AN EXAMINATION OF WHAT MIGHT BE DONE TO MOVE MODELING LOCAL FOODS FORWARD

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Abstract:

Local food systems have experienced a dramatic rise in prominence, although only a small percentage of food actually comes from these systems. That rise in prominence has come coupled with a renewed academic interest in modeling local foods within an economic development context. This research will identify the necessary steps for building a computable general equilibrium (CGE) framework. As CGE modeling describes the shifts a regional economy would experience if producers and consumers were to convert from common production agriculture to small, localized food systems, this thesis takes the position that in order to fully address economic benefits of local food systems, a CGE is necessary.

Once data requirements are resolved, the described model can examine economic tradeoffs of shifting the Oklahoma food supply to locally grown. With this model, research will be able to inquire whether or not the region would be economically better off if consumers bought an increased percentage of locally grown produce each year. An increase of both local food demand and supply are described as the primary drivers of the transition within the model.

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CHAPTER I

MOTIVATION AND BACKGROUND

Local food systems have achieved multi-disciplinary support as a way to abate declining rural populations and rising unemployment rates. Michael Pollan (2006), Wendell Berry (1996) and other popular authors call for an overhaul of modern-day agriculture so as to root production to local systems. Even some economists such as those at the Economics Institute of Loyola University – New Orleans (1999) indicate that buying locally is a potential way to take advantage of comparative advantage through import substitution. Coupled with growing consumer support of these systems (Gunter, 2011), these endorsements are motivating policymakers to examine the benefits to each locale that might come from local food systems. For example, all fifty states have a state-grown promotion program. Even federal programs, such as the Know Your Farmer, Know Your Food campaign, endeavor to harness the American desire to purchase locally grown foods.

Though these systems are dramatically rising in prominence, only 0.8% of all food comes from these systems (Gunter, 2011). As evidenced by the doubling of farmers' markets in recent years and the increase of participation in organizations such as the Oklahoma Food Cooperative (Holcomb and Kenkel, 2011), Oklahoma residents are requesting larger quantities of local foods, yet the state's current requesting larger quantities of local foods, yet the state's current production system would need to adapt to support greater demand. In fact, the 2007 Census of Agriculture assessed that less than four percent of the farms in Oklahoma participate in direct sales for human consumption (3.69%) or sell value-added products (3.34%). Furthermore, less than one half of one percent self-identify as involved in Community Supported Agriculture (0.33%). This data suggests that a minute percentage of Oklahoma producers are directly engaged in a local food system[1] . In light of these statistics, it seems that local food systems might have limited economic development impact, suggesting that its use as a development strategy might be misguided. This research strives to systemically define a suitable method of examining the regional economic benefits from local food systems. Before policymakers use public tax dollars to promote local food structures as an effective economic development tool, research should be able to address how local food systems fit with established economic concepts such as import substitution and export-based theory.

The local foods movement has been justified with many arguments. Advocates like Michelle Obama (Swarns, 2009) describe how local foods are healthier, higher in

[1] Local food systems have been defined by the 2008 Food, Conservation, and Energy Act as systems which specialize in producing and selling food within "less than 400 miles from its origin, or within the State which it is produced."(Martinez, 2010) For this research, local foods will be primarily defined as products grown and distributed within the state of Oklahoma.

quality, better for the environment, and even a stimulus for stagnant economies. The scope of this research will be limited to investigating the last claim: in what way could a model appropriately analyze whether local foods actually provide an overall economic benefit for a regional economy? While the social benefits of involving consumers in the agricultural marketing process have been amply listed, the concept of buying locally seems to imply a subtle distrust of Adam Smith's (1910) "invisible hand"[2] and of the benefits of trade.

Currently, the literature includes a collection of studies which aim to quantify the economic impacts of farmers' markets, farm-to-school programs, and other local food institutions. A few of these studies even account for various opportunity costs associated with the given programs. None, however, have considered how factors of production would need to be reallocated to promote local systems in agriculture; an issue which might potentially diminish or even eliminate these perceived economic gains. This thesis will provide a step toward assessing a more reasonable estimate of the gains to Oklahoma's economy which might be contributed by promoting local food systems within the state.

[2] In his book *An Inquiry into the Nature and Causes of the Wealth of Nations,* Smith suggests that an "invisible hand" guides each rationally self-interested individual to do what is best for the society as a whole.

Review of the Literature

In order for a local food system to be economically efficient,[3] there have to be unrealized comparative advantages within the community that import substitution could exploit. Put simply, the local economy has to produce a presently imported food more efficiently than the former import region. Cooke and Watson (2011) contend that import substitution might be a more effective economic development policy than export enhancement, because import substitution provides one extra benefit in comparison to export enhancement – a "deepening" of the local economy. This "deepening" by cause of import substitution creates larger purchases within the local economy, such as what might happen if a local bakery were to begin purchasing more of its wheat from a local farmer. Therefore, local foods might find legitimacy as a tool for economic development given the benefits generated by this positive economic augmentation.

Numerous studies have used static input-output models to attempt to quantify the economic growth some economists attribute to specific small-scale distribution channels. Many, however, do not consider the forgone costs involved with choosing a next-best alternative relative to the choice made to shop at farmers' markets or other direct distribution channels, or where the extra "dollar" comes from that is used to "shock" the input-output model. One study estimates the total economic benefits of Oklahoma farmers' markets to be $6 million in 2002 (Henneberry, Whitacre, & Agustini, 2009), but does not account for the reality that when consumers decide to make purchases at

[3] While there are many ways to evaluate the benefits to local food systems, this research will examine economic efficiency as defined by McConnell and Brue where, "the use of the minimum necessary resources to obtain the socially optimal amounts of goods and services." This entails both productive and allocative efficiency. (McConnell & Brue, 2005)

farmers' markets they forego purchases from a traditional retailer. By virtue of this oversight, the research likely overestimates these positive economic gains generated by farmers' markets.

Conversely, another study accounts for this cost by comparing the economic impacts of farmers' markets to sales at traditional retailers (Hughes, Brown, Miller, & McConnell, 2008). Using vendor survey data, these authors estimate gross impacts of farmers' markets to the state economy. They then use consumer spending patterns on food products through more conventional food marketing systems to estimate the economic impact of lost spending via those traditional food systems and find that farmers' markets generate economic benefits greater than traditional venues to the local community, yet the difference between the two is minor.

Gunter (2011) also found a small positive direct impact of local food systems in a study aimed toward successfully modeling and assessing value chains within local food systems. The study suggests, however, that this gain might not cover the necessary infrastructure expenses needed to sustain these value chain systems. Gunter (2011) additionally provides a guideline of how to aptly construct local producer production functions (Figure 1).

