On Measuring the Importance of Local food to Regional Economies

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Abstract

Factors contributing to consumers' preferences for local foods span many interests, but for local policy makers, interest is focused primarily on the potential of local food systems to support the local economy and local jobs. To this extent, an expansion of local sales constitutes import substitution, where local foods supplant existing imports. This study uses the IMPLAN modeling system and the associated technical coefficients for the broader food shed surrounding and including the Chicago Metropolitan Area as the region and data source for analysis. The study compares the approaches to measuring the economic value of local food systems described in Miller, Mann et al. (2015) and Watson, Kay et al. (2015). The prior provides a "follow the money" approach to estimating the direct effects of food-related production that remains in the modeling region. The latter approach provides a mathematically elegant approach for isolating the total contributions of local food systems, but cannot separate out the direct effects. Considerations of the roles of important coefficients are introduced (Jensen and West 1980, Miller and Blair 2009 pp. 567). We show complementarities in these approaches.

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1 Introduction and Background

Policy makers and advocates of local food systems (LFS) are interested in measuring the economic value and impacts of local food. The current state of research on methods of quantifying the economic value of LFS continues to lag the pace of demand for valuation studies (Miller, Mann et al. 2015). Impact studies of key local foods outlets, like farmer's markets and community supported agriculture (CSAs), tend to come up short on measuring the broader value of local food systems, as direct effects are mostly limited to receipts that can be conveniently measured (Low, Adalja et al. 2015, Lee, Miller et al. 2016). This study reviews the role of Input-output modeling and the social accounting matrix in measuring the size and economic contribution of local food systems, with an economic region of 38 counties surrounding and making up the Chicago-Naperville, IL-IN-WI Combined Statistical Area.

While local food advocates may set targets of how much regional food consumption should come from local supply sources, they have limited options for measuring baseline or changes from baseline measures. This indeed occurred recently when the authors were approached by a local food advocacy group to justify future targets. As it turned out, their blind target was not far from baseline estimates at the state level (Miller, Mann et al. 2015), but as we show here, baseline values may differ substantially across regions, depending on local supply. If the researcher is willing to accept a few assumptions on what is and is not included in the measure of local foods, a systematic measure of the economic value of local foods can be estimated using standard regional transactions matrices.

This article shows how standard economic input-output (IO) models can be used to gauge baseline values of the size of local food systems following (Miller, Mann et al. 2015), and how these baselines can then be used to measure the economic impact of local food systems (Cooke and Watson 2011, Watson, Kay et al. 2015). We further look toward the existing literature on important inverse coefficients to show how policy prescriptions can be targeted for maximizing economic impacts based on key purchasing sectors, including intermediate purchasers and institutions.

2 Methods

Local food systems have been thoroughly examined over the past two decades. At the same time, there remain a number of unresolved challenges that impact the framework, results, and policy implications of studies focused on such systems. This examination of the Chicago Wilderness Local Food System is not an exception as the two major hurtles encountered include defining the local food system and the method(s) used to measure it. The main issue is the interconnectedness between the local food definition, which restricts the kind of data that can be used to measure the system, and the specific method for measuring the system. The method of measuring impacts the workable definition that defines the local food system. For example, if measuring the value of receipts at farmers markets, then sales from the farmers markets defines local food.

The most recent attempts to measure local food systems have approached this issue from one of two general frameworks: 1) methods that allow for flexible definitions; and 2) definitions of local food that are driven by specific modeling methods. For example, if the local food system is specifically defined by the unique goods offered in a region's farmers markets and consumed in the selected geographic region, then data must be collected that accurately reflect the unique basket of goods and region that provides it (Otto and Varner 2005, Hughes, Brown et al. 2008). However, these types of data are labor and cost intensive to collect, and as a result, are not widely available for all geographies and time. Alternatively, methods-driven definitions may include features of local food systems that are outside the scope and interest of a particular study but are less costly to implement. For example, regional IO models may include fresh and processed local foods as well as a range of consumers (e.g., households, government, and non-governmental organizations) within a single measure. While IO models provide a comprehensive assessment of the size of the local food system (Miller, Mann et al. 2015), they are not effective at delineating the different means of access to the local food, e.g., various forms of direct sales.

2.1 Measuring Local Food Benchmarks

We start with a standard representation of the regional industry by industry social accounting matrix as presented in Watson, Kay et al. (2015) and shown in Table 1. This simplified transactions table underlies most regional IO models for calculating economic impact. More importantly for this analysis, the transactions table shows, with a significant level of detail, the annual transactions that firms and households make from supplying industries. For this three-industry example, reading down the industry column shows what the corresponding industry purchased for the production of q_i output. That is, industry one, purchases z_{11} from its own industry, z_{21} from industry 2, z_{31} from industry 3, pays out v_1 to households and to indirect business taxes, and purchases m_1 imports as intermediate inputs. The sum of these purchases will equal industry 1 output, q_1, which includes all intermediate purchases (industry sales and imports) and payments to factors and profits (incomes).

		Industry Purchases			Consumption	Exog Demands	Totals
		1	2	3			
Industry Sales	1	z_{11}	z_{12}	z_{13}	c_1	x_1	q_1
	2	z_{21}	z_{22}	z_{23}	c_2	x_2	q_2
	3	z_{31}	z_{32}	z_{23}	c_3	x_3	q_3
Income		v_1	v_2	v_3		x_4	v
Imports		m_1	m_2	m_3	m_4		m
Totals		q_1	q_2	q_3	c	x	q

Table 1: Stylized industry by industry input-output table

Reading across an industry row shows who buys a given industries output. Here, industry 1 sells z_{11} to itself, z_{12} to industry 2, and z_{13} to industry 3 as intermediate inputs to their production. It also sells c_1 to local consumers and exports x_1 outside the region to other domestic or global markets. Since every expenditure is someone else's revenue, the value of any industries production should equate with the value of its sales.[1]

By dividing all cells by their corresponding column totals, cell entries indicate the share of output, local consumption and regional exports that make up of each corresponding sector. The industry column

[1] In social accounting, carry-overs of or drawdowns of inventory across years is captured by institutional sales to one's self.

vectors of the resulting table represent unit production functions, or how much of each input is necessary to produce $1 worth of output. From this, we can deduce that a decrease in imports will necessarily result in an increase in some combination of other industry inputs or value-added shares, such that the column continues to sum to one.

