. Components of school gardens and count from the 2019 FTS Census.

Variable	Description
Q29_1	How many schools in the SFA had gardens.
totalschools	Total number of schools in the district

Note: Variables created by authors using U.S. Department of Agriculture's Food and Nutrition Service's 2019 Farm to School Census.

Finally, we aggregate the intensity variables for procurement and education, weighted by proportion of schools in the SFA participating in the activities, and add the component of staffing to obtain the variable for overall FTS intensity (fts_int). See Table A5 and Table A6 for a description of the variables used.

$$fts\_int = proc\_int\ [\frac{Q24\_1}{totalschools}] + educ\_int\ [\frac{Q25\_1}{totalschools}] + staff$$

Table A5. Components of staffing from the 2019 FTS Census used for calculating FTS intensity.

Category	Subcategory	Variable	Description	Value
Staffing support for FTS activities	Availability of dedicated staff	Q46	Dedicated staff for FTS activities	=1 {if full-time staff dedicated to FTS activities =0.5 {if full-time/part-time staff spend some hours for FTS activities =0 {otherwise
	Training of staff	Q4_i_20	Provide training to school food service staff on Farm to School or school gardens	=1 if 'yes' =0 otherwise

Note: Variables created by authors using U.S. Department of Agriculture's Food and Nutrition Service's 2019 Farm to School Census.

Table A6. Components of school count and characteristics from the 2019 FTS Census.

Variable	Description
Q24_1	Number of schools served local food of any kind
Q25_1	Number of schools provided food, nutrition, or agricultural education

Source: U.S. Department of Agriculture's Food and Nutrition Service's 2019 Farm to School Census.

B: Variables Used to Generate Capital Stock Indices

Table B1. Variables included in principal component analysis to derive county-level capital stock indices.

Description of Variables	Source	Mean	S.D.	Minimum	Maximum
Built Capital					
Food & beverage manufacturing estab. per 10,000 people, 2015	U.S. Census Bureau (2014)	1.746	5.128	0.000	183.674
Other manufacturing estab. per 10,000 people, 2015	U.S. Census Bureau (2014)	10.637	31.225	0.000	1,084.711
% of population with access to fixed advanced telecomm., 2016	FCC (2016)	63.461	32.254	0.000	100.00
Inverse of population-weighted distance (km) to nearest interstate highway ramp, 2007	Dicken et al. (2011)	0.109	0.126	0.0.004	1.839
Cultural Capital					
% of workforce employed in the arts, 2013	U.S. Census Bureau (2015)	15.970	5.866	0.540	50.182
Author constructed racial diversity index from 0 (no diversity) to 10 (complete diversity), 2010	U.S. Census Bureau (2010)	3.392	2.211	0.191	9.159
Public libraries per 100,000 people, 2012	Kushner & Cohen (2018)	18.342	24.608	0.540	360.58
Creative industry businesses per 100,000 population, 2014	Kushner & Cohen (2018)	139.310	96.927	0.000	1,478.800
Museums per 100,000 people, 2015	Kushner & Cohen (2018)	25.072	30.192	1.110	686.500
Financial Capital					
Cash & security holdings less government debt per capita, 2012	U.S. Census Bureau (2012)	0.271	5.410	−262.276	64.933
Bank deposits per capita at FDIC-insured institutions, 2016	FDIC (2016)	22.084	50.176	0.000	2,362.710
Owner-occupied units without a mortgage per capita, 2012	U.S. Census Bureau (2015)	0.132	0.044	0.024	0.325
Human capital					
% of adult population with at least a Bachelor's degree, 2015	U.S. Census Bureau (2015)	21.098	9.281	2.434	75.069
Health Factors Z-Score, 2013	Robert Wood Johnson Foundation (2013)	0.005	0.471	−2.098	2.203
Health Outcome Z-Score, 2013	Robert Wood Johnson Foundation (2013)	0.008	0.710	−2.821	2.797

