Journal of Agricultural and Resource Economics 42(2):180–194 ISSN 1068-5502

A Method for Evaluating the Economic Contribution of a Local Food System

Philip Watson, Stephen Cooke, David Kay, Greg Alward, and Alfonso Morales

Despite growing interest in local food, modeling the economic contribution of this endogenous system is inherently problematic. We present a combined hypothetical extraction and import-substitution social accounting matrix model that overcomes these problems in a theoretically consistent and computationally feasible manner. The method can be applied broadly to many different definitions of a "local food system" and uses the same underlying method as traditional economic-base contribution models. We apply this model to the state of Idaho and compare the economic contribution of the local food system against the economic contribution of the export food system.

Key words: economic contribution, hypothetical extraction, import substitution, local food

Introduction

Sales of locally produced food represent a growing segment of total U.S. agricultural revenue (Thilmany and Watson, 2004). In response to this trend, local and federal government policy makers have shown renewed interest in rural development strategies that support local food markets (Low et al., 2015; Low and Vogel, 2011b) and in understanding how local food systems contribute to local economies (Thilmany McFadden et al., 2016).

Much of the recent debate about the role of local food systems has centered on definitional issues concerning what should or should not be included in the accounting stance of a local food system (Martinez et al., 2010; Thilmany McFadden et al., 2016). The normative and positive issues surrounding what counts as a component of the "local food" system are a vital discussion and represent a fertile area of research. However, irrespective of the definition of local food, a theoretically consistent and empirically feasible system for modeling the complex interactions of a given definition of "local food" in a regional economy is needed. This methodological concern has rarely been elaborated on in the previous literature and represents the primary focus of this paper. Furthermore, we develop and deploy a method for evaluating a local food system comparable to the standard methods used to evaluate the ubiquitous economic-base contributions of agriculture.

A limited number of studies have discussed methodological issues of evaluating the regional economic contribution of local systems (Hughes et al., 2008; Henneberry, Whitacre, and Agustini, 2009; Varner and Otto, 2008). Most of these studies, however, have been limited to a specific component of a local food system (e.g., farmers' markets). For example, Hughes et al. (2008) investigated the economic impacts of farmers' markets in West Virginia using an "opportunity cost framework." While that method may be appropriate for evaluating consumer expenditure

---

Philip Watson is an associate professor in the Department of Agricultural Economics and Rural Sociology at the University of Idaho. Stephen Cooke and David Kay are senior economists at the Alward Institute for Collaborative Science. Greg Alward is a senior scientist in the College of Natural Resources' Policy Analysis Group at the University of Idaho. Alfonso Morales is an a professor in the Department of Urban and Regional Planning at the University of Wisconsin.
This project was partially supported by the Idaho Agricultural Experiment Station and the USDA National Institute for Food and Agriculture.
Review coordinated by Hikaru Hanawa Peterson.

substitutions within a single sector (i.e., farmers' markets and grocery stores), it is less clear that this method is appropriate for evaluating the contribution of local food across all potential sectors, including producers, processors, and distributors.

The approach we develop applies a hypothetical extraction method (Miller and Lahr, 2001) to an import-substitution social accounting matrix model (Cooke and Watson, 2011; Persky, Ranney, and Wiewel, 1993). This method is straightforward, replicable, cost-effective, and uses easily accessible input-output models.[1] In addition, the method is applicable to a broad set of different definitions of the idea of a local food system and can be used to measure the contribution of any submarket within the local food system.

Lastly, we demonstrate this method for a very broad definition of local food using the state of Idaho as an example region. For the purposes of the example, we initially define local food markets to include all local sales of locally produced raw agricultural products and processed-food products. We then apply this method to increasingly constrained alternative definitions of a local food system. While these definitions are not intended to be exhaustive, they demonstrate how the underlying method could be applied to more restrictive definitions without loss of consistency or generality.

Background

The economic contribution and impact studies in the local food literature have mostly concentrated on specific segments of a local food system that sell locally produced food directly to local consumers (e.g., farmers' markets, roadside stands, and pick-your-own produce) or through intermediated marketing channels (e.g., grocery stores, restaurants, food hubs, and farm-to-school programs) (Low et al., 2015; Martinez et al., 2010; Henneberry, Whitacre, and Agustini, 2009; Hughes et al., 2008). These studies have used direct sales to households to estimate the value of indirect supply chain activity required to bring these products to market. Direct sales are then added to the value of indirect supply chain activity to represent the entire impact of the food market on the regional economy. While these studies have been instrumental in forming our understanding of the economic contribution and extent of specific portions of the total local food system, there are several issues that must still be addressed when trying to estimate the total size, extent, and economic contribution of a region's entire local food system.

First, the definition of local food markets, as commonly applied to economic impact studies, has not typically included agricultural sales from farmers to food processors. This definition excludes much of the value-added processing associated with local marketing chains and thus paints a potentially incomplete picture of the role that local agriculture plays in supporting jobs and income. While there may be reasons to exclude these intermediated sales in a local food definition, it is advisable to have a method that is flexible enough to allow for their inclusion or exclusion in a systematic model that mitigates the potential for double counting.

Second, economic impact estimates are typically not benchmarked to any external metric. As such, it is far too easy to unwittingly produce results that over-estimate the impact of local food markets (Watson et al., 2015). For example, a reporting series that attempts to measure the impact of many farms or agricultural submarkets may produce a series of impact results. If these reports are not benchmarked to agriculture's total observed output, it is easy to imagine a scenario in which the sum of impact results may add to an amount greater than the industry's entire output. Obviously, such an outcome would not be realistic and could be avoided if the extent of agriculture's economic contribution were determined beforehand and then used to benchmark individual impact studies.

Third, the economic impact model is calibrated to measure changes in demand from markets or institutions outside a region (Waters, Weber, and Holland, 1999; Watson and Beleiciks, 2009). Local food markets, by definition, are not located outside a region. They represent demand from

[1] The use of an import-substitution framework to economically evaluate local food systems is, for example, recommended by a recently convened USDA expert panel (http://www.localfoodeconomics.com)

the variety of customers within a region. As such, the traditional economic impact model cannot be used to measure changes associated with internal markets unless its multiplier parameters are first adapted.