To exemplify how the industry-by-industry transactions table shown in Figure 1 can be used to quantify local food transactions, suppose the three industries in this stylized example represent apple production (industry 1), food processing (2), and retail trade (3). Further, assume that apple production represents the totality of agricultural production in the region and that applesauce represents the totality of food processing. As described in Miller, Mann et al. (2015), three equations can represent the value of local foods that are retained in the region as unprocessed or processed direct sales to consumers or as intermediated sales through more conventional channels.

To operationalize this, consider that local apple producers may sell to other apple producers (z_{11}), to apple processors (z_{12}) and directly to consumers (c_1). Retail purchases are treated separately. That is, direct sells of local food can be measured as the row sum of purchases as:

$$Local\ Direct\ Sales = z_{11} + z_{12} + c_1 \quad (1)$$

Processors take apples and generate sales of applesauce. However, not all processor production is applesauce and not all of the value of applesauce is comprised of local apples. Other ingredients and inputs, including imported apples may go into the production process. Regardless, a share of the applesauce will remain local, and measuring the value of local foods calls for capturing this value. Local food's share of food processor value added is captured by the first term in equation 2. Only that proportion that is not exported should be retained as local. The apple output share of manufacturing value added is multiplied by the share of processed output that remains local, as captured in the second term in equation 2.[2]

$$Local\ Processed\ VA = \left(\frac{z_{12}}{q_2 - v_2} v_2\right)\left(\frac{q_2 - x_2}{q_2}\right) \quad (2)$$

The value of trade transactions is captured in the final equation. Trade transactions require special considerations, as the trade sector transactions z_{13} only measures the margins the trade sectors earn in handling apples. For fresh apple sales, the trade revenue is simply z_{13}. Capturing the value of processed apples trade requires capturing retail margins of locally grown apples purchased by consumers and the share of retail margins earned from the sale of processed applies sourced locally. That is:

$$Local\ Trade = z_{13} + \left(\frac{z_{12} + Local\ Processed\ VA}{q_2}\right) z_{23}, \quad (3)$$

[2] This is not a conventional definition (or "first generation" definition) of "local food" in the context of what some consumers may expect from farmers markets. However, the concept of "local food" is evolving due in part to the inclusion of processed local foods, intermediaries, and holistic approaches to estimate the value of local foods systems.

This stylized example illustrates the extent of measuring local agricultural production that remains in the local economy, or the economic value of the local food system in output terms. Using fixed ratios of employment to output by sector will provide employment direct effects of the local food system. Similarly, labor income and gross regional product can be estimated with similar fixed ratios to output, providing direct estimates consistent with current methods of estimating such within the input-output model context.

There is an inherent shortcoming in using standard regional transactions table in this assessment. In this, the trade transactions reflect sector average margins earned at the wholesale and retail levels. These margins are heavily weighted toward conventional trade channel margins that may not be reflective of the local food value chains. Accordingly, discussions with wholesale and retail distributors in the Chicago region revealed a very different value proposition with local foods than conventional foods, where meeting tight margins was less a priority than delivering quality service and high-value produce. That is, for the practitioner estimating the size of the local food system, modifying the trade margins to reflect local food margins may be warranted in generating final outcomes.

2.2 Measuring Economic Contribution of Local Foods

Recent papers include Cooke and Watson (2011), Watson, Cooke et al. (2015) and Watson, Kay et al. (2015), used the social accounting matrix as the basis for valuing local food systems. Methods drew on approaches to measuring the changes in inter-regional transactions from import-substitution. In Cooke and Watson (2011), the authors explored how the underlying transactions respond to changes in local food purchases. Several important contributions arose in this conjecture. First, the paper provided a basis for modeling changes in intermediate purchases of local food, where prior research focused on impacts of household consumption of locally-sourced, unprocessed foods – those commonly purchased directly from the farmers through farmers markets, community supported agriculture and the like. Second, the approach recognized changes in production that give rise to changes in multipliers due to intermediate transactions. The second set of papers (Watson, Kay et al. 2015, Watson, Kay et al. 2015) brings to light the asymmetry between industry impacts and industry contributions within a standard IO framework. As IO models are export demand driven, they are not well suited for modeling structural changes in the local economy. These papers provide a framework for quantifying the contribution of existing industry within the modeling region and relax the assumption of static production sectors.

Starting with Cooke and Watson (2011), the framework starts with a standard input-output economic impact specification derived from Table 1 as:

$$\mathbf{q} = (\mathbf{I} - \mathbf{A})^{-1}\mathbf{x}. \tag{4}$$

In equation 4, $\mathbf{q}$ is an N vector of total outputs that is reproduced as some multiple of the N vector exogenous demands, $\mathbf{x}$. The NxN matrix $(\mathbf{I} - \mathbf{A})^{-1}$ is derived from Table 1, where the $\mathbf{I}$ matrix is an NxN identity and the $\mathbf{A}$ matrix of technical coefficients have elements $a_{ij} = z_{ij}/q_j$. The matrix $(\mathbf{I} - \mathbf{A})^{-1}$ is a matrix of multipliers and called the Leontief inverse (or $\mathbf{L}$), named after Wassily Leontief, the 20th century economist who derived the mathematics underlying this model. The $\mathbf{L}$ matrix is also called the *total requirements matrix* because summing down a column shows the total value of direct and secondary imports required for generating one-dollars' worth of the corresponding sector output. The vector of industry IO multipliers, $\mathbf{k}$, is calculated as the corresponding column sums of the $\mathbf{L}$ matrix. The standard IO framework requires specifying how exogenous demands change, assuming the underlying structure of the economy remains unchanged, and calculating the total change in output.

Because a change in local demand changes the underlying structure of the local economy, it will lead to a change in the value of the multipliers. For example, from Table 1, if industry 2 increases local purchases from industry 1 then $\Delta z_{12} > 0$ and $\Delta m_2 < 0$. That is, local inter-industry purchases deepen, reducing leakages from the economy. This deepening of the local economy decreases reliance on imports, indicating $\Delta\mathbf{k} \geq \mathbf{0}$. From this framework, new multiplier for industry 1 ($k_1 + \Delta k_1$) multiplied by the change in local demand (Δz_{12}) measures the economic impact of changes in local food demand. For small changes in local demand, Δk_1 will be small.