Description of Variables	Source	Mean	S.D.	Minimum	Maximum
% of population food secure, 2017	Robert Wood Johnson Foundation (2017)	85.353	4.121	62.500	95.700
% of population with health insurance, 2017	Robert Wood Johnson Foundation (2017)	82.873	6.190	53.989	96.724
Primary care physicians per 10,000 people, 2015	HRSA (2014)	5.467	3.505	0.000	65.441
Natural Capital					
Natural Amenities Scale, 1999	McGranahan (1999)	0.054	2.290	−6.400	11.170
% of farmland acres designated as prime, 2012	USDA NRCS (2012)	0.061	0.142	0.000	5.561
% of all acres under conservation easement, 2016	NCED (2016)	1.410	2.775	0.000	28.371
% of total acres in conservation programs and woodlands, 2017	USDA FSA (2017)	1.488	2.632	0.000	25.445
Percent of total acres in National Forests, 2017	USFS (2017)	4.734	12.471	1.111	93.595
Social Capital					
Social establishments per 1,000 people, 2014	Rupasingha et al., (2006)	1.379	0.703	0.000	6.887
% of eligible voters that voted, 2012	Rupasingha et al., (2006)	66.849	9.131	34.942-	111.596
% response rate to U.S. Population Census, 2010	Rupasingha et al., (2006)	70.505	11.161	0.000	95.000
Number of nonprofit organizations per 1,000 population, 2014	Rupasingha et al., (2006)	6.923	19.466	0.000	757.655

Source: Schmit, Todd M., Becca BR Jablonski, Alessandro Bonanno, and Thomas G. Johnson. "Measuring stocks of community wealth and their association with food systems efforts in rural and urban places." Food Policy 102 (2021): 102119. https://doi.org/10.1016/j.foodpol.2021.102119

C: Additional Regression Results (Chapter 2)

Table C1. Regression results of the association between FTS intensity and the stocks of community wealth and state FTS policies, given the school food environment.

Variables	FTS Participation Estimated Coefficient	Average Marginal Effects	FTS Intensity Partial Effects
Stocks of Community Wealth			
Built capital – manufacturing	0.009 (0.016)	0.003 (0.005)	0.051 (0.064)
Built capital - infrastructure	-0.003 (0.002)	-0.001 (0.001)	-0.002 (0.008)
Cultural capital – arts and diversity	0.017** (0.007)	0.005** (0.002)	-0.016 (0.024)
Cultural capital – creative industries	0.009*** (0.003)	0.003*** (0.001)	0.032** (0.012)
Financial capital – finance	-0.006 (0.013)	-0.002 (0.004)	-0.032 (0.041)
Human capital – health and education	-0.002 (0.002)	-0.001 (0.001)	0.010 (0.006)
Human capital – food security and medical services	0.006*** (0.002)	0.002*** (0.001)	-0.003 (0.008)
Natural capital – natural amenities and conservation	0.000 (0.002)	0.000 (0.001)	0.006 (0.006)
Natural capital - farmland	0.030*** (0.011)	0.010*** (0.003)	-0.022 (0.036)
Social capital – nonprofit and social establishments	-0.020** (0.008)	-0.006** (0.002)	0.086*** (0.032)
Social capital – public voice and participation	0.005*** (0.002)	0.002*** (0.001)	-0.011 (0.008)
State FTS Policies			
Procurement policies	0.092*** (0.017)	0.030*** (0.005)	0.124* (0.064)
Education policies	-0.088*** (0.027)	-0.029*** (0.008)	-0.292*** (0.102)
Other policies	0.016 (0.012)	0.005 (0.003)	0.041 (0.041)
Challenges in FTS			
Vendor challenges	-0.067** (0.027)	-0.022** (0.008)	0.149 (0.102)
Price and purchase challenges	0.130*** (0.029)	0.042*** (0.009)	0.020 (0.113)
Kitchen challenges	-0.174*** (0.023)	-0.057*** (0.007)	0.293*** (0.100)
SFA Characteristics			
log (SFA size)	0.199*** (0.011)	0.065*** (0.003)	-0.029 (0.072)
Free and reduced-price meals	-0.005 (0.016)	-0.002 (0.005)	0.168*** (0.058)
Urbanicity [a]			
RUCC 2 (medium metro)	0.110** (0.047)	0.036** (0.015)	0.101 (0.167)
RUCC 3 (small metro)	0.173*** (0.061)	0.056*** (0.019)	0.155 (0.217)
RUCC 4 (nonmetro, adjacent to metro with large town)	0.083 (0.069)	0.029 (0.023)	0.337 (0.250)
RUCC 5 (nonmetro, not adjacent to metro with large town)	0.096 (0.096)	0.033 (0.031)	0.316 (0.357)
RUCC 6 (nonmetro, adjacent to metro with small town)	0.162** (0.073)	0.053** (0.023)	0.063 (0.265)
RUCC 7 (nonmetro, not adjacent to metro with small town)	0.065 (0.081)	0.022 (0.026)	-0.038 (0.298)
RUCC 8 (nonmetro, adjacent to metro, completely rural)	0.064 (0.122)	0.021 (0.040)	0.662 (0.457)
RUCC 9 (nonmetro, not adjacent to a metro area, completely rural)	-0.007 (0.113)	-0.002 (0.037)	-0.028 (0.424)
Fresh Fruit and Vegetable Program			
FFVP [b]	0.418*** (0.037)	0.131*** (0.011)	
Constant	-1.353 (1.042)		8.153** (3.331)
R^2			0.087
Inverse Mills Ratio			-4.051*** (0.590)