Finally, the cost of data collection required to isolate demand changes in small submarkets can limit the types of modeling questions asked by researchers (Miller et al., 2015). For example, many previous studies of the economic impacts of farmers' markets involved collecting primary data though surveys (Henneberry, Whitacre, and Agustini, 2009; Hughes et al., 2008). This is an inherently costly endeavor and, while necessary to estimate the economic impact of a specific farmers' market, would be prohibitive to obtain an estimate of the economic contribution of local food systems in general. Some initiatives now being pilot-tested may make such data collection a regular part of some submarkets, including a large initiative spearheaded by the USDA.[2]

To advance the field and overcome these limitations, we propose a method that combines import-substitution models with hypothetical extraction. Miller and Lahr (2001) and Dietzenbacher and Lahr (2013) provided an overview of the theory and methods of hypothetical extraction, which has been employed to study many sectors of a regional economy, including the service sector (Kay, Pratt, and Warner, 2007) and the commercial fishing sector (Leung and Pooley, 2001). The basic logic of the model is to evaluate how much the output of a regional economy would decrease if an industry were to be eliminated (Miller, 1966). This output reduction is not only a function of the direct loss of output but also the loss in output that results from the subsequent hollowing out of the economy. In the case of a hypothetical extraction, the regional economy must now import all the goods previously produced by the extracted industry. This estimation technique can be thought of as a negative import-substitution approach to modeling economic activity.

Import substitution has a lengthy and contentious history in the economic development literature (Bruton, 1998; Pred, 1966; Little, 1982). However, from an economic development perspective, import substitution represents a deepening of a regional economy that results from producing goods for local consumption where those goods would have been previously imported. This process is a part of the "stages of development" growth theory developed by Rostow (1962) and Kuznets (1955) and advocated for by Jacobs (1969). However, the technique is not wedded to any particular macroeconomic perspective. Importantly, Cooke and Watson (2011) showed that an import-substitution model can be derived from the very same Leontief input-output model used in traditional economic impact assessment and that has been used in previous models of the economic impacts of specific components of the local food system (Henneberry, Whitacre, and Agustini, 2009; Hughes et al., 2008).

Lastly, and crucially, the definition of the "local food" sector deserves attention. There is a growing interest in defining a "local food system" not simply by where the food was produced and where it was ultimately consumed. Rather, definitions of local food are expanding beyond geography to also include how food is marketed (Low and Vogel, 2011a; Thilmany McFadden et al., 2016; Jablonski and Schmit, 2016). Under this definition, "local food" is a function of both geographic origin and marketing channel. This distinction, while fraught with normative judgments, is important to capture the economic contribution of a "local food system" that corresponds to a broader definition used by some groups. While the tautological definition of "local food" as "food that is both produced and sold to final demand in the same geographic region" is one reasonable definition of "local food," it is not the only possible definition. For example, if "local food" is defined not only by geographies of production and consumption, then additional information is needed on production functions and marketing channels associated with a specific subset of production and consumption expenditures that are defined as local (Jablonski and Schmit, 2016). We attempt to describe a method for evaluating the economic contribution of a "local food system" that can be applied to a broad set of definitions.

[2] This USDA project convened experts in local food economics to produce a guide that coalitions might use to scope and conduct measurement projects for their local food systems. The project provides training in data collection and assessment of local food initiatives. For more information visit http://www.localfoodeconomics.com.

Table 1. Notational Social Accounting Matrix (SAM) for a Three-Sector Regional Economy

		Local Industries			Local Households	Exogenous Demand	
		I1	I2	I3	(Consumption)	(Exports)	Total
	I1	z_{11}	z_{12}	z_{13}	c_{14}	y_1	x_1
Local Industries	I2	z_{21}	z_{22}	z_{23}	c_{24}	y_2	x_2
	I3	z_{31}	z_{32}	z_{33}	c_{34}	y_3	x_3
Local Households (value added)		v_1	v_2	v_3		$y_4 = v_4$	v
Exogenous Inputs (Imports)		m_1	m_2	m_3	m_4		m
Total		x_1	x_2	x_3	c	y	

Notes: Here we define "exogenous demand" as any sales outside the region. As per convention, SAMs present sales between the accounts across the row and purchases between accounts down a column. By definition, in total, $c = v$ and $y = m$.

Evaluation Method

The method we develop to evaluate the economic contribution and extent of a regional local food system is based on a social accounting matrix (SAM) model that shares much of its structure with the National Income and Product Accounts (NIPA), which are the primary macroeconomic accounts for the United States (Kuznets, 1955). While the NIPA accounts track national economic activity, regional social accounts serve much the same function for subnational regions. The regional social accounts explicitly track both local production and local consumption of goods and services and are, therefore, well suited to estimating the extent of a local food market as social accounts lend themselves to general equilibrium modeling of the interactions between the various segments of the regional economy. They can therefore be used to estimate the contribution of local food to the entire regional economy (Waters, Weber, and Holland, 1999).

SAM models and related input-output models require a considerable number of simplifying assumptions, most notably fixed prices and Leontief production functions. These models are often abused when used to forecast the impact of *ex ante* events or when the assumptions of an input-output model are violated (Watson et al., 2007; Crompton, 2006). While input-output-type models may not be the most appropriate for forecasting or estimating *ex ante* changes in a regional economy from implementing a new local food system or policy, we contend that, when applied appropriately, these models are defensible when looking at *ex post* contributions (Watson et al., 2015).

Throughout this section, we refer to a hypothetical, three-sector SAM for illustrative purposes. However, in the empirical application section we apply this method to a 2013 536-sector IMPLAN SAM for the state of Idaho. Doing so allows us to derive an upper-bound estimate of the contribution of local food markets to the state's economy.

Regional Social Accounts

The data necessary to evaluate the extent and economic contribution of local food can be derived from regional social accounts and organized into a regional SAM. The modeling framework and data architecture described here are invariant to definitional changes. Without a loss of consistency, the method described here could be applied to a broad set of definitions of "local food."