Figure 1: Input/Output Studies of Farmers' Markets

Henneberry, Whitacre, and Agustini (2009)	Hughes et al (2008)	Gunter and Thilmany (2011)
Oklahoma farmers' markets added *113 jobs* and generated a total economic impact of almost *$6 million*	After accounting for opportunity cost, West Virginia farmers' markets added *43 jobs* and *$.653 million*	When value chains are appropriately modeled, Weld County (CO) Farm-To-School added *<1 job* and *<$60,000*

While these studies find positive benefits to local food systems, others are uncertain of these positive economic gains. One such case study observed a local food market in Oklahoma to quantify the total economic gains that might be generated by converting generic crop production to vegetable production in response to increased demand for locally grown produce (Biermacher, Upson, Miller, & Pittman, 2007). This study found that consumers who shopped at the Noble Produce Market would in fact pay a premium for the locally grown crops, but that a large portion of the harvested products never actually reached the consumer. For example, after accounting for the quantity of defective and surplus products that could not be adequately stored, 52% of the 11,925 pounds of field tomatoes perished. The authors mention how larger producers closely located to processing plants might have been able to convert some of the wasted produce into value-added products such as tomato paste. The authors suggest that rather than promoting smaller producers, policy resolutions might be made to promote these apparent returns to scale in food production. Even Cooke and Watson (2011) note that "if the quality or the price of the locally produced good is inferior to the imported good, then the results of this model do not hold." The authors reiterate that in the absence of an unrealized comparative advantage, "Buy Local!" campaigns are not necessarily beneficial.

Furthermore, other opportunity costs exist if consumers were to demand products from smaller scale systems. Employment, capital and land would have to shift away from its current uses to grow and harvest the local crop. With the base assumption that all productive Iowa cropland is already being farmed, Swenson (2009) models lost soybean and corn production due to increased produce cultivation in Iowa. Using an input-output model, the research concludes that local food production, processing, and retailing could create up to 75 net new jobs within a six county region in Iowa. Swenson also suggests three questions policymakers must answer before they move to promote local foods. He asks: "What do people actually eat? Can the commodity be grown or raised efficiently in this area?" [And] "…can producers realize an income from the activity?"

Continuing the progression of models found in literature, this study will contribute to the literature by describing a transition from input-output analysis toward computable general equilibrium modeling (CGE) as a method to evaluate local food systems. This thesis will examine how to model the economic tradeoffs of shifting Oklahoma's current food chains from the current system to locally grown. Put simply, the research provides a framework of inquiry as to whether or not the region would experience a positive economic gain if consumers were to simultaneously buy an increased percentage of their food from increased local production each year. A combination of increasing local food demand and supply are the primary drivers of the model.

Objectives

The overall objective of this research is to propose a framework for accurately determining the impacts of a transition from current large-scale agricultural production to small-scale local food systems within the state of Oklahoma. Using a static computable general equilibrium model, the effects (both of shift in demand and supply) of several counterfactual scenarios are outlined for the Oklahoma economy. Specifically, this research seeks to describe the structure of an Oklahoma CGE model that simulates how changes of modern agricultural practices toward local food systems would affect (1) employment, (2) household welfare, (3) gross state product, and (4) global economic welfare.

CHAPTER II

CONCEPTUAL FRAMEWORK

While many models exist which represent regional economies, partial equilibrium modeling, input-output analysis and computable general equilibrium (CGE) modeling have gained exceptional traction. Of particular interest to this paper are the latter two. These models begin with a social accounting matrix (SAM) and trace the relationships exhibited between sectors within a given community. The following section describes the ways CGE models can overcome various limitations of input-output analysis particularly for the sake of modeling regional food systems.

Input-Output Analysis

As demonstrated in Hughes and Holland (1994), input-output analysis tracks backward linkages across industries located in a specific geographic region. These models are designed to measure marginal changes to an economy given a change in final demand. Input-output results are described by three impacts: direct, indirect and induced. Direct impacts represent expenditures and production which originate directly from the specified economic activity. Input-output analysis then allows one to quantify those secondary, indirect changes in economic activity that come from the purchase of inputs to produce the product demanded. Finally, input-output analysis allows the researcher to estimate induced changes in economic activity. These changes occur as a result of employee wages and salaries of the directly and indirectly affected industries.

Input-output analysis is based on a linear system of equations where the output of each industry is equal to total demand. As such, the complete system can be written as,

(1) $\mathbf{x} = \mathbf{A_i}\,\mathbf{x} + \mathbf{f}$

where:

$$\mathbf{x} = \begin{bmatrix} x_1 \\ \cdots \\ x_n \end{bmatrix},\ \mathbf{A_i} = \begin{bmatrix} a_{11} & \cdots & a_{1n} \\ \vdots & \ddots & \vdots \\ a_{i1} & \cdots & a_{in} \end{bmatrix}, \text{ and } \mathbf{f} = \begin{bmatrix} f_1 \\ \cdots \\ f_n \end{bmatrix}$$

and:

x_n = total output of industry *i* used by *n* industries in a given region,

a_{in} = technical coefficient for how much of input *n* is needed to produce one dollar of industry *i*'s output,

and f_n = final demand of the i^{th} industry.

It follows that,

(2) $\mathbf{x} - \mathbf{A_i}\,\mathbf{x} = \mathbf{f}$

(3) $(\mathbf{I} - \mathbf{A_i})\,\mathbf{x} = \mathbf{f}$

(4) $(\mathbf{I} - \mathbf{A_i})^{-1}\,\mathbf{x} = (\mathbf{I} - \mathbf{A_i})^{-1}\,\mathbf{f}$

(5) $\mathbf{x} = (\mathbf{I} - \mathbf{A_i})^{-1}\,\mathbf{f}$

therefore,

(6) $\Delta\mathbf{x} = (\mathbf{I} - \mathbf{A_i})^{-1}\,\Delta\mathbf{f}$

A technical coefficients table (frequently denoted $\mathbf{A_i}$) is created by dividing an industry's value of inputs purchased from all industries by total output of each industry. These coefficients explain how $1 spent producing an industry's output is distributed throughout the local economy. Finally, the direct and indirect coefficients table can be found by subtracting the technical coefficient matrix from an identity matrix and then inverting the differenced matrix $\mathbf{(I- A_i)^{-1}}$. Inverting the matrix $\mathbf{(I- A_i)}$ implies that $\mathbf{(I- A_i)(I-A_i)^{-1} = I}$, thereby yielding the indirect matrix. Because $\mathbf{(I-A_i)}$ represents the total requirements of a linear system, this transformation specifically leads to the direct and indirect table - known as the total requirements matrix. Since this model assumes that the local economy is in equilibrium, the model shows that as one industry increases output, it will require inputs from other local industries, who in turn will have to increase output. This structure makes input-output models particularly useful for measuring marginal economic effects.