This approach gets a bit more complicated when attempting to apply it to changes in local final demands. Local purchases for final consumption compete against imported goods for final consumption and therefore, exhibit an element of import substitution. However, since it is for final consumption, such purchases should not feedback into the local economy as changes in the production process. Hence, institutional purchases of locally-sourced foods should be treated as changes in exogenous demand, subject to fixed multipliers (Miller, Mann et al. 2016).

Watson, Cooke et al. (2015) and Watson, Kay et al. (2015) provided another framework for interpreting industry contribution to local economies. By diagonalizing the vector of final demands in equation 4, the output vector is transformed to an NxN matrix of outputs.

$$\overline{\mathbf{q}} = \mathbf{L} \cdot \hat{\mathbf{x}}. \qquad (5)$$

In equation 6, the symbol ^ above the vector of exogenous demands denotes the NxN diagonalized vector $\mathbf{x}$, where each value x_i is placed on the diagonal as $\hat{x}_{ii}$. Additionally, a bar ($\overline{\ }$) is added to the $\mathbf{q}$ matrix to delineate it from the vector of total outputs, $\mathbf{q}$. According to Waters, Weber et al. (1999), a sector's export base is the component of a sector's output that fulfills export production, and can be measured as the column sum over all production sectors (industry sectors), as:

$$EB_i = \sum_j \overline{q}_{ij}, \text{ where } j \in industry\ sectors \qquad (6)$$

Alternatively, reading across the $\overline{\mathbf{q}}$ rows will reproduce the vector of total outputs $\mathbf{q}$. A sector's export base can be larger or smaller than the sector's total output because its contribution to the export base captures the intermediate input's contribution. From Table 1, if we were to subtract the column of exogenous, or export demands $\mathbf{x}$ from the total output column $\mathbf{q}$, we will get a measure of contributions to import substitutions – that is, a vector of supply to local uses. Comparing the value of export base to the values of import substitutions is an indication of the contribution a sector makes to wealth creation in the region (Watson, Kay et al. 2015). To this extent, wealth is created by exporting and generating an inflow of payments, while selling to local uses averts an outflow of funds for importing goods.

From economic base theory, the economic base drives the local economy (Waters, Weber et al. 1999), as the causal association is from basic (base) to non-basic economic activity (Tiebout 1956). Therefore, this approach to assessing the sector contribution to economic activity is grounded in is therefore subject to the critiques of economic base theory, as summarized in Tiebout (1956).

2.3 Measuring Net impacts of Local Food Sales

When undertaking economic impact assessments of import substitution, it is important to recognize that directing current production to local uses has an implicit cost of not directing that output to exports (Conner, Knudson et al. 2008, Swenson 2009, McFadden, Conner et al. 2016). That is, it is easy for a researcher to model the economic impacts of local food sales from farmers market receipts and overlook that by selling through the farmers market, the grower did not sell the same produce through other channels. When modeling the economic impact of local foods, the impacts should be net of the export value foregone of the local sales. The net economic effects of increasing local food systems can be measured in two parts. The first part is the associated impacts of reducing food sector exports. The second is the increased local uses of food sector output. For one-to-one diversion of exports to local uses, a positive economic impact can be shown.

The export impacts of a change in output can be calculated with the standard input-output equation, as:

$$\Delta\mathbf{Q}^{E} = \mathbf{L}^{\mathbf{0}} \cdot \Delta\mathbf{F}^{E}, \tag{7}$$

where, $\mathbf{L}^{\mathbf{0}}$ is the baseline Leontief inverse, $\Delta\mathbf{F}^{E}$ is the value of direct sales (in this case change in export sales), and $\Delta\mathbf{Q}^{E}$ is the vector of the total change in output required for generating $\Delta\mathbf{F}$ final sales, including direct and secondary effects. Equation 7 is the standard export-oriented economic impact assessment, where the Leontief matrix reflects fixed local expenditure patterns. Alternatively, increasing local demand shifts the relationships that underlie the Leontief inverse. The impact of an increase in local demand, holding exports constant, can be estimated as:

$$\Delta\mathbf{Q}^{L} = \mathbf{L}^{\mathbf{1}} \cdot \Delta\mathbf{F}^{L}, \tag{8}$$

where $\mathbf{L}^{\mathbf{1}}$ is the modified Leontief inverse reflecting a greater share of industry and consumer purchases of food imports being supplied by local producers, $\Delta\mathbf{F}^{L}$ is the value of output diverted to local consumption and $\Delta\mathbf{Q}^{L}$ is the vector of total change in output required for generating $\Delta\mathbf{F}^{L}$ in output.

Combining equations 7 and 8 provides as estimate of a one-to-one shift from exports to local sales. The net effects are calculated as combined impacts, or as:

$$\mathbf{NE} = \Delta\mathbf{Q}^{L} + \Delta\mathbf{Q}^{E} = \mathbf{L}^{\mathbf{1}} \cdot \Delta\mathbf{F}^{L} + \mathbf{L}^{\mathbf{0}} \cdot \Delta\mathbf{F}^{E}. \tag{9}$$

Modeling a simple diversion of export to local sales results in an additive inverse equality as:

$$\Delta\mathbf{F}^{L} = -\Delta\mathbf{F}^{E}. \tag{10}$$

Substituting equation 10 for $\Delta\mathbf{F}^{E}$ into equation 9 and simplifying provides:

$$\mathbf{NE} = \left(\mathbf{L^1} - \mathbf{L^0}\right) \cdot \Delta\mathbf{F}^{\boldsymbol{L}}. \tag{11}$$

That is, the net effect of diverting production from export sales to local uses, is the change in the Leontief inverses multiplied by the value of goods diverted to local use (Miller and Blair 2009, pp. 574). Given that change in local uses are positive, the multipliers associated with $\mathbf{L^1}$ will be larger than those of $\mathbf{L^0}$, resulting in a positive net impact. Total, aggregate impacts are simply the sum of industry net effects ($\sum_i NE_i$).