A SAM is a statistical framework that utilizes double-entry bookkeeping to trace all monetary flows and organize the flow-of-value statistical data for a national, state, or regional economy over a given period. Mathematically, a SAM is a square matrix in which each nonzero element records the value of a financial transaction between economic actors. Table 1 presents a notational, three-sector SAM for a hypothetical economy. Industry rows record sales to all possible endogenous (i.e., local) and exogenous outlets including endogenous intermediate demand (zij); endogenous final demand associated with household spending (c_{i4}); and exogenous final demand associated with, for example, household investment income, government spending, and exports (y_i). The total of these transactions represents the total industry output of a given sector (x_i). Note that total consumption

Table 2. Endogenous Requirements Matrix (A) of Regional Economy

		Local Industries			Local
		I1	I2	I3	Households
	I1	a_{11}	a_{12}	a_{13}	a_{14}
Local Industries	I2	a_{21}	a_{22}	a_{23}	a_{24}
	I3	a_{31}	a_{32}	a_{33}	a_{34}
Local Households		a_{41}	a_{42}	a_{43}	

Notes: The aij elements are defined as $\frac{zij}{x_j}$ and represent the share of total inputs spent on local inputs.

(c_{i4}) is equal to total income (v_{4j}) and that y_4 and v_4 are identical and can be interpreted as both an export and income (i.e., income into the region from exogenous sources). Industry columns record purchases and represent Leontief production functions that include local input purchases (zij), factor payments (income; v_{4j}), and imported input purchases (m_{5j}). Within the SAM accounting framework, economic actors are required to meet their budget constraints to maintain equilibrium between buyers and sellers. As such, all row sums are balanced with corresponding column sums.

In the hypothetical, three-sector economy industry I1 represents the region's manufacturing sector, industry I2 represents the region's aggregated food-processing and agricultural production sector, and industry I3 represents the region's service/retail sector (table 1). Industry row I2 is partially highlighted to represent sales of locally produced food to local industries and institutions. This definition of local food includes locally produced food products sold as inputs to other production processes ($z_{21} + z_{22} + z_{23}$). Examplex would include locally produced milk sold to a local cheese manufacturer, grocery store, or restaurant. This definition also includes locally produced food products marketed directly to local consumers (c_{24}), such as locally produced milk sold directly to households at farmers' markets. Our definition of local food markets does not include locally produced food products that are exported to markets outside of the state (y_2), such as locally produced milk shipped to other states. The requirements table (table 2) is derived from the regional SAM, where aij equals the share of total industry outlay for every ith row and jth column and the full dimension matrix of aij coefficients is denoted as matrix $\boldsymbol{A}$ (Miller and Blair, 2009, p. 16).

Measuring Gross and Base Economic Contributions

Waters, Weber, and Holland (1999) were the first to formally suggest a simple modification to the standard Leontief input-output model that increases the amount of useful information produced. The procedure consists of diagonalizing the vector of final demand to create the matrix $\hat{\boldsymbol{Y}}$. Diagonalizing a vector simply means placing the elements of the vector along the major diagonal of an $n \times n$ matrix. By doing, so the $n \times n$ multiplier matrix can then be multiplied by an $n \times n$ diagonal matrix of final demand and yield an $n \times n$ matrix of gross and base output ($\boldsymbol{X}$). Equation (1) presents the formal economic-base model:

$$\boldsymbol{X} = (\boldsymbol{I} - \boldsymbol{A})^{-1}\hat{\boldsymbol{Y}}, \quad (1)$$

where $\boldsymbol{X}$ represents a matrix of industry output, $\hat{\boldsymbol{Y}}$ represents a diagonalized matrix of final demands, and $(I - A)^{-1}$ represents an $n \times n$ matrix of interactions between the endogenous sectors of the economy and is also called the "Leontief inverse." This Leontief inverse can also be thought of as a matrix of partial output multipliers, where the column sum of the endogenous sector columns through the output producing sector rows is the output multiplier for each respective sector.[3]

Applied to the Leontief model, this procedure results in an $n \times n$ output matrix ($\boldsymbol{X}$) rather than the $n \times 1$ output vector produced by standard Leontief input-output model. It squares the amount of useful information produced by the model, simultaneously separates each industry's export-base

[3] Note that for all equations we adopt the convention of denoting matrices in bold, upper-case letters, vectors in bold, lower-case letters, and scalars in italicized, lower-case letters.

contribution (as a row vector of column sums) from import-substitution contribution (as a column vector of row sums), and produces a square matrix that ensures that export-base contributions sum to total industry output. The principal diagonal of this output matrix contains an estimate of direct effects and own use by industry, while the off-diagonal elements contain an estimate of indirect export-base contributions by industry (down the columns) and indirect import-substitution contributions by industry (across the rows). Given these subtle but important differences, Watson et al. (2015) recommended that all economic contribution studies be conducted in this manner to prevent the possibility of double-counting or over-estimation.

The sum of export-base output and gross output across all sectors is equal in total. However, export-base output and gross output are almost never equal by sector. The difference between gross and base output by sector can be used to discern the main role that an industry plays in bringing money to or keeping money within a regional economy (Watson et al., 2015).

Modeling a "Reverse" Import Substitution

Thus far, we have defined local food markets, derived a state-wide Leontief inverse, and multiplied this inverse by a diagonal matrix of final demand to produce a matrix of gross and base output that defines the export-base contribution of each sector, including local food sectors. However, local sales of locally produced food products are not a part of exogenous final demand, and their contribution cannot be measured by introducing a shock to exogenous final demand. Instead, these markets represent demand that is internal to a region. These receipts represent a form of import-substitution, and their contribution should be measured by modeling a direct change to intermediate demand.