Note: N = 8,162 (2,631 censored and 5,531 observed). ***, **, and * represent coefficients statistically different from 0 at the 1%, 5%, and 10% significance level, respectively. Standard errors in parentheses. Standard errors in the outcome equation have been corrected for selection bias. The inverse Mills ratio is defined as a ratio of the standard normal density function and the standard normal distribution function of the first stage model.

[a] Represented by the USDA Rural Urban Continuum Codes (RUCCs). Excluded RUCC category 1 (large metropolitan).

[b] Participation in the Fresh Fruit and Vegetable Program as exclusion restriction.

Table C2. Regression results of the association between FTS intensity and the stocks of community wealth and state FTS policies, given the school food environment, including the SFA Nassau BOCES.

Variables	FTS Participation Estimated Coefficient	Average Marginal Effects	FTS Intensity Partial Effects
Stocks of Community Wealth			
Built capital – manufacturing	0.007 (0.016)	0.002 (0.005)	0.052 (0.064)
Built capital - infrastructure	-0.003 (0.002)	-0.001 (0.001)	-0.002 (0.008)
Cultural capital – arts and diversity	0.016** (0.007)	0.005** (0.002)	-0.018 (0.024)
Cultural capital – creative industries	0.010*** (0.003)	0.003*** (0.001)	0.031** (0.012)
Financial capital – finance	-0.008 (0.013)	-0.002 (0.004)	-0.030 (0.041)
Human capital – health and education	-0.002 (0.002)	-0.001 (0.001)	0.010 (0.006)
Human capital – food security and medical services	0.006*** (0.002)	0.002*** (0.001)	-0.004 (0.008)
Natural capital – natural amenities and conservation	0.000 (0.002)	0.000 (0.001)	0.007 (0.006)
Natural capital - farmland	0.029*** (0.011)	0.009*** (0.003)	-0.022 (0.036)
Social capital – nonprofit and social establishments	-0.020** (0.008)	-0.006** (0.002)	0.088*** (0.032)
Social capital – public voice and participation	0.006*** (0.002)	0.002*** (0.001)	-0.012 (0.008)
State FTS Policies			
Procurement policies	0.090*** (0.017)	0.029*** (0.005)	0.123* (0.064)
Education policies	-0.092*** (0.027)	-0.030*** (0.008)	-0.293*** (0.102)
Other policies	0.018 (0.012)	0.006 (0.003)	0.042 (0.042)
Challenges in FTS			
Vendor challenges	-0.065** (0.027)	-0.022** (0.008)	0.164 (0.102)
Price and purchase challenges	0.129*** (0.029)	0.042*** (0.009)	0.016 (0.114)
Kitchen challenges	-0.175*** (0.023)	-0.057*** (0.007)	0.283*** (0.100)
SFA Characteristics			
log (SFA size)	0.199*** (0.011)	0.065*** (0.003)	-0.033 (0.072)
Free and reduced-price meals	-0.006 (0.016)	-0.002 (0.005)	0.160*** (0.058)
Urbanicity [a]			
RUCC 2 (medium metro)	0.111** (0.047)	0.037** (0.015)	0.102 (0.168)
RUCC 3 (small metro)	0.170*** (0.061)	0.055*** (0.019)	0.156 (0.218)
RUCC 4 (nonmetro, adjacent to metro with large town)	0.088 (0.069)	0.029 (0.023)	0.344 (0.250)
RUCC 5 (nonmetro, not adjacent to metro with large town)	0.100 (0.096)	0.033 (0.031)	0.305 (0.358)
RUCC 6 (nonmetro, adjacent to metro with small town)	0.175** (0.072)	0.057** (0.023)	0.066 (0.266)