Building on the industry purchases which are traced backward through the supply chain, CGE models relax assumptions imposed by input-output (e.g., allowing scarcity to be introduced into the model). Moreover, while both CGE and Input-Output are based on a Social Accounting Matrix, a CGE model can more suitably measure intricate, interrelated economic effects of transitioning more production to local foods.

In other words, modeling local food systems requires a model flexible enough to allow for changes in the prices of factors and industries.

Computable General Equilibrium

As made prominent by economists such as Kenneth Arrow (Arrow & Hahn, 1971), CGE models have improved the capability for researchers to model linked markets and industries as prices fluctuate (Hussain, Munn, Holland, Armstrong, & Spurlock, 2012). Because CGE models allow adjustments of input and factor prices from an exogenous shock on a regional economy, they have been readily applied to many policy-related discussions such as the implications of fiscal reforms, tax increases, and trade policy changes like quotas and subsidies (Partridge, 1998).

These models are particularly useful for estimating economic effects when the economy adjusts to larger than marginal impacts – both globally and regionally. Anderson and Valenzuela (2008) estimate the global adoption of genetically modified (GM) cotton. They find that the potential productivity gains for lesser-developed countries to be very high. The study concludes that this supply-side change to equilibrium would be especially beneficial for countries especially in sub-Saharan Africa. Furthermore, Arndt et al. (2010) discusses the effects on growth and income distribution within Mozambique due to biofuels. After calculating a baseline equilibrium value, the model creates sectors dedicated to sugarcane for ethanol and jatropha for biodiesel production. They select these two crops because of their diversity in production – jatropha is more labor intensive and grown on smaller farmers while sugarcane tends to be grown on a plantation. Arndt et al. then run two counterfactual scenarios based on the two crops and find that investment in biofuels would increase Mozambique’s annual economic growth and concurrently reduce poverty.

General equilibrium models also provide a framework to analyze economies within a specific region. For example, Schriener et al. (1996) presents the framework for a regional general equilibrium model that includes prices, quantities and income – particularly for the state of Oklahoma. The study discusses various policy responses to rising rural poverty issues and develops a framework of analysis for each. Shriener et al. then uses the example of sport fishing expenditures in Oklahoma as one possible way to increase welfare change. From another policy perspective, Lips and Rieder (2005) estimate the effects of removing a raw milk quota in the European Union. The study provides a way to implement production quotas in CGE modeling at the member country level. The study predicts a slight output increase and a significant price decline if quotas were to be eliminated within the member countries of the European Union.

In principle, a general equilibrium model generates a matrix of demand and supply equations to represent the backward linkages (expenditures) within a regional economy. Within these models, prices and quantities are allowed to adjust in response to a counterfactual adjustment of the model. These models make assumptions frequently around the relationship between prices and quantities. Computable general equilibrium models often assume that regional exporters and importers have perfectly elastic export demand and supply functions, allowing for the research to focus on a precise regional level.

Perfectly elastic export demand implies that when prices change within the local market, consumers will decide to purchase imported goods and services until an equilibrium price is once again reached, such as when prices rise in a farmers' market past what a consumer might be willing to pay. Perfectly elastic export demand also implies local producers can export as much as they want without affecting the export price.

Similarly, perfectly elastic supply suggests that if input prices increase, local producers will obtain their inputs from outside the modeled economy. Also, when both supply and demand of traded goods are perfectly elastic, markets are implicitly competitive and goods as well as production technologies are homogeneous. This implies that an increase in local prices, for example, might induce greater imports of a good as consumers seek cheaper alternatives. Consider what might happen if a regional drought caused prices for fall pumpkins to increase at pumpkin patches across the state of Oklahoma. In that scenario, fall demand for pumpkins would have to be met with a non-local supply. Similarly, if local input prices rise or inputs to be sourced from nonlocal locations drop in a foreign region, one would export production to shift to that location, thereby decreasing production within the local region.

Standard Equations for CGE Modeling

While these models can be built and tailored to meet the specific needs of the researcher, Löfgren (1999) simplifies the general model structure into three “blocks” of equations used to summarize an economy:

1. Production and commodity block,
2. Institution block, and
3. System constraint block.

The production and commodity block includes Constant Elasticity of Substitution (CES) production functions[4];

(7) $$QA_a = ad_a \times \prod_{f \in F} QF_{fa}{}^{\alpha_{fa}} \quad a \in A$$

where QA_a is the level demanded of activity *a*,

ad_a is the efficiency parameter in the production function for activity *a*,

QF_{fa} is the quantity of factor *f* used to produce activity *a*,

α_{fa} is the share of value-added for factor *f* in activity *a* when all $\Sigma\, \alpha_{fa} = 1$

$a \in A$ is the set of activities, i.e. industries aggregated to one-digit NAICS sectors, and

$f \in F$ is the set of the factors land, labor, and capital,

which when evaluated to maximize profits imply the following factor demand functions[5];

(8) $$WF_f \times WFDIST_{fa} = \frac{\alpha_{fa} \times PA_a \times QA_a}{QF_{fa}} \quad f \in F, a \in A$$

where PA_a is the price of activity *a*

WF_f is the price of factor *f*, and

$WFDIST_{fa}$ is wage distortion factor for factor *f* in activity *a*,

Included are also activity price functions;

(9) $$PA_a = \sum_{c \in C} PQ_c \times \theta ac \quad a \in A$$

where θ_{ac} is the yield of output *c* per unit of activity *a*,

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[4] Quadratic production functions more appropriately model agriculture because of the possibility of having negative total production. Therefore, while all other production functions will be modeled as CES, both Local and Non-Local Agriculture production will be modeled as quadratic functions.

[5] In a competitive market, an input is paid the value of its marginal product. Thus, the derivative of the production function with respect to an input multiplied by the price of the output (the Marginal Value of the Product) equals the input price.

PQ_c is the composite commodity price of commodity *c,* and

$c \in C$ is the set of commodities, i.e. goods that industries produce aggregated to one-digit NAICS sectors,

value-added price functions;

(10) $$PVA_c = PA_a - \sum_{c \in C} PQ_c \times ica_{ca} \quad a \in A$$

where PVA_a is the value-added price of commodity c,

ica_{ca} is the quantity of *c* as intermediate input per unit of activity *a*,

$shry_{hf}$ is the share for household *h* in the income of factor *f*, and

and commodity output functions;

(11) $$Q_c = \sum_{a \in A} \theta_{ac} \times QA_a \quad c \in C$$

where Q_c is the output level in commodity *c*. This equation accounts for activities which might produce multiple commodities.