2.4 Inverse Importance Coefficients

Equation 11 provides a basis for understanding the potential impact of increasing local demand, but does so on the basis all users increase their purchases in equal proportion to current expenditures.[3] A policy analyst may be interested in the relative impacts of targeting sectors as purchasers of locally sourced commodities. For which it may be more impactful for particular sectors to purchase from local suppliers than others. For example, will increasing local sales of apples for processing to applesauce generate a larger impact than increasing local sales to restaurants? This line of inquiry follows that of "important coefficients" (ICs) of a matrix inverse (Miller and Blair 2009, pp. 567).

From Table 1, and following Cooke and Watson (2011), an increase in industry 2's purchases of industry 1 output, $\Delta z_{12} > 0$, may generate relatively larger or smaller secondary impacts than, say, an change in industry 2's purchases from industry 3, Δz_{32}. By assessing the relative size of economy-wide impacts, by each successive z_{ij}, one can assess the relative merit of focusing economic development efforts on key industry linkages. A survey of the research in this area can be found in Casler and Hadlock (1997).

This analysis follows Sherman and Morrison (1950) and Woodbury (1950) in assigning changes to an inverse matrix from changes in its primal form. Miller and Blair (2009) show the equivalent application in IO modelling. The computational approach was developed as a pre-personal computer and computationally assessable specification for asserting the impact of a change in the elements of the technical coefficients matrix A to changes in the Leontief inverse, and hence the multipliers. It averts the need to generate an inverse of the post-change matrix. In practice, modern computers can manage all but the largest of matrix inversions.

Accordingly, important coefficients underlying the social accounting matrix (SAM) are identified by the proportional change in the size of the largest impacted total requirements matrix elements to the change in a direct requirements matrix element. Given a technical requirements matrix $\mathbf{A}$ derived from a transactions table $\mathbf{Z}$, a change in any set of elements produces a new technical requirements matrix $\mathbf{A}^*$. As the total requirements matrix $\mathbf{L}$ is derived as:

$$\mathbf{L} = (\mathbf{I} - \mathbf{A})^{-1}. \tag{12}$$

The post change total requirements matrix is calculated as:

[3] That is, the net impact calculation is analogous to an increase in the sector's regional purchase coefficient (RPC), as applied equally to all purchasing sectors.

$$\mathbf{L}^{*} = (\mathbf{I} - \mathbf{A}^{*})^{-1}. \quad (13)$$

Proportional changes in the elements of L are calculated as:

$$\mathbf{P} = 100 \cdot (\mathbf{L}^{*} - \mathbf{L}) \oslash \mathbf{L}, \quad (14)$$

where $\oslash$ denotes elementwise division. Equation 14 calculates an NxN matrix of percent changes. Iterating through each element of the technical coefficient matrix, Hewings (1984) suggest that a coefficient generates a significant change in the economy if it generates at least one $\mathbf{P}$ coefficient whose absolute value exceeds some benchmark β. That is, $\mathbf{P}_{rs}$ is significant if $p_{ij} > \beta \; for \; all \; i = 1, 2, \dots, N \; and \; j = 1, 2, \dots, N$, where *r* and *s* represent the row and column of the iterated element of the $\mathbf{A}$ matrix changed. Hewings (1984) set β equal to 20 percent. Alternatively, important coefficients can be identified by comparing the percent change in resulting multipliers, as:

$$\mathbf{PM} = 100 \cdot \mathbf{i}' \cdot \left((\mathbf{L}^{*} - \mathbf{L}) \oslash \mathbf{L}\right). \quad (15)$$

In equation 15, the vector $\mathbf{i}$ is an N column summing vector of ones and **PM** is a 1xN vector of the percent change in the size of sector multipliers. That is, a change in one technical coefficient, a_{rs}, will result in changes in all sector multipliers. To gauge overall influence over the regional economy, a weighted average of the percent change in **PM** coefficients is calculated as:

$$APM = \sum_{j=1}^{N} PM_j \cdot \left({Q_j}/{Q} \right), \quad (16)$$

where APM is a scalar aggregate percent change in multipliers, and $Q = \sum_{i}^{N} Q_i$. That is, the term in parentheses are weights of industry share of total industry output. Larger values of APM denote changes in the technical coefficients that generate larger overall changes in regional output through indirect and induced effects.

3 Study Region Data

An industry-by-industry social accounting matrix for 38 counties making up the regional fringe of Chicago is generated using IMPLAN Pro 3.1 with 2013 data (IMPLAN Group LLC 2015). Figure 1 shows the U.S. Cropscape shades (Han, Yang et al. 2014, USDA National Agricultural Statistics Service Cropland Data Layer 2016), designating land use and commodity types, with counties and primary road transportation networks overlays for the modeling region. This area entails the whole of the Chicago-Naperville-Elgin combined statistical area and three counties of the Milwaukee-Racine-Waukesha combined statistical area. The Cropscape layer indicates a significant portion of the area's agricultural fields is in corn (yellow) and soybeans (green). Light green regions show areas of forests, wetlands, fallow land and farmland, and pastures. When moving into Southwest Michigan Counties of Berrien, Cass and Van Buren, the crop profile turns more toward specialty crops like grapes, cherries and blueberries. What is not evident in Figure 1, is the sporadic sprinkling of non-corn and non-soybean acres throughout the 38-county region. Though such acres are dwarfed by corn and soybeans, there exists a diversity of crop production to contribute to the diverse eating preferences of Chicago residents.

