Evaluating the Extent and Economic Contribution of a Local Food System through an Import Substitution Framework

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Executive Summary

Local sales of locally-produced food represents a growing segment of total U.S. agricultural revenue. A count of the number of farmers' markets in the U.S. has been on the rise in recent years, USDA has recently initiated a new count of intermediated local food sales, and government agencies have shown renewed interest in rural development strategies that support local food markets (Low el al. 2015; Low & Vogel, 2011; Thilmany & Watson, 2008). Because of these trends, there has been increased interest among federal and state policy makers in understanding the value of local foods markets. The purpose of this paper is to describe a new methodology to estimate the total economic contribution of a region's local food markets, in particular, the value of Wisconsin local food markets.

The local foods literature typically defines "local foods" as farm foods sold directly to consumers (i.e. farmers' markets, roadside stands, pick-your-own produce, etc.) or through intermediated marketing channels that sell directly to consumers (i.e. grocery stores, restaurants, food hubs, farm-to-school programs, etc.) (Low et al., 2015; Martinez et al., 2010). This definition is often also applied to economic impact assessments of farm-to-school programs or farmers' markets (Henneberry, Whitacre & Agustini, 2009; Hughes, Brown, Miller, & McConnell, 2008). In these studies direct sales to households are used 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. Although this approach is an effective way to measure marginal changes in particular sub-markets, such as direct-to-consumer farm food markets, this approach is also limited in several respects.

First, the definition of local food markets, as commonly applied to economic impact studies, does not include agricultural sales from farmers to food processors. Implementing such a definition excludes much of the value-added process associated with local marketing chains and paints an incomplete picture of the role that local agriculture plays in supporting jobs and income (Low & Vogel, 2011).

Second, measuring the economic impact associated with particular sub-markets falls well short of estimating the extent and economic contribution of a region's entire food system (Miller et al., 2015).

Third, economic impact estimates are typically opened-ended and 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 sub-markets 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 where 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 was determined beforehand and used to bench mark individual impact studies.

Fourth, the economic impact model is calibrated to measure changes in demand from markets or institutions outside a region. Local food markets, by definition, are not located outside a region. They represent demand from 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 sub-markets can place a limitation on the type of modeling questions undertaken by researchers (Miller et al., 2015).

Given these limitations, the primary focus of this paper is to describe a theoretical and applied methodology for comprehensively evaluating the extent and economic contribution of a region's entire local food system. The approach is straightforward, replicable, cost-effective, and utilizes easily-accessible input-output models. In addition, the method is not sensitive to definitional issues and can be used to measure the contribution of any particular sub-market within the local food system. In order to estimate the economic contribution of Wisconsin's entire local food system, we define local food markets to include all local sales of locally-produced raw, agricultural products and processed-food products.[‡] However, even if this definition were scaled back to represent the contribution of a particular sub-market, the underlying method could still be applied without loss in consistency or generality. Finally, the method is calibrated to provide an upper-bound estimate for the economic contribution of all local food markets within a region. As such, the estimate could be used to benchmark results from other impact studies in order to reduce the risk of double-counting or over-estimation.

[‡] Please see bolded arrows in Figure 1 for an illustration of the circular flow implied by this definition, as well as Table 11 for a list of sectors included in this definition.

The method described in this paper is based on a social accounting matrix (SAM) for the State of Wisconsin. We begin by accounting for all local sales of locally-produced raw, agricultural products and processed-food products. These transactions represent direct sales to Wisconsin's agricultural and food processing sectors from all other industries and households within the state (Figure 1).

Following this, we derive an economic impact model (i.e. multiplier matrix) for the State of Wisconsin in order to account for all indirect rounds of supply chain activity associated with these local food sales. From this baseline model, we measure gross state product to establish the size of Wisconsin's economy when local food markets are included.

We then simulate a shock to all local food markets where firms cease producing for these markets. This is accomplished by removing all local sales of locally-produced raw, agricultural products and processed-food products from the social accounting matrix. This procedure hollows out Wisconsin's local supply chains and forces all other industries to make up the gap in their production function by importing additional food inputs.

We use this modified social accounting matrix to derive a new economic impact model (i.e. multiplier matrix). Because local sales of locally-produced food products have been removed, this new model represents an economy that has experienced an across-the-board decrease in all industry output multipliers. Interacting this modified multiplier matrix with the baseline level of exports allows us to estimate the potential size of Wisconsin's economy when local food markets are excluded. Comparing results between our baseline model and our simulated model allows us to estimate the maximum extent to which gross state product may decline if local food markets ceased to exist. We interpret this result as an upper-bound estimate on the level of direct and indirect economic activity attributable to the state's local food markets.

Using this method we estimate that ***Wisconsin local food markets contributed up to $9.9 billion (3.6%) in Gross State Product during 2012*** (Table 10). This estimate include both direct and indirect economic activity and represent an upper-bound estimate for the total economic contribution attributable to these markets.

To further calibrate these results, additional research would be required 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, it does represents an exciting avenue for future food markets research.