The institution block equations include factor incomes;

(12) $$YF_{hf} = shry_{hf} \times \sum_{a \in A} WF_f \times WFDIST_{fa} \times QF_{fa}$$

$$h \in H, \; f \in F$$

where YF_{hf} is the income of household *h* from factor *f,*

$shry_{hf}$ is the share for household *h* in the income of factor *f*, and

$h \in H$ is the set of households,

household income functions;

(13) $$YH_h = \sum_{f\in F} YF_{hf} + tr_{h,gov} + EXR \times tr_{h,row} \quad h \in H$$

where YH_h is the income of household *h*,

$tr_{h,gov}$ is the transfer from households to government (such as taxes)

EXR is the foreign exchange rate (domestic currency per unit of foreign currency)

$tr_{h,row}$ is the transfer from households to the rest of the world

household demand functions which seek to maximize utility subject to a budget constraint;

(14) $$QH_{ch} = \frac{\beta_{ch} \times YH_h}{P_c} \quad c \in C, h \in H$$

where QH_{ch} is the consumption of commodity *c* by household *h*, and

β_{ch} is the share in household *h* consumption spending of commodity *c* based on a CES household utility function,

government revenue;

(15) $$YG = \sum_{h\in H} ty_h \times YH_h + EXR \times tr_{gov,row} + \sum_{c\in C} tq_c \times (P_c \times Q_c)$$

where ty_h is the rate of household income tax,

$tr_{gov,\text{row}}$ is the transfer from government to the rest of the world,

tq_c is the sales tax rate,

P_c is the price of commodity *c*, and

Q_c is the quantity of commodity *c*,

government expenditures;

(16) $$EG = \sum_{h\in H} tr_{h,gov} + \sum_{c\in C} PQ_c \times qg_c$$

where $tr_{h,gov}$ is the transfer from households to governments, and

PQ_c is the composite commodity price of commodity *c*,

qg_c is government commodity demand of commodity *c*,

and investment demand;

(17) $$QINV_c = qinv_c \times IADJ$$

where $QINV_c$ is the quantity of investment demand,

$qinv_c$ is the base-year investment demand, and

$IADJ$ is the investment adjustment factor.

Finally, the system constraint block contains market-clearing conditions necessary for the model to run, which will be discussed in more detail later. These equations include market equilibrium conditions for the total demand for factors equates to;

(18) $$\sum_{a \in A} QF_{fa} \leq qfs_f \quad f \in F$$

where qfs_f is the supply of factor *f*

Market equilibrium conditions for the total demand of commodities equates to;

(19) $$Q_c = \sum_{i \in I} QI_{ic} \quad c \in C, i \in I.$$

where $i \in I$ is the set of all institutions, including households government and the rest of the world, and

QI_c is the quantity demanded of commodity *c* by institution *i*.

The model requires savings and investment to balance so that

(20) $\sum_{h\in H} mps_h \times (1-ty_h) \times YH_h + (YG-EG) + EXR \times FSAV = \sum_{c\in C} PQ_c \times QINV_C + WALRAS$

where mps_h is the share of disposable household income to savings,

$FSAV$ is foreign savings, and

$WALRAS$ is dummy variable held zero at equilibrium.

Lastly, the price normalization constraint;

(21) $$\sum_{c\in C} cwts_c \times P_c = cpi$$

where cpi is the consumer price index (CPI)

$cwts_c$ is the weight of commodity c in the CPI,

helps assure that only one solution exists. In that way, price changes can be interpreted as changes outside the CPI – as determined by the Bureau of Labor Statistics.

Applicability of CGE to Local Foods

General equilibrium modeling provides a way to answer research questions that involve economic issues such as changing prices and market constraints. First, these models have a strong microeconomic foundation since they rely on interrelated supplies and demand, causing changing prices (Borges, 1986). This is particularly relevant to local foods for multiple reasons. Second, in order to accommodate additional demand in any given sector, the model allows factor input prices and product prices to adjust endogenously. This relaxes the infinite supply assumption of input-output models, allowing the model to be not only demand-driven but also affected by regional supply constraints. As limited land availability for agricultural production is the most apparent supply constraint within local food production, CGE creates the ability to set a more realistic constraint. Third, functions can be non-linear to more appropriately reflect consumer preferences and production technologies. For example, input substitutability can be modeled using a constant elasticity of substitution (CES) functional form. In other words, because preferences and production functions are not linear, the model can be made more realistic and not constrained to marginal impacts. Also, because of weather or other conditions, planting and cultivating crops may lead to no output. This also exemplifies a nonlinear production function. Finally, as employment is endogenous to the model, researchers can relax the common zero unemployment assumption inherent of input-output analysis.

Also, constraining employment within the model implies that wage changes can be observed within a CGE framework. For example, if a lawyer were to decide to abandon her practice in favor of local food production, she would likely see a dramatic decline in her wage. Overall, modeling equilibrium enables one to identify how changes in demand or supply affect each other as well as how the economy is affected by policy changes such as greater political support for local food systems.

CHAPTER III

METHODS AND PROCEDURES

Summary of the Data

This model will use data available from IMPLAN for the state of Oklahoma. This data provides complete transaction tables and estimated trade flows across 440 industries within the state. IMPLAN augments federal data sources to fill in missing data due to disclosure issues.

The model aggregates sectors based on activities and commodities similar to one-digit NAICS sectors (J. J. Monge & Bryant, 2012), thereby aggregating IMPLAN sectors into ten separate activities and commodities based on common aspects within the aggregated sectors (Table 1). These IMPLAN sectors correspond to total expenditures for industries within the Oklahoma economy.

An added "local foods" sector is constructed using budgets representative of Oklahoma production practices. This differentiates production and demand for agricultural crops into two categories; (1) conventional, "non-local" producers who produce homogenous commodities for export to domestic and foreign markets, and (2) smaller scale, "local" growers producing primarily specialty crops for consumption within Oklahoma. The local production sector will be based on specific sectors rather than an aggregate production function across multiple crops because different crops have different production and demand requirements.

Table 1: CGE Aggregation Scheme			
NAICS Sectors		**Activities**	**Commodities**
11	"Non-Local" Agriculture	1-19	3001-3019
-------	"Local" Agriculture	--------	-------
21-23	Mining, Utilities, and Construction	20-40	3020-3040
31-33	Manufacturing	41-318	3041-3318
42, 48-49	Wholesale Trade, Transportation and Warehousing	319, 332-340	3319, 3332-3340
44-45	Retail trade	320-331	3320-3331
51-56	Information, Finance and Insurance, Real Estate Rental and Leasing, Professional, Scientific, and Technical Services, Management of Companies and Enterprises, Administrative and Support and Waste Management and Remediation Services	332-390	3332-3390
61-62	Educational Services, Health Care and Social Assistance	391-401	3391-3401
71-72	Arts, Entertainment, and Recreation, Accommodation and Food Services	402-413	3402-3413
81	Other Services (except Public Administration)	414-426	3414-3426
92	Public administration	427-432, 437-440	3427-3432, 3437-3440