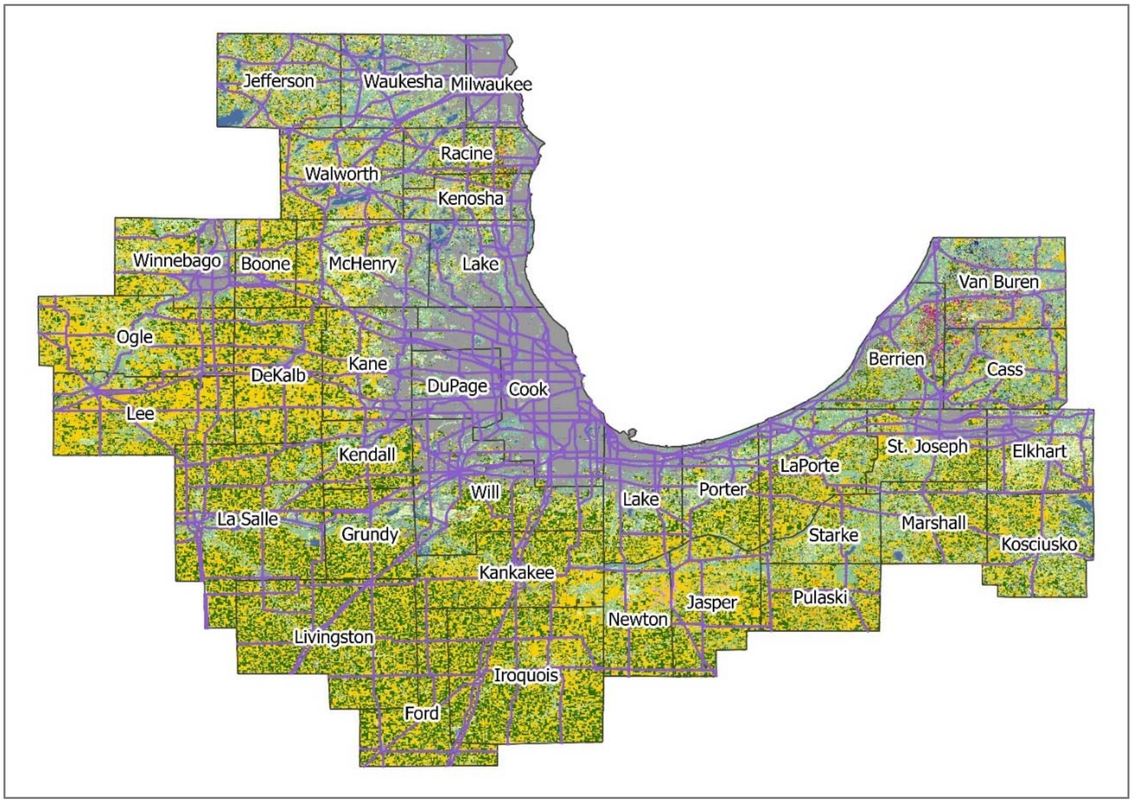

Figure 1: 2014 Cropscape layer for the 38-County Chicago Wilderness

All 38 counties were aggregated into a single region for analysis. To facilitate calculations, sectors were aggregated into 2-digit NAICS categories. However, crop-producing sectors were broken out and a second manufacturing category was created from manufacturing for food processing sectors. The sector aggregation is presented in Table 2. It is notable that a sizeable portion of grain production tends to go toward non-food manufacturing sectors.

3.1 Estimated Local Food Benchmarks

Table 3 shows local uses and production for the Chicago Wilderness and relates those to key measures of economic activity, including employment, labor income, and contributions to gross regional product (regional equivalence to gross domestic product). Starting with the Sales/Output column in **Table 3**, this measures the value of production and uses at producer's prices. The four crop producing sectors in the 38-county region produced \$3.97 billion in output in 2012. About \$2.52 billion was exported outside the 38-county region for consumption or processing, leaving \$1.46 billion for local uses. That is, about 37 percent (~1.46/3.97) of Chicago Wilderness crop production is consumed or processed in the Chicago region. of this, about \$0.64 billion is sold to local food processors.

Model Industry Aggregates	30 Food Processing
11 Ag, Forestry, Fish & Hunting	Flour milling
Grain farming	Rice milling
Vegetable and melon farming	Malt mfg
Fruit farming	Wet corn milling
Tree nut farming	Soybean and other oilseed processing
Greenhs., nrsry., & floriculture	Fats and oils refining and blending
21 Mining	Breakfast cereal mfg
22 Utilities	Beet sugar mfg
23 Construction	Sugar cane mills and refining
31-33 Manufacturing	Non-chocolate confectionery mfg
30 Food Processing	Chocolate and confectionery mfg from cacao beans
42 Wholesale Trade	Confectionery mfg from purchased chocolate
44-45 Retail trade	Frozen fruits, juices and vegetables mfg
48-49 Transportation & Warehousing	Frozen specialties mfg
51 Information	Canned fruits and vegetables mfg
52 Finance & insurance	Canned specialties
53 Real estate & rental	Dehydrated food products mfg
54 Professional- scientific & tech svcs	Fluid milk mfg
55 Management of companies	Creamery butter mfg
56 Administrative & waste services	Cheese mfg
61 Educational svcs	Dry, condensed, and evaporated dairy product mfg
62 Health & social services	Ice cream and frozen dessert mfg
71 Arts- entertainment & recreation	Animal, except poultry, slaughtering
72 Accommodation & food services	Meat processed from carcasses
81 Other services	Rendering and meat byproduct processing
92 Government & non NAICs	Poultry processing
	Seafood product preparation and packaging
	Bread and bakery product, except frozen, mfg
	Frozen cakes and other pastries mfg
	Cookie and cracker mfg
	Dry pasta, mixes, and dough mfg
	Tortilla mfg
	Roasted nuts and peanut butter mfg
	Other snack food mfg
	Coffee and tea mfg
	Flavoring syrup and concentrate mfg
	Mayonnaise, dressing, and sauce mfg
	Spice and extract mfg
	All other food mfg

Table 2: Model Aggregates

Because we are defining local foods as that which is produced and remains in the local region through to consumption, we include only the value of goods through to local final consumption. Raw, or unprocessed foods have two channels to local consumption: 1) as unprocessed food and 2) as processed foods. In addition to the $644.3 million unprocessed foods purchased by processors, local household purchase $134.8 million, food services purchase $2.7 million and institutions purchase $2.7 million. In addition, about $30,000 is earned in retail and wholesale margins.[4] Local foods' share of locally

[4] Retail and wholesale margins may posit a conservative fallacy of strictly relying on the regional transactions table for allocating expenditures, as such margin estimates are largely weighted toward the low-margin conventional

processed food amount to $101.7 million purchased by households, $21.7 million by food service, and $6.4 million by institutions. In addition, retail and wholesale margins on locally-sourced processed foods amounted to about $200,000.