In their work comparing the effects of export expansion to import substitution, Cooke and Watson (2011) demonstrated how to compare the economic impacts of a change in final demand versus a change in intermediate demand. Expanding the A matrix portion of the Leontief output equation so that it is expressed in terms of endogenous purchases (z) and exogenous purchases/imports (m) for each element i and j yields[4]

$$aij = \left(\frac{zij}{\sum_i zij + m_j} \right). \tag{2}$$

By substituting equation (2) into equation (1) and taking the total differential, the respective partial derivative of output with respect to exogenous demand (e.g., exports) can be expressed as equation (3), which is the familiar Leontief inverse, and the partial derivative of output with respect to imports can be written as equation (4):

$$\frac{\boldsymbol{dx}}{\boldsymbol{dy}} = (\boldsymbol{I} - \boldsymbol{A})^{-1}; \tag{3}$$

$$\frac{\boldsymbol{dx}}{\boldsymbol{dm}} = -\lim_{\boldsymbol{\Delta m} \to \boldsymbol{\Delta z} \to 0} (\boldsymbol{I} - (\boldsymbol{A} + \boldsymbol{\Delta M}))^{-1}. \tag{4}$$

The derivative in equation (4) is almost identical to the output multiplier expressed in equation (3) except for the import change ($\boldsymbol{\Delta M}$) identified in the denominator. This term changes the ratio of domestic and imported inputs as well as the value of the output multiplier. As such, a change in imports may be used to measure the marginal impact associated with import-substitution or import-expansion. Depending on the sign, a change in imports signifies either a deepening ($-\boldsymbol{\Delta M}$) or hollowing out ($+\boldsymbol{\Delta M}$) of inter-industry transactions within the region. Scaling this procedure to simultaneously model import changes across multiple industries is equivalent to changing a selection of coefficients from the $\boldsymbol{A}$ matrix and all partial derivatives from the Leontief inverse.

[4] Cooke and Watson (2011) presented their model in scaler algebra form in a one-sector economy. For consistency purposes with the other sections of this paper, we present an n-dimensional expansion of that model.

Compared to the constant multiplier effect associated with export expansion, the output response from an import-substitution shock quickly outperforms the output response from an export shock. However, despite the obvious attractiveness of using a positive import-substitution shock to measure the value of local food markets, it is difficult to assume *a priori* the extent of a feasible import-substitution shock for local food markets without detailed information about local supply constraints and industry competitiveness. As such, we opt to measure the contribution of local food markets as a negative shock to intermediate demand.

By simply switching the sign associated with $\boldsymbol{\Delta M}$ (a unit change in imports), we can model the reduction in economic activity associated with import expansion. In this case, a unit increase in imports ($\boldsymbol{\Delta M}$) causes the ratio of domestic and imported inputs to decrease and leads to a smaller output multiplier. As imports continue to increase, this causes output growth to decelerate until the import-expansion slope (equation 4) under-performs relative to the export-expansion slope (equation 3). For local food markets, such an impact would occur as industries and households opt to purchase imported food products over locally produced food products. Such an outcome would represent a hollowing out of inter-industry transactions and local supply chains.

The attractiveness of applying an import-expansion approach (negative shock) to local food receipts is that it avoids the *a priori* feasibility assumption of an open-ended import-substitution shock. Instead, by assuming a shock to existing local food markets that causes local industries to cease production for these markets, we can remove all local food receipts from intermediate and endogenous institutional demand and assume that local industries and households make up the difference by importing all required food inputs.

Hypothetical Extraction within an Import-Substitution Framework

To implement an import-expansion shock in our empirical social accounting matrix, we employ a hypothetical extraction method to evaluate a sector's contribution to a regional economy when that contribution is not necessarily driven by a final demand change. The method is similar to the hypothetical extraction techniques discussed by Dietzenbacher and Lahr (2013) and is based on measuring the general equilibrium effects of a total or partial removal of an endogenous industry. Equation (5) represents the case where industry n has been extracted from an nxn direct requirements matrix, $\boldsymbol{A}$, by setting the nth row or column to zero and denoting the new matrix as $\overline{\boldsymbol{A}}$. The new vector of gross output is denoted as $\overline{\boldsymbol{X}}$:

$$\overline{\boldsymbol{X}} = (\boldsymbol{I} - \overline{\boldsymbol{A}})^{-1}\hat{\boldsymbol{Y}}. \tag{5}$$

The difference in gross output before and after extraction is then measured as the difference in the output vectors between equations (1) and (5) and equals

$$\sum_j \left(\sum_i (\overline{\boldsymbol{X}} - \boldsymbol{X}) \right), \tag{6}$$

where i and j are row and column subscripts, respectively.

To further describe our particular type of extraction, let matrix $\boldsymbol{A}$ be partitioned into four square submatrices, as follows:

$$\boldsymbol{A} = \begin{bmatrix} \boldsymbol{a}_{11} & \boldsymbol{a}_{12} \\ \boldsymbol{a}_{21} & \boldsymbol{a}_{22} \end{bmatrix}. \tag{7}$$

Full hypothetical extraction of a set of industries could yield $\boldsymbol{a}_{11} = \boldsymbol{a}_{12} = \boldsymbol{a}_{21} = 0$, where both the $i-n$th rows and $j-n$th columns have been set to zero. However, other cases of partial hypothetical extraction can also be derived from equation (7). The particular form of partial industry extraction performed in this paper is similar to the case where $\boldsymbol{a}_{11} = \boldsymbol{a}_{12} = 0$ because only a set of $i-n$th industry rows have been extracted.[5] The set of industry rows extracted in this paper correspond to the set of agricultural production and food-processing industries found in the region and defined by the research.

Following this, the multiplier matrix is recalculated and applied to the original matrix of final demand in order to derive a new output matrix. The difference between the original and new output matrices represents the economic contribution that would be lost if local food markets ceased to exist. This method accounts for the value of all direct local food sales as well as the value of all indirect local food sales that occur as other sectors purchase local food to manufacture inputs needed to produce goods and services for exogenous final demand. In short, this technique accounts for the total contribution of local food sales across all rounds of intermediate expenditure. For demonstration purposes, we provide a numerical SAM model for a hypothetical three-sector economy in Appendix A.

Interpreting Results

We interpret these results to represent an upper-bound estimate because the method employs a critical assumption about how industries respond to an intermediate demand shock. When local receipts are pushed from intermediate demand to imports, a corresponding increase takes place in the export column to maintain the regional trade balance. This increase is such that it exactly offsets the decreased multiplier effect associated with an increase in imports. As such, no change in total industry output is observed if the *ex post* vector of exogenous final demand is applied against the *ex post* multiplier matrix. A reduction in output is only observed if the level of exports is held constant while the *ex ante* vector of exogenous final demand is applied against the *ex post* multiplier matrix.