The Social Accounting Matrix

Following in the tradition of Wassily Leontief (Leontief & Duchin, 1986), both CGE and input-output models have at their core a "social accounting matrix," which describes the exchanges of firms, households and other institutions within the given economic region. The social accounting matrix is divided into three specific parts - the processing sectors, the payments sectors, and the final demand sectors. These three parts sum to total gross outputs and total gross outlays (Miernyk, 1965). This table outlines how different industries spend money; the columns represent industries' consumption of other industries' output, while the rows represent sales by industries to other industries. The data within the table reflects a snapshot of the local economy at a point in time and is useful for calibrating blocks of equations to reflect supply and demand flows in a local economy. IMPLAN (1998) defines the SAM as follows (Table 2):

Table 2: Structure of the Social Accounting Matrix

		1 Industry	2 Commodity	3 Factors	4 Institutions	5 Foreign Trade	6 Domestic Trade
1	Industry		1x2			1x5	1x6
2	Commodity	2x1			2x4		
3	Factors	3x1					
4	Institutions		4x2	4x3	4x4	4x5	4x6
5	Foreign Trade	5x1		5x3	5x4	5x5	
6	Domestic Trade	6x1		6x3	6x4		

where cells are defined as;

2x1 Domestic use of commodities by industries or payments to commodities

3x1 Factor incomes

5x1 Total foreign imports to industry use or payments to imports

6x1 Total domestic imports to industry use

1x2 Domestic industry make

4x2 Institutional commodity sales

4x3 Factor or value added distributions

5x3 Foreign factor imports

6x3 Domestic factor imports

2x4	Domestic institutional use or final demands by institution
4x4	Inter-institutional transfers
5x4	Foreign institutional imports or foreign imports to final demand
6x4	Domestic institutional imports or domestic imports to final demand
1x5	Total foreign commodity exports
4x5	Foreign institutional exports
5x5	Foreign trans-shipments
1x6	Total domestic commodity exports
4x6	Domestic institutional exports

Local Food Production

In order to model those activities of food producers for local markets, enterprise budgets are used to develop the production functions of the new local food sector within the transaction matrix of the SAM. Following the methodology established by Willis and Holland (1997), line items of the enterprise budgets are matched to sectors within the SAM. Namely, the enterprise budgets of two separate producers represent the bounds for an average acre of local production within the state. Watermelon and tomato budgets will be used. These crops are representative of Oklahoma "Local Food" production as watermelons and tomatoes are already grown and distributed in substantial quantities within the state. These crops reflect two "extremes" of crop production – watermelons in the sense of growing a traditional row crop and tomatoes in to characterize growing multi-harvest crops.

Production and consumption will be determined using the following functional forms. This functional form combines multiple inputs or consumable products into one aggregated quantity. The combination of entities therefore exhibits a fixed elasticity of substitution. Annual watermelon budgets made available by Triple S Farms near Hydro, OK, represent the budget requirements for local row crops. Watermelon output is modeled as:

$$\$1\ of\ \boldsymbol{Watermelon\ Output} = 0.088 * \boldsymbol{lag} + 0.033 * \boldsymbol{lbr} + 0.001 * \boldsymbol{fin} + 0.036 * \boldsymbol{mfr} + 0.030 * \boldsymbol{rent} + 0.001 * \boldsymbol{retail} + 0.026 * \boldsymbol{util} + 0.159 * \boldsymbol{inc} + 0.611 * \boldsymbol{whol} + 0.008 * \boldsymbol{mgmt} + 0.006 * \boldsymbol{deprec} + 0.001\boldsymbol{tax}$$

Where:

lag = Local agriculture, such as honeybee rental

lbr = Employee compensation

fin = Finance and insurance

mfr = Manufacturing

rent = Land rents

retail = Retail trade

util = Utility expenses

inc = Proprietor income

whol = Wholesale trade

deprec = Machine depreciation

mgmt = Management

tax = Indirect business taxes

Notice the high cost to wholesale trade inherent of growing traditional row crops for market due to brokerage and marketing fees. This is important within local agriculture as the producer of this type of local food finds it most efficient to grow for local and non-local markets combined. The producer works with the wholesaler to do both.

A tomato farming production function was generated based on enterprise budgets available from the Oklahoma Agricultural Experiment Station (OAES) and validated with plasticulture data retrieved from the Oklahoma Department of Agriculture, Food and Forestry (ODAFF). This function represents multi-harvest crop production techniques. Within the SAM, tomato output is modeled as:

$$\$1\ of\ \boldsymbol{Tomato\ Output} = 0.039 * \boldsymbol{lag} + 0.276 * \boldsymbol{lbr} + 0.035 * \boldsymbol{fin} + 0.206 * \boldsymbol{mfr} + 0.013 * \boldsymbol{rent} + 0.040 * \boldsymbol{retail} + 0.034 * \boldsymbol{util} + 0.127 * \boldsymbol{inc} + 0.312 * \boldsymbol{whol} + 0.005 * \boldsymbol{deprec} + 0.028 * \boldsymbol{mgmt} + 0.001\boldsymbol{tax}$$

Note this function requires significantly higher labor costs as growing multi-harvest crops similar to tomatoes require significantly more labor than a row crop typically would.

Demand for the local agriculture commodity is distributed following an aggregated scheme of industries and institutions. The majority of this value is distributed across institutional spending such as Farm-To-School (FTS) and direct-to-household expenditures. These sectors will demand the majority of the product based primarily on data collected from ODAFF regarding the Oklahoma FTS program and data available within the 2007 Census of Agriculture involving farms sales for direct-to-human consumption. Total household consumption will be proxied by total sales at registered farmers' markets in Oklahoma in 2009 to match the year of the IMPLAN data. Total institutional sales are proxied for by using values of actual FTS sales filled with local produced in a year. This is supplemented with data from a wholesaler regarding consumption by restaurants and other institutions. Both local agriculture demand and supply are subtracted out of the corresponding non-local agriculture vectors of the SAM. Therefore, local foods will be substituted for non-local foods within a nested equation within the demand function. The remainder of the remaining household budget will be allocated after demand for non-local and local foods are fulfilled.