	Sales/Output ($000,000s)	Employment	Earnings ($000,000s)	GRP ($000,000s)
Total Output	**3,973.3**	**16,635**	**316.5**	**193.8**
Less Exports	2,515.0	10,079	160.5	57.4
Contribution to Import Substitution	**1,458.3**	**6,556**	**156.0**	**136.5**
Local Supply to Food Processors	644.3	2,835	57.6	41.1
Local Fresh				
Households	134.77	1,114	61.1	89.2
Retail/Wholesale	0.03	0	0.0	0.0
Food Service	2.66	16	1.0	1.4
Institutions	2.71	14	0.7	0.9
Total Local Fresh	**140.16**	**1,145**	**62.7**	**91.5**
Local Processed				
Households	101.67	210	13.1	22.2
Retail/Wholesale	0.20	0	0.0	0.0
Food Service	21.66	45	2.8	4.7
Institutions	6.44	13	0.8	1.4
Total Local Processed	**129.97**	**268**	**16.8**	**28.4**
Total (Local Fresh+Local Processed)				
Households	236.44	1,324.37	74.20	111.37
Retail/Wholesale	0.23	0.66	0.04	0.06
Food Service	24.32	61.13	3.78	6.15
Institutions	9.15	27.20	1.50	2.30
Total Local	**270.13**	**1,413**	**79.5**	**119.9**

Table 3: Estimated Baseline Local Foods Economics

Source: IMPLAN and authors' calculations (may not sum due to rounding)

When combining the values fresh and processed goods, households in the Chicago Wilderness makes up about $236.4 million of local food sales, while food services make up about $24.3 million and institutions make up about $9.2 million. Retailers and wholesalers earn margins of about $230,000. Of the $1.46 billion of fresh food that is not directly exported about $784.42 million of the local supply is accounted for with local uses for local food, with $140.16 million consumed from fresh and $644.26 as fresh inputs into processed goods. Of the $644.26 million in processed food from local supply, about $129.97 million remains local to consumption. The remainder of the local fresh and local processed foods is purchased by sectors not traditionally tied to uses of food. The largest component is manufacturing purchases of agricultural output not for food processing. Non-food uses of corn are

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food channels. Based on conversations with wholesalers and distributors in the Chicago region, we believe these baseline margins for locally-directed foods are low.

common in the chemical and petrochemical industries. Some production is reverted back into agricultural sectors as seed for next year's crop or for home consumption (not reported). Other uses that are not counted may show up in corporate cafeterias, which are listed under the NAICS category of the hosting business. Because of these later possibilities, that other industries are utilizing agri-food inputs that are outside the scope of conventional channels that food traverses, the estimates are likely conservative.

Next we apply standard IO modeling techniques to estimate employment, labor income and contributions to annual gross regional product. IO modeling assumes some fixed ratio of each to sales by industry. That is, typical rates for crop production and food manufacturing are calculated and applied accordingly. Expected direct employment in the Chicago Wilderness limited to local foods is about 1,413 with annual income topping $79.5 million. The employment counts that IMPLAN uses are based on Bureau of Economic Analysis counts, where there is no delineation of part-time and full-time employment and the allocation may differ by industry. Labor income also entails proprietor incomes and comes out to about $56,259 annual wages per job. Finally, total local food output from farm to household generates about $119.9 million to gross regional product.

The IMPLAN data also allows us to estimate the total household expenditures for food and compare this to our estimates. In this only household expenditures on crop products and processed foods is considered. Processed foods will include estimates of protein purchases. To this extent, Chicago Wilderness residents purchase about $19.937 billion in fresh and processed foods, where about 1.4 percent is provided by local suppliers of crops. A similar analysis for the whole state of Michigan found local sources supplied about 17 percent of Michigan food demand (Miller, Mann et al. 2015).

3.2 Relative Economic Contributions

In this section, we look at the empirical estimates of the economy-wide contribution of agri-food production in the Chicago Wilderness to the local economy. We draw heavily from the work of Watson, Kay et al. (2015) and methods are presented in Section 2.3.

The first table to review shows the distribution of sector sales. In **Table 4**, intermediate sales are sector sales to other producing industries. Such industries purchase inputs from other sectors in the process of generating goods and services for final use. For instance, the food processing sector is a large intermediate buyer of agricultural producers' output. The local final sales column shows the value of purchases consumers make at the producers' prices.[5] For grains, this would be whole corn purchases that may take place directly from the grower, or through an intermediary, such as through a retailer. Regardless, the key point is the price shown is the price the grower receives and the consumers' purchase is for non-processed grains. The total local sales are the sum of intermediate and local final sales. External sales are largely made up of the value of those goods shipped out of the region. Output is the sum of total local and external sales. Evident in **Table 4** is that grain farming and food processing

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[5] The model is closed up to the household level. That is, all non-household institutional purchases are treated as external or export purchases. This amounts to a small share of total output.

sales are largely driven by external purchases, as about 71% of output is accounted for with external sales.

	Intermediate Sales	Local Final Sales	Total Local Sales	External Sales	Output
Ag, Forestry, Fish & Hunting	1,827.4	106.7	1,934.1	2,124.8	4,058.9
Grain farming	1,048.3	24.8	1,073.1	2,655.1	3,728.2
Vegetable and melon farming	26.5	82.8	109.3	25.9	135.2
Fruit farming	32.5	26.7	59.2	48.4	107.6
Tree nut farming	0.3	0.4	0.7	1.5	2.3
Greenhouse, nursery, and floriculture	57.3	78.2	135.5	162.4	297.9
Food Processing	5,010	6,322	11,332	28,726	40,059

Table 4: Sector Demand Profiles
Source: IMPLAN and authors' calculations

In interpreting **Table 4**, it is important to realize that these are direct value of transactions and do not take into account secondary effects that give rise to economic impacts. **Table 5** views the sector impact distribution through the lens of secondary effects. There, the Direct Base column depicts exogenous, or export sales. The indirect base are secondary transactions to other sectors in the Chicago Wilderness required in producing the agricultural commodities or processed foods. The export sales drive these secondary transactions, hence, the sum of the direct and indirect base is the total economic base or the export base. The local purchases column is the sum of intermediate (industry purchases) and household purchases for local output. The ratio gives an indication to the extent that the sector supplies external markets relative to local markets. In this, it is clear that grain production is much more tied to external markets while vegetable and melon farming production is much more directed toward local uses. For fruit farming, while grapes are included in this category and are present throughout the Chicago Wilderness area, the relatively high concentrations eastern counties favors exports, driving up the export base. For example, the core of blueberry, cherry and apple production occurs in the three counties of Southeast Michigan making up the Wilderness. The nature of this concentration, just as the nature of grain production concentration throughout the region, favors export markets.