RUCC 7 (nonmetro, not adjacent to metro with small town)	0.082 (0.081)	0.027 (0.026)	-0.011 (0.298)
RUCC 8 (nonmetro, adjacent to metro, completely rural)	0.073 (0.122)	0.024 (0.040)	0.651 (0.458)
RUCC 9 (nonmetro, not adjacent to a metro area, completely rural)	0.024 (0.112)	-0.008 (0.037)	-0.054 (0.421)
Fresh Fruit and Vegetable Program			
FFVP [b]	0.418*** (0.037)	0.131*** (0.011)	
Constant	-1.354 (1.042)		8.166** (3.334)
R^2			0.086
Inverse Mills Ratio			-4.094*** (0.590)

Note: N = 8,163 (2,631 censored and 5,532 observed). ***, **, and * represent coefficients statistically different from 0 at the 1%, 5%, and 10% significance level, respectively. Standard errors in parentheses. Standard errors in the outcome equation have been corrected for selection bias. The inverse Mills ratio is defined as a ratio of the standard normal density function and the standard normal distribution function of the first stage model.

[a] Represented by the USDA Rural Urban Continuum Codes (RUCCs). Excluded RUCC category 1 (large metropolitan).

[b] Participation in the Fresh Fruit and Vegetable Program as exclusion restriction.

D: Survey (Chapter 3)

1. Have you consumed pork (example: chops, ribs, bacon, ham) in the last year?

   (Survey instruction: This is a screening question. Only those who respond with a "yes" in this question will proceed with the survey.)

   - Yes
   - No

2. Over the past one year, how often did you consume un-processed pork products (example: chops, ribs, loin)?

   - At least once a day
   - At least once a week
   - About once a month
   - Less than once a month
   - Never

3. Over the past one year, how often did you consume processed pork products (example: bacon, ham, sausages)?

   - At least once a day
   - At least once a week
   - About once a month
   - Less than once a month
   - Never

4. How important for you is lower cost versus improved food safety while purchasing food? Please mark, on a scale of 1 to 3, where **1 means lower prices of food is most important** and **3 means food safety is most important**.

   - 1 - Lower food prices is most important
   - 2 - Food price and safety equally important
   - 3 - Food safety is most important

5. Have you had any incidents of sickness from food-borne illness in the last two years?
    - Yes
    - No
    - Cannot say

The next section of the survey will discuss African Swine Fever, which is a disease that affects pigs.

6. (Survey instruction: Below are three separate news announcements. Present each announcement to one-third of the respondents in a random order):
    - Please read the following announcement related to African Swine Fever:

      African Swine Fever (ASF)

      African swine fever is a highly contagious and deadly viral disease affecting both domestic and feral swine of all ages. ASF is not a threat to human health and cannot be transmitted from pigs to humans. It is not a food safety issue.