Each of these modeling choices represents an important assumption about how local producers react to a shock in intermediate demand. If the *ex post* vector of exogenous final demand is applied, the model assumes that producers can seamlessly transfer local food receipts from intermediate demand to exogenous final demand without cost. If this were completely true, it would imply that local food markets contribute only marginally to total industry output because, given a shock to intermediate demand, local food producers always have the option to inexpensively transfer receipts to exogenous final demand customers. On the other hand, if exports are held constant at their *ex ante* level, the model assumes that, given a shock to intermediate demand, local food producers cannot afford the transaction costs involved in marketing to exogenous final demand customers and simply quit producing. In this scenario, a large reduction in total industry output is observed. A feasible range is likely somewhere between these two end points, which is why we interpret our method as producing an upper-bound estimate for the contribution of local food markets.

Empirical Application to the State of Idaho

To provide an empirical application, we first operationalize a definition of "local" food markets and apply the model to an example region: the state of Idaho. Since we are evaluating the economic contribution of an entire local food system, we employ a broad but intuitive definition of local food markets. This definition includes local intermediate and institutional demand for all agriculture and food-processing sectors that produce commodities for human consumption (table 3). Additionally, we apply this method to a non-exhaustive subset of alternative definitions of "local food" and analyze them in the same way (table 4).

---

[5] We can show that this extraction method for measuring economic contribution is accurate if and only if one sector's row is "zeroed out" in each analysis.

Table 3. IMPLAN Sectors Included in the Broadest Definition of Idaho's Local Food System

Agricultural Food Production	Food Processing
1 Oilseed farming	43 Flour milling and malt manufacturing
2 Grain farming	44 Wet corn milling
3 Vegetable and melon farming	45 Soybean and other oilseed processing
4 Fruit farming	46 Fats and oils refining and blending
5 Tree nut farming	47 Breakfast cereal manufacturing
6 Greenhouse, nursery, and floriculture production	48 Sugar cane mills and refining
9 Sugarcane and sugar beet farming	49 Beet sugar manufacturing
10 All other crop farming	50 Chocolate and confectionery manufacturing from cacao beans
11 Cattle ranching and farming	51 Confectionery manufacturing from purchased chocolate
12 Dairy cattle and milk production	52 Nonchocolate confectionery manufacturing
13 Poultry and egg production	53 Frozen food manufacturing
14 Animal production, except cattle and poultry and eggs	54 Fruit and vegetable canning, pickling, and drying
17 Commercial Fishing	55 Fluid milk and butter manufacturing
18 Commercial hunting and trapping	56 Cheese manufacturing
	57 Dry, condensed, and evaporated dairy product manufacturing
	58 Ice cream and frozen dessert manufacturing
	59 Animal (except poultry) slaughtering, rendering, and processing
	60 Poultry processing
	61 Seafood product preparation and packaging
	62 Bread and bakery product manufacturing
	63 Cookie, cracker, and pasta manufacturing
	64 Tortilla manufacturing
	65 Snack food manufacturing
	66 Coffee and tea manufacturing
	67 Flavoring syrup and concentrate manufacturing
	68 Seasoning and dressing manufacturing
	69 All other food manufacturing
	70 Soft drink and ice manufacturing
	71 Breweries
	72 Wineries
	73 Distilleries

Notes: Numbers correspond to IMPLAN 536-sector scheme.

Direct Contribution of Idaho Local Food Markets

In 2013, endogenous (i.e., local) sales of food and food products totaled just over $5 billion, or 3.8% of total state output (total industry output in the state of Idaho in 2013 was just over $133 billion in 2013). Agricultural food sales made up about 35% of these local food receipts ($1.8 billion) and processed food sales accounted for the other 65% ($3.3 billion). Exogenous agricultural receipts summed to over $14 billion, or 10.7% of total state output. Agricultural food sales made up about 39% of exogenous food receipts ($5.5 billion) and processed food sales accounted for the other 61% ($8.7 billion). Together, intermediate and final demand make up total industry output for Idaho's agricultural production and food-processing sectors, accounting for 14.3% of total state industry output.

The gross sales reported above represent the direct contribution of non-local food markets (exogenous demand) and local food markets (endogenous demand) to state output. However, these do not account for the export base of local food industries (i.e., the indirect rounds of spending undertaken by local industries to produce the inputs required by Idaho's food sectors to make goods and services required by exogenous final demand customers). Nor does this accounting specifically consider the import-substitution base of local food markets (i.e., the indirect rounds of local food spending that occur as backward-linked industries purchase locally produced food products as an input into their production function so that they may produce inputs needed by industries directly impacted by exogenous final demand sales).

Export-Base Contribution of Idaho's Exogenous Food Markets

To measure the export base associated with Idaho's local food sectors, we use an IMPLAN social accounting matrix to derive a statewide Leontief inverse (multiplier matrix). We then interact this inverse with a diagonal matrix of exogenous final demand to derive the export base of Idaho's food sectors (Waters, Weber, and Holland, 1999).

In 2013, the export base of agricultural production and food-processing sectors in Idaho supported over $27.2 billion in economic activity, or a little over 20.4% of total state output. Agricultural food production accounted for a total of $10 billion in economic-base activity, and food processing accounted for a total of $17.2 billion in economic-base activity. These estimates represent the direct, indirect, and induced effects of exogenous sales and represent the preferred method for conducting *ex post* economic contribution studies (Watson et al., 2015).

It is interesting to note that the base output share for agricultural food production (1.77%) is smaller than the gross output share for agricultural food production (2.27%). Conversely, the base output share for food processing (9.43%) is larger than the gross output share for food processing (6.78%). This outcome demonstrates the existence of a marketing chain between local food processors and local food producers that helps Idaho retain the economic benefits associated with value-added food production. In other words, while both production agriculture and food processors have both base output (exogenous sales) and non-base output (endogenous sales), production agriculture is more of an intermediate input into processed foods that are then sold outside of Idaho.