	Direct Base	Indirect Base	Total Base	Local Purchases	Ratio TB/LP
Ag, Forestry, Fish & Hunting	2,124.8	1,570.3	3,695.1	4,058.9	0.91
Grain farming	2,655.1	2,644.8	5,299.9	3,728.2	1.42
Vegetable and melon farming	25.9	19.4	45.3	135.2	0.33
Fruit farming	48.4	38.2	86.6	107.6	0.80
Tree nut farming	1.5	1.2	2.7	2.3	1.20
Greenhouse, nursery, and floriculture	162.4	143.6	306.0	297.9	1.03
Food Processing	28,726	22,814	51,540	40,059	1.29

Table 5: Base versus Gross Output ($Millions)
Source: IMPLAN and authors' calculations

3.3 Estimated Impact of a 10% Increase in Local Uses

Next, we perform a hypothetical analysis of change in local demand and assess how this change will impact the Chicago Wilderness economy. The initial change we model is an increase in local demand by

10%. In this each crop farming sector's total export sales are decreased and taken up by local sectors in proportion to current purchases. That is, there is a one-to-one diversion of exported goods to local uses. This assumption relieves a common critique of local foods impact estimates that do not recognize that economic effects of local food sales often entails inverse economic effects of lost export food sales. That is, we directly subtract out export sales in our local food impact estimate. **Table 6** shows the simulated change in sales by agricultural sector. In this example, both intermediate and local final uses of agricultural crops increase by 10%. However, while food processors increase their purchases of local inputs by 10%, no assumption is made on the change in intermediate and final demand for local processed foods. While this represents a $1.242 billion reshuffling of the agri-food economy, keep in mind that the additional sales to local uses is fully offset by a reduction in export sales.

	Change in Sales	
	Local	Exports
Grain farming	1,073.1	-1,073.1
Vegetable and melon farming	109.3	-109.3
Fruit farming	59.2	-59.2
Tree nut farming	0.7	-0.7
Total	1,242.4	-1,242.4

Table 6: Scenario Changes in Sales ($Millions)

Following the method described in section 2.3, net effects in terms of how sales are calculated by sector. **Table 7** shows the sector-by-sector net impacts of this simulation, indicating that the total impact of diverting $1.242 billion exports for local consumption generates net change of $530,182 in local sales. This estimate includes both direct and secondary transactions. As may be expected, the largest source of net impacts is the grain farming sector, largely stemming from the large share of the direct change in transactions. In this, it may be unrealistic to assume that Chicago consumers will absorb $1.073 billion in new unprocessed grain production. However, processors that use grains in producing milled products may have some capacity in increase purchases from local sources. Additionally, though a change in local demand from Ag, Forestry, Fish and Hunting sector was not modeled, it is evident they benefit from this change. This is because this sector often provides services and inputs in the crop production sector. Other sectors also experience a change in sales as the transactions reverberate throughout the economy.

Sector	Output Impact
11 Ag, Forestry, Fish & Hunting	8,756
Grain farming	269,824
Vegetable and melon farming	2,058
Fruit farming	480
Tree nut farming	6
Greenhouse, nursery, and floriculture production	27
21 Mining	336
22 Utilities	7,857
23 Construction	7,384
31-33 Manufacturing	42,661
30 Food Processing	1,344
42 Wholesale Trade	25,601
44-45 Retail trade	7,809
48-49 Transportation & Warehousing	13,464
51 Information	6,518
52 Finance & insurance	37,598
53 Real estate & rental	47,570
54 Professional- scientific & tech svcs	12,562
55 Management of companies	3,633
56 Administrative & waste services	6,094
61 Educational svcs	2,272
62 Health & social services	11,167
71 Arts- entertainment & recreation	1,833
72 Accommodation & food services	4,781
81 Other services	5,174
92 Government & non NAICs	3,372
Total Sales Net Effect	530,182

Table 7: Net Sales Impacts ($)

The findings in **Table 7** can be used to estimate other metrics of impact including employment, earnings, and gross regional product. Using standard economic impact modeling techniques of assigning fixed ratios of each to output, such metrics are reported in **Table 8**. Here, the $530,182 net change in sales is expected to give rise to about 2.4 regional jobs with annual labor income of $94,301. That is, the jobs created are expected to generate annual wages of about $39,751. Additionally, this simulation shows contributions to gross regional product will grow by about $150,267.

Regional Measure	Value
Change in Sales	$530,182
Change in Employment	2.4
Change in Labor income	$94,301
Change in GRP	$150,267
Average annual earnings	$39,751

Table 8: Summary of Impacts

3.4 Identification of important sectors

We limit consideration to changes in technical coefficients of key food purchasing industries and of household for the five agricultural producing sectors. That is, we successively increase the sector demand for locally-produced agri-food products by 20 percent and measure the percent change in all industry sector multipliers[6], weighted by the sector output. The findings are reported in Table 9. As shown, increasing local food processing purchases of grain farming output by 20 percent generates relatively larger secondary effects than increasing wholesale or retail purchases. Here, increasing food processor purchases will likely result in a 10.11 percent increase in overall multipliers of the Chicago Wilderness. This compares with approximately no change in multipliers for the two trade sectors. Alternatively, higher income household sector purchases tend to generate larger economy-wide impacts than lower income households. This mostly reflects scale affects, where higher income households purchased $5.53 million from local grain farming in 2012, according to IMPLAN, compared to $0.7 million for the lowest income group. Hence, a 20% increase in the higher income group constitutes a much larger direct effect change in local demand than the same for the low income group.