      ASF is found in countries around the world. More recently, it has spread to the Dominican Republic and Haiti. ASF has also spread through China, Mongolia, and Vietnam, as well as within parts of the European Union. It has never been found in the United States – and we want to keep it that way.

      Source: U.S. Department of Agriculture, Animal and Plant Health Inspection Service (USDA APHIS)

      Learn more at: https://www.aphis.usda.gov/aphis/ourfocus/animalhealth/animal-disease-information/swine-disease-information/african-swine-fever/seminar#:~:text=African%20swine%20fever%20is%20a,in%20countries%20around%20the%20world.
    - Please read the following announcement related to African Swine Fever:

      African Swine Fever (ASF)

      The U.S. Department of Agriculture announced that the Dominican Republic (DR) has confirmed cases of African swine fever (ASF). The cases were confirmed as part of a cooperative surveillance program between the United States and the DR. The United States remains free of ASF – an animal disease affecting only pigs with no human health implications – and imports no pork, animal feed or other pork production-related products from the Dominican Republic.

"The United States has significantly bolstered biosecurity to protect the U.S. swine herd since ASF broke in China nearly three years ago and began spreading to other parts of the world," said Liz Wagstrom, chief veterinarian with the National Pork Producers Council.

Source: National Pork Producers Council (NPPC)

Learn more at: https://www.nppc.org/asf

- Please read the following announcement related to African Swine Fever:

  African Swine Fever (ASF)

  Al has 28,000 pigs spread out across 16 sites in northeast Iowa. Biosecurity is top of mind for him and other pork producers after African Swine Fever, a highly contagious viral disease in pigs, was confirmed in Haiti and the Dominican Republic over the summer of 2021.

  The highly contagious and deadly disease affects both domestic and feral (wild) pigs and there is no treatment or vaccine available for it. USDA is monitoring the recent outbreaks of ASF is Asia and Europe and has proactively taken steps to increase our safeguarding efforts to keep the disease out of the United States.

  African swine fever does not affect human health, and it is not a food safety issue. It cannot be transmitted from pigs to humans.

  Source: NPR via Iowa Public Radio

  Learn more at: https://www.kcur.org/2022-02-14/as-african-swine-fever-plagues-other-countries-the-u-s-works-to-keep-it-out

7. Consider the following **hypothetical situation**:

Suppose there is a widespread outbreak of African Swine Fever (ASF) in the United States. Hog farms where the outbreak occurs report the death of their pigs and confirm the outbreak. The pork supply chain is likely to include meat from hogs that were infected with the virus.

Please answer the following questions regarding your purchase of pork. Please try and answer as close as possible to your actual response that you anticipate in the case of an outbreak of ASF. Your responses continue to be anonymous.

8. For the two categories pork products listed next, please decide whether you are willing to pay the price that is indicated to purchase the product. The categories of pork include:
   - Un-processed pork products like chops, ribs, and loin.
   - Processed pork products like bacon and ham.

9. Would you be willing to purchase **un-processed pork products (example: chop, ribs, and loin)** during an outbreak of African Swine Fever if it is offered at the **same price as before** the outbreak?
   - Yes
   - No

10. (Survey instruction: For the respondents who select "No" in question 9, present each price discount to one-third of the respondents in a random order. There are a total of three discounts.):
    - Would you be willing to purchase **un-processed pork products (example: chop, ribs, and loin)** during an outbreak of African Swine Fever if it is offered at a **price 25% lower** than before the outbreak?
      i. Yes
      ii. No
      iii. Not purchase pork at any price
    - Would you be willing to purchase **un-processed pork products (example: chop, ribs, and loin)** during an outbreak of African Swine Fever if it is offered at a **price 50% lower** than before the outbreak?
      i. Yes
      ii. No
      iii. Not purchase pork at any price
    - Would you be willing to purchase **un-processed pork products (example: chop, ribs, and loin)** during an outbreak of African Swine Fever if it is offered at a **price 75% lower** than before the outbreak?
      i. Yes
      ii. No
      iii. Not purchase pork at any price