Inputs of Production

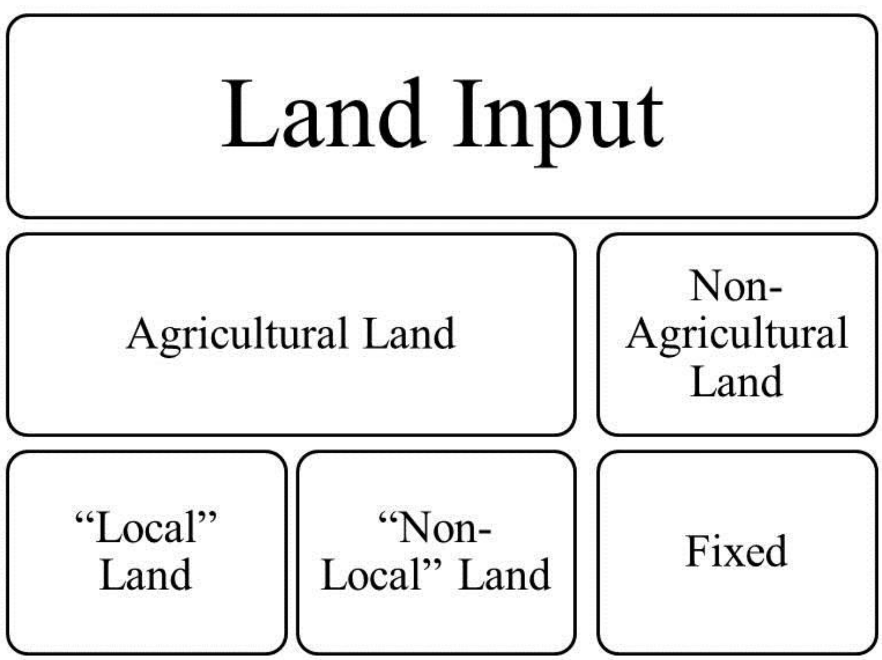
This CGE model follows guidelines similar to Stodick, Holland, and Devadoss (2004) and Lofgren (1999). As the majority of the data comes from the social accounting matrix (SAM) as generated by IMPLAN, the Stodick, Holland, and Devadoss model designates "Labor" and "Capital" as the only two inputs of production. For the sake of this model, one additional factor must be considered. Especially in Oklahoma, agriculture is land-intensive. In fact, about 80% of the nearly 44 million acres[6] that make up the state of Oklahoma are designated as farmland. Of those acres, cash rents vary across activities. According to the USDA National Agricultural Statistics Service

[6] The 2007 Census of Agriculture estimates Oklahoma land area including non-agriculture to be 43,905,445 acres and Oklahoma land area designated for farms to be 35,087,269 acres.

(NASS), cash rent values for Oklahoma farmland range from $5.50 for an acre of pastureland in Cimarron County to $78 an acre for irrigated cropland in Craig County. Therefore, to more realistically determine the impacts of local foods, the modified model includes "Land" along with "Labor" and "Capital" as an input.

Land values are based on a weighted average of the "Oklahoma Rental Rates and Land Values" as generated by NASS. The data includes county level rental rates for the three agricultural classifications and county acreages – pastureland, non-irrigated cropland, and irrigated cropland. Multiplying corresponding acreage by the county rental rate by classification, total agricultural land rents in Oklahoma are estimated to be $613,192,154. Similar to Monge and Bryant (2012), this value is distributed solely across local and non-local agricultural sectors as a production input for the two sectors as the model assumes non-agriculture land area is held constant (Figure 2).

Figure 2: Land as a Factor of Production



Agricultural land is initially allocated between local and non-local sectors based on estimates available within the 2007 Census of Agriculture as organized by the Economic Research Service (ERS). This data includes income from farm sales made direct to the consumer. Revenues from “local” sales translate into land allocation as a percentage of total sales that is local multiplied by the land rent value. The model establishes starting land requirements of local agriculture on this direct sales value compared to all other farm sales. IMPLAN sector 360 includes rental income of real estate businesses. In other words, IMPLAN reports payments to land by labeling it as an intermediate commodity. Estimated land rents are compared to the value in IMPLAN’s sector 360, and taken away from the capital account. Any amount less than the IMPLAN value is deemed non-agricultural land rent and is automatically added to the real estate sector. That additional capital can then be accounted for in capital accounts.

Components of Value-Added

Another important aspect of the model involves allocating inputs across components of value-added for the local foods sector. IMPLAN primarily cites the Quarterly Census of Employment and Wages (QCEW) dataset made available by BLS and supplements this data with County Business Patterns (CBP) from the Census Bureau as well as the Regional Economic Information System (REIS) from BEA. The SAM dataset includes four separate categories in which value added is allocated (Figure 3).

Figure 3: Components of Value-Added within the SAM Matrix

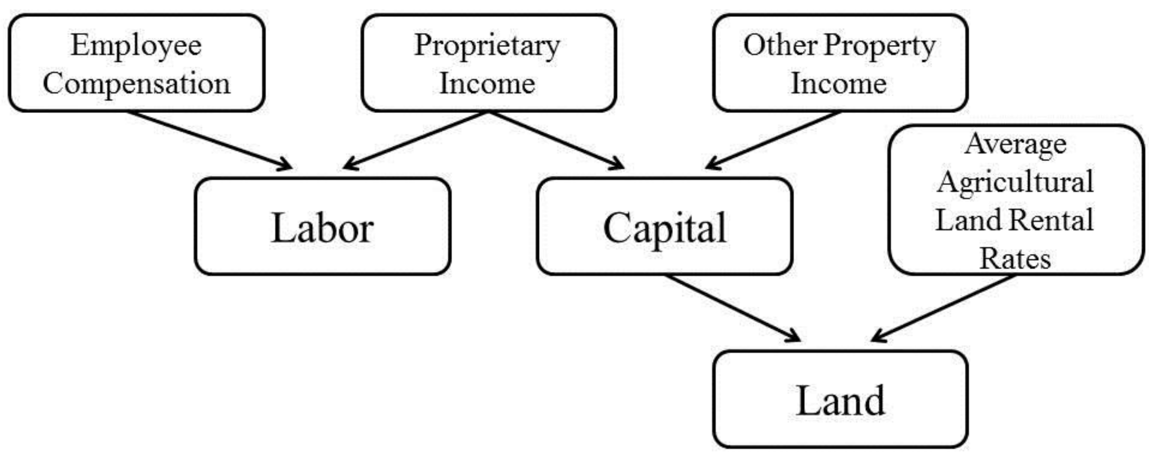
Employee Compensation	Proprietor Income	Other Property Income	Indirect Business Taxes
Wages, benefits, and employer paid payroll taxes	Income Received by self-employed business owners and unincorporated business entities	Corporate profits, allowance for capital consumption, and dividends, interest income, payments for rent, and royalties	Taxes incurred on activity products, production factors, output values, and import duties on inputs

Employee Compensation includes wages, benefits, and employer paid payroll taxes. Proprietor Income consists of income received by self-employed business owners and unincorporated business entities. Other Property Income is comprised of corporate profits, allowance for capital consumption, dividends, interest income, payments for rent, and royalties. Finally, the value-added categories of the SAM matrix include Indirect Business Taxes.