	Grain farming	Vegetable and melon farming	Fruit farming	Tree nut farming	Food Processing
Food Processing	10.1105	1.9431	4.0146	3.1077	4.5826
Wholesale Trade	0.0000	0.0015	0.0033	0.0056	0.0817
Retail trade	0.0015	0.0015	0.0035	0.0056	0.0277
Educational svcs	0.0358	0.1071	0.0190	0.0236	0.8750
Health & social services	0.0083	0.1191	0.0037	0.0061	2.1583
Arts- entertainment & recreation	0.0015	0.0201	0.0280	0.0446	0.2413
Accommodation & food services	0.0388	0.2552	0.0406	0.0534	6.4642
Households LT10k	0.0065	0.0843	0.0617	0.0884	0.1516
Households 10-15k	0.0070	0.0864	0.0629	0.0926	0.1524
Households 15-25k	0.0350	0.4363	0.3188	0.4623	0.7788
Households 25-35k	0.0596	0.6932	0.5111	0.7183	1.2644
Households 35-50k	0.1336	1.5519	1.1512	1.5768	2.8792
Households 50-75k	0.2999	3.3239	2.4966	3.2503	6.3702
Households 75-100k	0.2895	3.1565	2.3936	2.9866	6.2062
Households 100-150k	0.4168	4.2272	3.2456	3.8515	8.5544
Households 150k+	0.4638	3.9861	3.1158	3.4874	8.3376

Table 9: Percent change in Aggregate Multipliers corresponding to Row changes in demand for column commodities.

Source: IMPLAN and authors' calculations

Figure 2 graphically shows the percent from a 20 percent change in household purchases, largely reproducing the household agri-food impacts shown in Table 9. It is evident that directing local grain

[6] Households are assumed to not generate multiplier impacts but rather increase direct demand for agri-food output and hence generate secondary impacts measured in the multiplier changes.

outputs to households is likely to generate smaller impacts than promoting local fruit, vegetables and nut output.

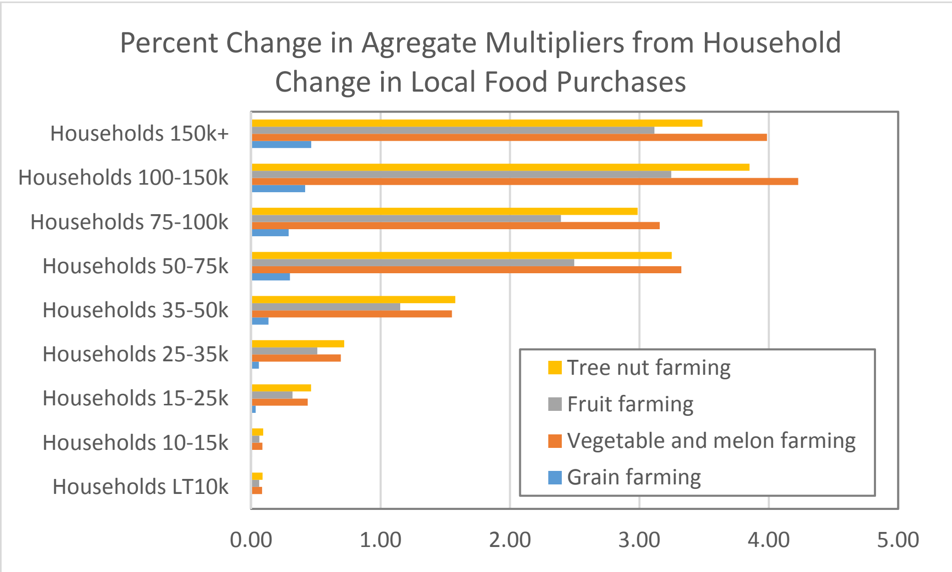

Figure 2: Impacts from 20 percent change in household purchases

As evident in Figure 2, impacts are largest for higher income groups, where higher income groups tend to exhibit higher aggregate expenditures in the Chicago Wilderness. Table 10 shows the IMPLAN baseline expenditures of the commodity types by household type, showing a near uniform increase in total expenditures with higher income groups. To be sure, regression equations were estimated by commodity of the results in Figure 2 against the total expenditures in Table 10, showing a close association between household category baseline expenditures and changes in the corresponding multipliers.

	Grain farming	Vegetable and melon farming	Fruit farming	Tree nut farming
Households LT10k	0.704	2.910	0.910	0.017
Households 10-15k	0.498	1.953	0.607	0.012
Households 15-25k	1.325	5.235	1.633	0.031
Households 25-35k	1.482	5.464	1.720	0.032
Households 35-50k	2.335	8.597	2.722	0.049
Households 50-75k	4.144	14.552	4.665	0.080
Households 75-100k	3.677	12.706	4.112	0.068
Households 100-150k	5.072	16.306	5.342	0.084
Households 150k+	5.528	15.093	5.026	0.074

Table 10: Baseline Household Purchases of Local Agri-food Production ($millions)
Source: IMPLAN

5 Conclusions

The impetus of this research arose from a request to build talking points around the economic merit and feasibility of expanding Chicago's local food system. The research approach was directed at overcoming some of the obstacles for measuring local food systems and has relevance to modeling the economic impact of regional import substitution programs in general. In this, a framework for measuring the value of local food systems, estimating the larger economic contribution of the local food system, and setting policy targets for expanding such systems is outlined within a standard IO framework. While the results shown in this report are preliminary, the findings suggest that a small share of total non-protein food consumption in the 38 county-region that makes up the Chicago Wilderness is supplied by local sources. We hypothesize an increase in local food demand across all sectors and households and gauge the economic impact where local food purchases one-for-one supplant export sales. Net impacts are calculated based on changes in the underlying transactions table. Next, rather than assuming all sector purchases increase, we gauge the relative impacts should certain sectors increase their purchases of local-sourced foods to identify those sectors to target for the largest economy-wide impacts.

The approach outlined in this article addresses several issues associated with past attempts at measuring the economics of local food systems. First, rather than restrict consideration to sales through channels that are commonly associated with local food, such as farmers markets, CSAs, etc., the approach is comprehensive to all channels by which food may traverse from grower to consumer. In addition, in measuring the contribution of local to the larger economy, full accounting of opportunity costs can be captured within the estimation equations. Finally, the analysis is not limited to final uses but rather establishes a framework for interpreting the value of intermediate demands and indirect channels that local food traverses to final consumption.

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