11. Would you be willing to purchase **processed pork products (example: bacon, ham)** during an outbreak of African Swine Fever if it is offered at the **same price as before** the outbreak?
    - Yes
    - No

12. (Survey instruction: For the respondents who select "No" in question 11, present each price discount to one-third of the respondents in a random order. There are a total of three discounts.):
    - Would you be willing to purchase **processed pork products (example: bacon, ham)** during an outbreak of African Swine Fever if it is offered at a **price 25% lower** than before the outbreak?
        i. Yes
        ii. No
        iii. Not purchase pork at any price
    - Would you be willing to purchase **processed pork products (example: bacon, ham)** during an outbreak of African Swine Fever if it is offered at a **price 50% lower** than before the outbreak?
        i. Yes
        ii. No
        iii. Not purchase pork at any price
    - Would you be willing to purchase **processed pork products (example: bacon, ham)** during an outbreak of African Swine Fever if it is offered at a **price 75% lower** than before the outbreak?
        i. Yes
        ii. No
        iii. Not purchase pork at any price

13. How would you describe your understanding of your personal health risk associated with African Swine Fever?
    - High risk
    - Some risk
    - No risk
    - Uncertain

14. What would you expect to purchase more of during an outbreak of African Swine Fever? Select all those that apply.
    - Would not purchase more of anything
    - Beef
    - Poultry
    - Lamb
    - Seafood
    - Non-meat food product
    - Other

15. How would you describe your knowledge about African Swine Fever prior to this survey?
    - Very knowledgeable
    - Moderately knowledgeable
    - Limited knowledge
    - Not informed

16. Please indicate your perception of the trustworthiness of the various sources of news and information about food-safety, and food diseases provided below:

	Trust Completely	Trust Somewhat	Neutral	Distrust	Strongly Distrust	Not Applicable
Television and radio news	○	○	○	○	○	○
Social media	○	○	○	○	○	○
Print media	○	○	○	○	○	○
Centers for Disease Control and Prevention (CDC)	○	○	○	○	○	○
Meat producers	○	○	○	○	○	○
Academic sources	○	○	○	○	○	○
Word of mouth	○	○	○	○	○	○

17. How do you describe yourself?
    - Male
    - Female
    - Non-binary / third gender
    - Prefer to self-describe __________
    - Prefer not to say

18. How old are you?
    - 18-24 years old
    - 25-34 years old
    - 35-44 years old
    - 45-54 years old
    - 55-64 years old
    - 65-74 years old
    - 75+ years old

19. Including you, how many members do you have living in your household?
    - 1
    - 2
    - 3
    - 4
    - 5
    - 6
    - 7
    - 8+

20. Are there children under the age of 18 and/ or adults above the age of 65 in your household? Select all those that apply:
    - Children under the age of 18
    - Adults above the age of 65
    - Neither children nor older adults

21. What is the highest level of education you have completed?

- Some high school or less
- High school diploma or GED
- Some college, but no degree
- Associates or technical degree
- Bachelor's degree
- Graduate or professional degree (MA, MS, MBA, PhD, JD, MD, DDS etc.)
- Prefer not to say

22. Which of the following best describes you?

- White or Caucasian
- Hispanic or Latino
- Black or African American
- Asian or Pacific Islander
- Native American or Alaskan Native
- Other
- Prefer not to say

23. What was your total household income before taxes during the past 12 months?

- Less than $25,000
- $25,000-$49,999
- $50,000-$74,999
- $75,000-$99,999
- $100,000-$149,999
- $150,000 or more
- Prefer not to say

(End of survey)

E: Coefficient Estimates from the One-and-One-Half Bound Model

Table E1. Coefficient estimates of the socio-demographic variables on mean relative willingness to pay for unprocessed and processed pork from the one-and-one-half bound model.