Import-Substitution Contribution of Idaho's Local Food Markets

As mentioned earlier, Idaho's local food markets accounted for approximately $5 billion in intermediate demand receipts. This intermediate demand represents the total amount of locally produced food that is sold to local demand (both as intermediate inputs into other production and to endogenous demand from local households and local government) but not the indirect or induced effects associated with these markets. To estimate a total contribution associated with Idaho's intermediate food markets, we must first modify the social account matrix and then derive a new Leontief inverse using a hypothetical extraction rationale to determine the total change in economic activity if there were no locally produced food and therefore all food demanded was necessarily imported.

We begin by zeroing out all intermediate and local institutional demand receipts associated with Idaho local agricultural production and food-processing sectors. This simulates a shock to intermediate demand; local food receipts are no longer available for purchase and firms must increase their reliance on imports to make up the gap in their production function. This is accomplished by zeroing out the average regional purchase coefficient (RPC) associated with each local food sector in the IMPLAN V3 software. When the model is rebalanced, the IMPLAN V3 software reassigns the value of local food receipts to corresponding elements in the import row.

Table 4 presents three models of the economic-base contribution and local food contribution under different definitions of a "local" food system. Model 1 represents the definition that includes

Table 4. Summary Results of Economic Contribution of Various Definitions of Local Food along with the Analogous Economic-Base Contribution of the Respective Definition

	Definition of "Local Food"	Contribution of Local Food System	Traditional Economic-Base Contribution Analog	Traditional Economic-Base Contribution
Model 1	All locally produced food (production agriculture and food manufacturing) sold to a local buyer	$8.2 billion	Economic-base contribution of exogenous sales of all agricultural production and processed food	$27.2 billion
Model 2	Locally produced production agriculture sold to a local buyer	$5.4 billion	Economic-base contribution of exogenous sales of all agricultural production	$10.0 billion
Model 3	Locally produced fruits and vegetables sold to a local buyer	$362.4 million	Economic-base contribution of exogenous sales of fruit and vegetable production	$1.4 billion

all agricultural production and food-processing sectors (table 3). Model 2 reduces the definition to include only agricultural production sectors (excluding any food-processing sectors), and Model 3 includes only fruit and vegetable production. Under these definitions of the general food system, the corresponding local food systems can be defined as simply the endogenous portions of Model 1. This applies the definition of "all locally produced food that is also sold to any local buyer," which includes all endogenous production and endogenous sales of agricultural or processed food products. Model 2 defines local as "locally produced production agriculture that is sold to a local buyer." This would include agricultural production sold to local processors, local households, or local institutions but none of the food-processing sectors. In Model 3, " local food" is strictly defined as locally produced fruits and vegetables sold to local buyers and excludes other agricultural products (i.e., grains) that are produced and sold locally. While we do not mean to suggest that these are the only definitions of "local food," we include these alternative definitions in order to compare model results.

As expected, Model 1 provides both the largest contribution of local food, at $8.2 billion, and the largest export-base contribution, at $27.2 billion. Under this definition, local food in Idaho contributes 70% less to the state's economic output than do food system exports. Under Model 2, the local food system contribution drops to $5.4 billion and the export-base contribution drops to $10 billion. In Model 2, the local food economic contribution is 46% less than the export-base contribution. Finally, under the most restrictive model definitions, Model 3, the economic contribution of local food drops to $362.4 million and the economic-base contribution drops to $1.4 billion, 75% lower than the export base. This large difference is mostly because Idaho produces a lot of vegetables (potatoes and onions), most of which are exported out of the state.

Discussion and Conclusion

In order to evaluate the size and economic contribution of a region's local food sector, we develop a method that combines hypothetical extraction techniques with an import-substitution social accounting model. This yields a framework to evaluate a local food system that is comparable to methods used to estimate the food system using a traditional export-base model. [6]

Comparing the export-base orientated and import-substitution orientated sectors raises an interesting question. Why is the export-base contribution over twice the size of the import-substitution contribution? The answer relates primarily to the size of the Idaho's agricultural production and food-processing markets but also to the role that each of these markets plays within a broader marketing chain. The relative size of the export base compared to the import substitution in the agricultural production sector in other states and regions is likely to be very

[6] Our estimates of export-base and import-substitution contributions are not mutually exclusive. Aggregating these measures may lead to double-counting.

different. For example, Idaho's food-processing sectors, in particular cheese manufacturing and potato processing, drive much of this outcome because these industries are i) much larger than the agricultural production sectors, and ii) primarily oriented toward export markets.

Additionally, we evaluate this method using different definitions of a local food system (table 4). Predictably, this reduces the size of the economic contribution of local food. Interestingly, the size of the economic contribution of the local food system relative to the size of a similarly defined export-base contribution does not follow a predictable pattern but is more a function of the relative sizes of the endogenous market to the exogenous market for those specific commodities. The relative sizes of these markets will likely change across different definitions of a local food system and across different regions.

We should also note three important caveats associated with the method outlined in this paper. First, our method for estimating the contribution of intermediate demand markets relies heavily on an assumption that local producers cannot simply transfer local demand sales to exogenous markets. In other words, a local producer's sales to local consumers represent production that would not be possible without the existence of the local demand, and a sale to a local consumer does not substitute for a sale to an exogenous consumer. If local sales were perfect substitutes for exogenous sales, then the existence of local food systems would deepen the local economy but would not create any net additional economic activity. As such, we interpret our result to be an upper-bound estimate of the contribution of local food markets. Further calibrating this assumption would require additional research to determine more precisely how local producers would respond to a shock in local demand. Although this is beyond the scope of our current study, this question represents an exciting avenue for future food markets research. Second, IMPLAN is a linear economic model and, as such, all of the linear modeling caveats apply (i.e., fixed isoquants, fixed prices, unlimited supply, etc.) (Meter and Goldenberg, 2015). Further calibrating these classical input-output assumptions would require a more flexible economic model (i.e., computable general equilibrium model). Lastly, this is a method for the analysis of economic contributions, not the analysis of social welfare (Watson et al., 2007). For an in-depth discussion of the social welfare implications of "buy local," see Winfree and Watson (2017).