Within the scope of CGE modeling, the value for Indirect Business Taxes is an aggregated grouping of taxes incurred on activity products, production factors, output values, and import duties on inputs. While the IMPLAN data provides an appropriate foundation for the analysis, Indirect Business Taxes within the data create two specific issues that must be addressed within an accurate SAM. First, Indirect Business Taxes need to be disaggregated so import duties might be more appropriately modeled within the SAM.   Second, as IMPLAN data are based on BEA input-output tables, Indirect Business Taxes are incorrectly attributed to the collecting institutions as opposed to the paying institutions. Consequently, the model follows transformations as identified by Giesecke (2011) and Monge (2012) to account for misallocated indirect business taxes within the Oklahoma Social Accounting Matrix.

In this way, these four categories of value added generate the base data for labor and capital input values for each sector. Adding agricultural land rental rates to the corresponding IMPLAN capital values creates the land factor input value. (Figure 4)

Figure 4: Factor Inputs within the SAM Matrix



Model Description

The optimizing criterion for production and consumption functions is based on constrained maximization where the model simultaneously solves all equations to find equilibrium values. This model can be solved using GAMS software and the MILES solver. MILES is a mixed complementarity problem solver that evaluates complimentary slackness. In short, this program allows for complimentary slackness which allows for a rational shadow price given zero quantity produced. Conversely, it will generate a shadow quantity if price is equal to zero.

Constraints include a range of market-clearing conditions from which to analyze. These include conditions surrounding the prices and quantities of labor, capital, and land, as well as for institutional spending such as foreign exchange markets and household expenditures.

Part of the interest in local foods comes from the possibility of increasing employment opportunities within the state. Recognizing that farmers compete for labor without their industries and regions, wages will therefore be fixed to reflect competitive labor markets. Employment will clear the labor market; this allows for the possibility of unemployment.

Capital transition would play a crucial role during a changeover from a system that encourages mass-market production to an economic environment that encourages small-scale, local production. To clear the market, the model defines conversion as allowing capital to be mobile and fully employed. The intuition behind this clearing condition is that all capital is already employed to its most efficient use given current equilibrium conditions, but might transition given a new equilibrium. For example, a tractor that might be currently used for large-scale production agriculture would be able to transition to small-scale local agriculture. This means that capital prices will remain fixed as and quantity demanded will be allowed to shift across activities.

One additional assumption must be made to clear the market for land. The quantity of land available for the sum of local and non-local agricultural production is fixed. Implicitly, this assumption states that land currently in non-agricultural use will not be converted to produce local food and Oklahoma cannot grow in land area. Therefore, any land used for local agriculture must be taken from non-local agricultural production. This closing condition, therefore, allows for the price of land to adjust in response to market demand.

Because the prime rate has recently been held constant, the Marginal Propensity to Save (MPS) will be the vehicle left flexible, allowing savings to be driven by investments. As MPS is a measurement of household savings relative to household expenditures, the modeled consumers will have flexibility to save more or less of their household income depending on market constraints and total utility.

Finally, the model requires various sets of closing conditions for the foreign exchange market. The model must hold either foreign savings or the exchange rate as a constant. Commodities will be allowed to import and export in this model. Because Oklahoma's volume of imports and exports are small relative to the total quantities exchanged in the world market, it is highly unlikely that changes to Oklahoma's economy will affect foreign exchange rates. Therefore, the foreign exchange rate will be fixed.

Counterfactual Scenarios

Once the base equilibrium model has been run with these assumptions, the model would run a sequence of counterfactual scenarios. Changes in economic activity can be driven by two broad vehicles – shifts in supply and demand. Assuming markets begin in equilibrium and ceteris paribus, a positive shift in the supply curve will increase the quantity demanded and decrease prices, a positive shift in the demand curve will increase both prices and quantity supplied. These scenarios are driven by the two unique ways promoting local foods can be accomplished within the state – through boosting production or by increasing consumption.

The first counterfactual scenario will be driven by increased supply of local foods. Within this producer-driven counterfactual scenario, as individual farmers seek to capture more control over returns to agriculture and beliefs about local production being better for community and environment or both, the supply of local production will increase. Farmers would reallocate land from typical production to local agriculture. This might happen with a "Buy Local" campaign geared toward agricultural producers. Within the context of equation (8), demand for factor *land* from activity *local foods* would increase while *non-local foods* would decrease within the QF_{fa} parameters.

(8) $$WF_f \times WFDIST_{fa} = \frac{a_{fa} \times PA_a \times QA_a}{QF_{fa}} \quad f \in F, a \in A$$

The second counterfactual scenario will be driven by increased demand for local foods relative to non-local foods. This is simulated through a change in consumer preferences by changing the budget share parameter of the constant elasticity of substitution (CES) utility function to prefer local foods over non-local, representing a change in diets to favor consumption of local food commodities. This might happen if the Oklahoma Legislature began subsidizing the promotion of local foods with federal dollars that weren't necessarily generated directly from state constituents. Given equation (14), β_{ch} would see a change in the share of household consumption spending for the commodity "local foods" at an equal loss of consumption of "non-local foods."

(14) $$QH_{ch} = \frac{\beta_{ch} \times YH_h}{P_c} \quad c \in C, h \in H$$

Increases in both supply and demand will occur concurrently in counterfactual scenario three. In effect, producers will transition from current agricultural production practices to the local food sector and consumers will simultaneously shift their preferences to the local food commodity from non-local foods.

CHAPTER IV

RESULTS

As has been shown, appropriately framing the local foods conversation requires a flexible model which allows for changing prices and quantities within the local economy. This model will result in a more accurate assessment of the overall economic welfare gains to each state. Because of the intricacies of CGE modeling, many different types of effects can be examined. Namely, a completed model of this type will create a robust combination of results that might aid policy-makers in establishing direction for the local food community in Oklahoma. Furthermore, this model might serve as an introspective look at the implicit connection between the economic development strategies that involve growing locally as a way to substitute local products for imports.

The following section describes expected hypothetical results once data requirements can be fulfilled to comply with CGE standards. Overall, these results follow a logical pattern and reflect the discoveries found in previous literature.

Anticipated Results

The value of promoting a change from current large-scale production to small-scale local food production systems within the state of Oklahoma is largely determined by the medium of the transition. In the first counterfactual scenario, supply of local foods would increase. This might happen if, for example, a public policy were to subsidize beginning farmers who were willing to sell at farmers' markets. An example of this type of policy would be the USDA value-added grant program or the Oklahoma Department of Agriculture, Food, and Forestry plasticulture program. Figure 5 demonstrates the conceptual changes inherent of this type of economic shift within the local foods sector of the Oklahoma economy.