Variables	Unprocessed Pork	Processed Pork
Constant	-2.156**	-1.892**
	(1.018)	(0.962)
Bid	-2.730***	-2.619***
	(0.272)	(0.235)
log(income)	0.091	0.062
	(0.096)	(0.091)
Age	0.001	0.001
	(0.004)	(0.004)
Education	0.020	0.054
	(0.048)	(0.045)
Household size	-0.082	-0.012
	(0.055)	(0.052)
Female	-0.504***	-0.429***
	(0.126)	(0.118)
Children and/or old adults at home		
Children	0.142	0.128
	(0.175)	(0.164)
Old adults	-0.161	-0.065
	(0.169)	(0.160)
Children and old adults	0.647	0.313
	(0.353)	(0.337)
Neither children nor old adults (reference category)		
News source		
Media	-0.167	-0.027
	(0.147)	(0.139)
Producer	-0.101	-0.102
	(0.149)	(0.141)
Government (reference category)		
Mean relative willingness to pay [a]	0.3337	0.3746
Observations	1,519	1,519

Note: *** and ** represent coefficients statistically different from 0 at the 1% and 5% significance level, respectively. Standard errors in parentheses. For the summary statistics of the variables, see Table 3.2.

[a] Estimates obtained using equation (6).

Table E2. Coefficient estimates from the one-and-one-half bound model of the explanatory variables on mean relative willingness to pay (WTP) for respondents reporting non-zero WTP for pork, and high and low frequencies of pork consumption.

Variables	Unprocessed Pork High Frequency of Consumption	Low Frequency of Consumption	Processed Pork High Frequency of Consumption	Low Frequency of Consumption
Constant	1.289***	-0.368	01.422***	0.153
	(0.436)	(0.548)	(0.394)	(0.567)
Bid	-0.854***	-2.429***	-1.085***	-2.291***
	(0.301)	(0.415)	(0.272)	(0.433)
News source				
Media	-0.168	0.025	0.059	-0.220
	(0.207)	(0.232)	(0.186)	(0.259)
Producer	0.146	-0.126	0.087	-0.193
	(0.213)	(0.240)	(0.188)	(0.277)
Government (reference category)				
Prior food-borne illness				
Yes	0.433*	-0.093	0.127	0.098
	(0.243)	(0.335)	(0.221)	(0.361)
No (reference category)				
Unsure	1.005**	-0.609	0.299	-0.756
	(0.478)	(0.568)	(0.358)	(0.693)
Perceived health risk				
High risk	-1.409***	-1.721***	-1.443***	-1.741***
	(0.289)	(0.426)	(0.255)	(0.471)
Some risk	-0.527**	-0.680***	-0.466**	-0.635**
	(0.222)	(0.243)	(0.202)	(0.282)
No risk (reference category)				
Uncertain	-0.536**	-0.896***	-0.901***	-0.753**
	(0.267)	(0.264)	(0.227)	(0.306)
Prior ASF knowledge				
Very knowledgeable	1.651***	1.061**	1.224***	1.230**
	(0.348)	(0.496)	(0.323)	(0.583)
Moderately knowledgeable	0.574**	0.045	0.253	0.220
	(0.247)	(0.292)	(0.218)	(0.325)
Limited knowledge	0.195	-0.157	0.074	-0.125
	(0.228)	(0.231)	(0.193)	(0.259)
Not informed (reference category)				
Price vs safety [a]	-0.421***	-0.143	-0.317**	-0.132
	(0.143)	(0.155)	(0.124)	(0.180)
Mean relative willingness to pay [b]	0.8449	0.6810	0.8731	0.7660
Observations	582	592	763	413

Note: ***, **, and * represent coefficients statistically different from 0 at the 1%, 5%, and 10% significance level, respectively. Standard errors in parentheses. For the summary statistics of the variables, see Table 3.2.
[a] Continuous variable, increasing in preference for food safety over price of food.
[b] Estimates obtained using equation (7), modified to include respondents with non-zero willingness to pay.