However, despite these limitations, we believe the method outlined here provides an important contribution to the local food literature on at least three counts. First, the method is straightforward, replicable, and cost-effective. It utilizes easily accessible input-output models and can be used to measure the contribution of any intermediate demand market within any social accounting matrix regardless of regional or industry definitions. Second, the method proposes an innovative procedure to calibrate the Leontief model in order to directly measure the contribution of an intermediate demand market. Third, the method provides global insight into the extent and contribution of a region's entire local food system. As such, it may be used to benchmark the reasonableness of impact studies that seek to measure import-substitution effects associated with certain submarkets within the local food system.

[Received June 2016; final revision received March 2017.]

References

Bruton, H. J. "A Reconsideration of Import Substitution." *Journal of Economic Literature* 36(1998):903–936.

Cooke, S. C., and P. Watson. "A Comparison of Regional Export Enhancement and Import Substitution Economic Development Strategies." *Journal of Regional Analysis and Policy* 41(2011):1–15.

Crompton, J. L. "Economic Impact Studies: Instruments for Political Shenanigans?" *Journal of Travel Research* 45(2006):67–82. doi: 10.1177/0047287506288870.

Dietzenbacher, E., and M. L. Lahr. "Expanding Extractions." *Economic Systems Research* 25(2013):341–360. doi: 10.1080/09535314.2013.774266.

Henneberry, S. R., B. E. Whitacre, and H. N. Agustini. "An Evaluation of the Economic Impacts of Oklahoma Farmers Markets." *Journal of Food Distribution Research* 40(2009):64–78.

Hughes, D. W., C. Brown, S. Miller, and T. McConnell. "Evaluating the Economic Impact of Farmers' Markets Using an Opportunity Cost Framework." *Journal of Agricultural and Applied Economics* 40(2008):253–265. doi: 10.1017/S1074070800028091.

Jablonski, B. B. R., and T. M. Schmit. "Differential Expenditure Patterns of Local Food System Participants." *Renewable Agriculture and Food Systems* 31(2016):139–147. doi: 10.1017/S1742170515000083.

Jacobs, J. *The Economy of Cities*. New York: Random House, 1969.

Kay, D. L., J. E. Pratt, and M. E. Warner. "Role of Services in Regional Economy Growth." *Growth and Change* 38(2007):419–442. doi: 10.1111/j.1468-2257.2007.00377.x.

Kuznets, S. "Economic Growth and Income Inequality." *American Economic Review* 45(1955):1–28.

Leontief, W. W. *The Structure of American Economy, 1919–1939: An Empirical Application of Equilibrium Analysis*. New York: Oxford University Press, 1951.

Leung, P., and S. Pooley. "Regional Economic Impacts of Reductions in Fisheries Production: A Supply-Driven Approach." *Marine Resource Economics* 16(2001):251–262. doi: 10.1086/mre.16.4.42629336.

Little, I. M. D. *Economic Development: Theory, Policy, and International Relations*. New York: Basic Books, 1982.

Low, S., A. Adalja, E. Beaulieu, N. Key, S. Martinez, A. Melton, A. Perez, K. Ralston, H. Stewart, S. Suttles, and S. Vogel. "Trends in U.S. Local and Regional Food Systems." Report AP-068, U.S. Department of Agriculture, Economic Research Service, Washington, DC, 2015. Available online at https://www.ers.usda.gov/publications/pub-details/?pubid=42807.

Low, S. A., and S. Vogel. "Direct and Intermediated Marketing of Local Foods in the United States." Economic Research Report 128, U.S. Department of Agriculture, Economic Research Service, Washington, DC, 2011a. Available online at http://www.ers.usda.gov/publications/err-economic-research-report/err128.aspx.

Low, S. A., and S. J. Vogel. "Local Foods Marketing Channels Encompass a Wide Range of Producers." 2011b. *Amber Waves*.

Martinez, S. M., M. S. Hand, M. da Pra, S. Pollack, K. Ralston, T. Smith, S. Vogel, S. Clark, L. Lohr, S. A. Low, and C. Newman. "Local Food Systems: Concepts, Impacts, and Issues." Economic Research Report 97, U.S. Department of Agriculture, Economic Research Service, Washington, DC, 2010. Available online at http://www.ers.usda.gov/publications/err-economic-research-report/err97.aspx.

Meter, K., and M. P. Goldenberg. "Critical Analysis of Economic Impact Methodologies." In *Exploring Economic and Health Impacts of Local Food Procurement,* Chicago, IL: Illinois Public Health Institute, 2015, 111–124. Available online at http://www.crcworks.org/EHimpacts.pdf.

Miller, R. E. "Interregional Feedback Effects in Input-Output Models: Some Preliminary Results." *Papers in Regional Science* 17(1966):105–125. doi: 10.1111/j.1435-5597.1966.tb01344.x.

Miller, R. E., and P. D. Blair. "Input-Output Models at the Regional Level." In R. E. Miller and P. D. Blair, eds., *Input-Output Models at the Regional Level,* Cambridge: Cambridge University Press, 2009, 2nd ed., 69–118. OCLC: 783451927.

Miller, R. E., and M. L. Lahr. "A Taxonomy of Extractions." *Contributions to Economic Analysis* 249(2001):407–441.

Miller, S., J. Mann, J. Berry, T. Kalchik, R. Pirog, and W. Hamm. "A Replicable Model for Valuing Local Food Systems." 2015. Paper presented at the 54th annual meeting of the Southern Regional Science Association, Mobile, AL.

Persky, J., D. Ranney, and W. Wiewel. "Import Substitution and Local Economic Development." *Economic Development Quarterly* 7(1993):18–29. doi: 10.1177/089124249300700103.

Pred, A. *The Spatial Dynamics of U.S. Urban-Industrial Growth, 1800-1914; Interpretive and Theoretical Essays*. Regional Science Studies Series. Cambridge, MA: MIT Press, 1966. OCLC: 172911.

Rostow, W. W. *The Process of Economic Growth*. Oxford: Clarendon Press, 1962, 2nd ed.