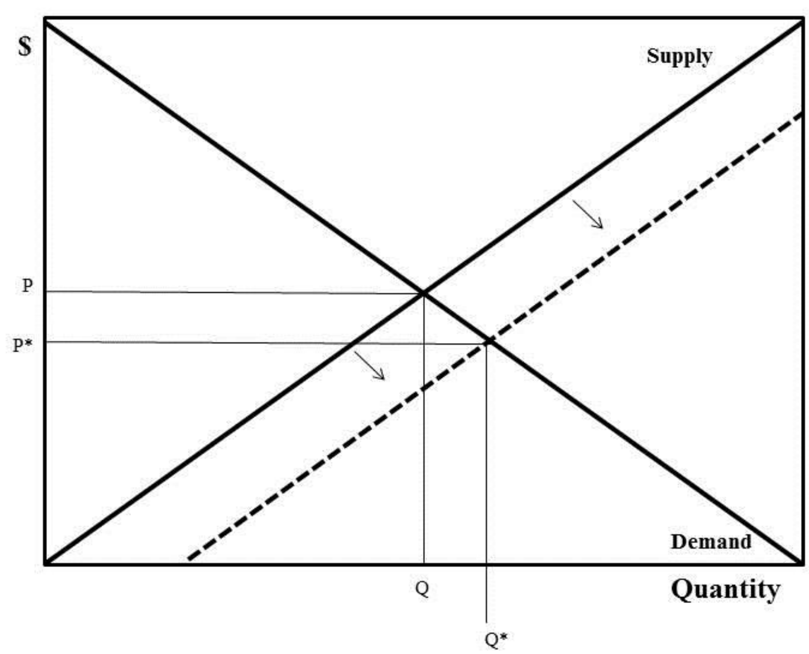


Figure 5: Equilibrium effects of a supply increase

As is evident, an increase in supply for local food will cause the quantity supplied to increase as well (Q to Q*). At the same time, however, the marketplace is flooded with products, causing a decrease in the equilibrium price of these goods (P to P*). In other words, while consumers might benefit from lower prices at the market, farmers would sustain lower prices for their goods. There may also be impacts on other markets, as well. As the model has been developed, if consumers purchase more local food, it means that they are also purchasing less non-local food from grocery stores and other food outlets. There would also be an increase in demand for inputs by local food producers, some of which would come from local sources. The net effect of all of these changes would be determined by the CGE model estimation, but one might suspect that additional employment generated by local food production would offset employment lost in other affected sectors.

The second counterfactual scenario causes an increase in the demand for local foods within the state of Oklahoma. This hypothetical increase in demand comes from a change in consumer preferences toward local foods as might be induced by a new campaign to promote local foods as a healthier alternative to non-local production agriculture. Figure 6 demonstrates what might happen within a partial equilibrium framework.

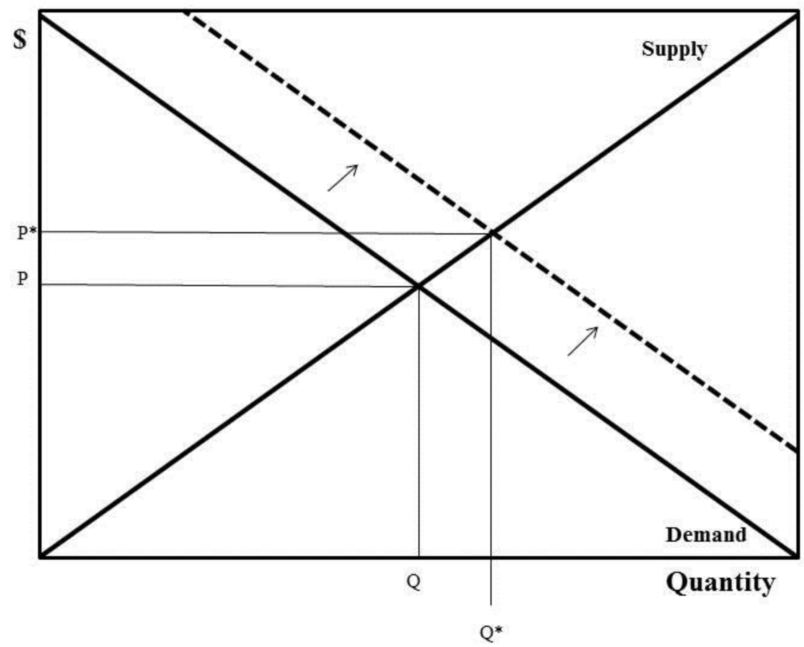


Figure 6: Equilibrium effects of a demand increase

If consumers were to demand more local foods, the quantity demanded would increase from Q to Q* along with the price of those products (P to P*). Consider how much higher of a price a farmer might be able to charge at a local farmers' market if the community as a whole were to decide to purchase more of these products. While this might be a net benefit to farmers, consumers might experience a loss in utility due to the income effect of higher prices on their budget constraint. Employment in the local food sector might see an increase as more money is spent in the sector, and this may offset lost employment in other affected markets which experience lower demand for their goods. In reality, both demand and supply shifts are occurring simultaneously. Determination of who will gain and lose can only occur by running a counterfactual scenario incorporating both demand and supply shifts. The outcome will depend upon which shift is greater, the elasticities of demand and supply, and local production conditions. By comparing the equilibrium conditions before and after this counterfactual scenario, one can determine who benefits and loses based upon changes in prices and output across sectors. An additional set of analysis can be performed to identify conditions under which changes to agriculture in Oklahoma could positively alter state welfare in a significant manner.

CHAPTER V

CONCLUSION

After examining current literature on local foods, the next rational direction for local food modeling is toward a computable general equilibrium model. These models might result in an adjustment in the direction of agricultural policy for two specific reasons.

Implications

First of all, one of the most popular accolades of local foods is that there might be substantial economic benefits inherent of these systems. This model will provide a more cohesive format to capture opportunity costs associated with re-allocating factors from current, efficient practices to small, generally less efficient systems. As this CGE model is built as a constrained maximization problem, policy-makers might be able to understand what barriers are actually keeping local foods from flourishing in a more efficient manner.

Second, modeling local foods within a CGE creates the flexibility to integrate other justifications into the model. CGE models can be used to evaluate the effects of virtually any regional effect that can be monetized. These effects and rationales could include the environmental benefits of decreased food miles as well as the social capital gains which other models might be less effective at showcasing. Because the model starts from a calculated equilibrium point, an infinite number of possible counterfactual scenarios could be tested.

To continue, since CGE requires such significant data, many other hypotheses involving local foods may be tested. For example, as IMPLAN divides household categories by income class, a future model might be able to capture the expenditure patterns of local food consumers by household income. Furthermore, assertions can easily be tested within the model, such as the role of institutional sales in growing the local food market. Also, as updated data becomes available; these models can be easily implemented and adjusted to reflect this new information within the system, thereby making CGE continuously relevant.

In conclusion, even though such a general consensus on certain benefits of local foods, economic modeling should strive to most appropriately measure any possible costs and benefits inherent of new production systems. These new discussions can help guide policy in a way that most efficiently allocates resources to promote the benefits of local foods while maintaining a careful, realistic expectation of the results of those expenditures.

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