Thilmany, D., and P. Watson. "The Increasing Role of Direct Marketing and Farmers Markets for Western US Producers." *Western Economics Forum* 3(2004):19–25.

Thilmany McFadden, D., D. Conner, S. Deller, D. Hughes, K. Meter, A. Morales, T. Schmit, D. Swenson, A. Bauman, M. P. Goldenberg, R. Hill, B. B. R. Jablonski, and D. Tropp. *The Economics of Local Food Systems: A Toolkit to Guide Community Discussions, Assessments and Choices*. Washington, DC: U.S. Department of Agriculture, Agricultural Marketing Service, 2016. Available online at https://www.ams.usda.gov/publications/content/economics-local-food-systems-toolkit-guide-community-discussions-assessments.

Varner, T., and D. Otto. "Factors Affecting Sales at Farmers' Markets: An Iowa Study." *Review of Agricultural Economics* 30(2008):176–189. doi: 10.1111/j.1467-9353.2007.00398.x.

Waters, E. C., B. A. Weber, and D. W. Holland. "The Role of Agriculture in Oregon's Economic Base: Findings from a Social Accounting Matrix." *Journal of Agricultural and Resource Economics* 24(1999):266–280.

Watson, P., and N. Beleiciks. "Small Community Level Social Accounting Matrices and their Application to Determining Marine Resource Dependency." *Marine Resource Economics* 24(2009):253–270. doi: 10.1086/mre.24.3.42629654.

Watson, P., S. Cooke, D. Kay, and G. Alward. "A Method for Improving Economic Contribution Studies for Regional Analysis." *Journal of Regional Analysis and Policy* 45(2015):1–15. Available online at https://ideas.repec.org/a/ags/jrapmc/243975.html.

Watson, P., J. Wilson, D. D. Thilmany, and S. Winter. "Determining Economic Contributions and Impacts: What is the difference and why do we care?" *Journal of Regional Analysis and Policy* 37(2007):141–146.

Winfree, J., and P. Watson. "The Welfare Economics of "Buy Local"." *American Journal of Agricultural Economics* forthcoming(2017). doi: 10.1093/ajae/aaw104.

Appendix A

Table A1 presents a numeric example of the three-sector, notational SAM shown in table 1. In this example, the local food industry (I2) sells 2 units to manufacturing (I1), 1 unit to other firms within the local food industry (I2), and 2 units to the service/retail sector (I3) for a total of 5 units of local intermediate demand. The local food industry (I2) also sells 3 units directly to local households (c). Altogether the local food industry (Z2) sells 8 units of locally produced food products to other local industries and household institutions. These 8 units represent the direct transactions associated with our local food market. Industry I2 also exports 14 units to markets and institutions outside the region, but these transactions are not part of the local food market. Instead, these exports fulfill demand from non-local food markets.

Table A1. Numerical SAM for a Three-Sector Economy

		Industry Purchases			**Household**	**Exogenous**	
		I1	**I2**	**I3**	**Consumption (c)**	**Sales (y)**	**Output (x)**
	I1	1	2	1	5	10	19
Industry Sales	I2	2	1	2	3	14	22
	I3	1	1	1	6	7	16
Household Income/value added (v)		7	9	5		2	23
Imports (m)		8	9	7	9		33
Outlays (x)		19	22	16	23	33	57

Notes: In total $y = m$ and $v = c$.

Table A2 demonstrates a shock to intermediate food demand using the numerical values from our three-sector social accounting matrix listed in table A1. The first four elements of row (I2) represent local intermediate and institutional food receipts. These elements have been zeroed out and added to corresponding elements in the import row (m) to simulate an intermediate demand shock in which locally produced food inputs are no longer available for purchase. This forces other industries to increase imports to make up the gap in their production function, which hollows out local supply chains by reducing the ratio of domestic and imported inputs and decreasing the value of all output multipliers.

Table A2. Numerical Example of Import Expansion Impact in a Three-Sector Economy Where Exports Are Constrained to the Levels Presented in Table A1

shock to ex ante social accounts

	I1	$I2$	$I3$	c	y	x
$I1$	1	2	1	5	10	19
$I2$	0	0	0	0	$22^{\bullet}$	22
$I3$	1	1	1	6	7	16
v	7	9	5		2	23
m	$10^{\bullet}$	$10^{\bullet}$	$9^{\bullet}$	$12^{\bullet}$		$41^{\bullet}$
x	19	22	16	23	$41^{\bullet}$	57

$$\overbrace{\begin{bmatrix} .05 & .09 & .06 & .22 \\ .00 & .00 & .00 & .00 \\ .05 & .05 & .06 & .26 \\ .37 & .41 & .31 & .00 \end{bmatrix}}^{\text{augmented A matrix}} \underbrace{\overbrace{\begin{bmatrix} 1.18 & 0.24 & 0.18 & 0.30 \\ 0.00 & 1.00 & 0.00 & 0.00 \\ 0.21 & 0.22 & 1.20 & 0.36 \\ \hline 0.50 & .057 & .044 & 1.22 \end{bmatrix}}^{\text{ex post multiplier matrix}}}_{1.39 \quad 1.46 \quad 1.38 \quad 0.66} \underbrace{\overbrace{\begin{bmatrix} 10 \\ 14 \\ 7 \\ 2 \end{bmatrix}}^{\text{ex ante exports}}}_{33} = \underbrace{\overbrace{\begin{bmatrix} 17.08 \\ 14.00 \\ 14.24 \\ \hline 18.47 \end{bmatrix}}^{\text{output}}}_{45.32}$$

In our hypothetical example, this shock to intermediate demand reduces all output multipliers (table A2). Manufacturing's multiplier (I1) is reduced by 21% (0.38 percentage points), the local food industry's multiplier (I2) is reduced by 17% (0.30 percentage points), and the service/retail sector's multiplier (I3) is reduced by 22% (0.40 percentage points). When these reduced multipliers are applied against a constant (*ex ante*) vector of exogenous final demand, the total effect reduces output by 20% (11.68 units). In other words, if intermediate demand markets for locally produced food products did not exist, the local economy might have been up to 20% smaller. We interpret this to mean that local food markets may contribute up to 20% of total industry output.