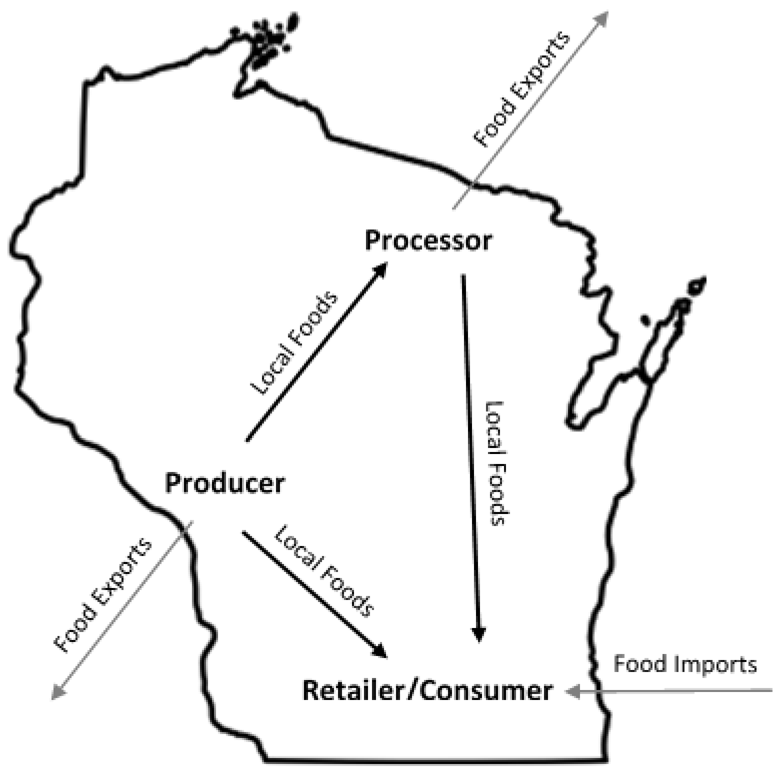

Figure 1. Wisconsin Local Food Markets

Table 10. Total economic contribution of Wisconsin local food markets, 2012

Scenario	**Wisconsin State Indicator** (thousands $)			
	Output	GDP	Labor Income	Jobs
1. Baseline modelling results	$549,322,078	$276,507,891	$152,481,790	3,480,619
2. Negative shock to local food markets	$519,846,088	$266,580,454	$148,109,607	3,352,239
Difference (-)	**$29,475,990**	**$9,927,437**	**$4,372,183**	**128,380**
% Change (-)	5.4%	3.6%	2.9%	3.7%

1 Introduction

Local sales of locally-produced food represents a growing segment of total U.S. agricultural revenue. A count of the number of farmers' markets in the U.S. has been on the rise in recent years, USDA has recently initiated a new count of intermediated local food sales, and government agencies have shown renewed interest in rural development strategies that support local food markets (Low el al. 2015; Low & Vogel, 2011; Thilmany & Watson, 2008). Because of these trends, there has been increased interest among federal and state policy makers in understanding the value of local foods markets. The purpose of this paper is to describe a new methodology to estimate the total economic contribution of a region's local food markets, in particular, the value of Wisconsin local food markets.

2 Literature Review

The local foods literature typically defines "local foods" as farm foods sold directly to consumers (i.e. farmers' markets, roadside stands, pick-your-own produce, etc.) or through intermediated marketing channels that sell directly to consumers (i.e. grocery stores, restaurants, food hubs, farm-to-school programs, etc.) (Low et al., 2015; Martinez et al., 2010). This definition is often also applied to economic impact assessments of farm-to-school programs or farmers' markets (Henneberry, Whitacre & Agustini, 2009; Hughes, Brown, Miller, & McConnell, 2008). In these studies direct sales to households are used 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. Although this approach is an effective way to measure marginal changes in particular sub-markets, such as direct-to-consumer farm food markets, this approach is also limited in several respects.

First, the definition of local food markets, as commonly applied to economic impact studies, does not include agricultural sales from farmers to food processors. Implementing such a definition excludes much of the value-added process associated with local marketing chains and paints an incomplete picture of the role that local agriculture plays in supporting jobs and income.

Second, measuring the economic impact associated with particular sub-markets falls well short of estimating the extent and economic contribution of a region's entire food system (Miller et al., 2015).

Third, economic impact estimates are typically opened-ended and 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 sub-markets 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 where 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 was determined beforehand and used to bench mark individual impact studies.

Fourth, the economic impact model is calibrated to measure changes in demand from markets or institutions outside a region. Local food markets, by definition, are not located outside a region. They represent demand from 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 sub-markets can place a limitation on the type of modeling questions undertaken by researchers (Miller et al., 2015).

Given these limitations, the primary focus of this paper is to describe a theoretical and applied methodology for comprehensively evaluating the extent and economic contribution of a region's entire local food system. The approach is straightforward, replicable, cost-effective, and utilizes easily-accessible input-output models. In addition, the method is not sensitive to definitional issues and can be used to measure the contribution of any particular sub-market within the local food system. In order to estimate the economic contribution of Wisconsin's entire local food system, we define local food markets to include all local sales of locally-produced agricultural commodities and processed food products. However, even if this definition were scaled back to represent the contribution of a particular sub-market, the underlying method could still be applied without loss in consistency or generality. Finally, the method is calibrated to provide an upper-bound estimate for the economic contribution of all local food markets within a region. As such, the estimate could be used to benchmark results from other impact studies in order to reduce the risk of double-counting or over-estimation.

3 Methodology

The primary focus of this paper is to describe a theoretical and applied methodology for evaluating the extent and economic contribution of a local food system. The method we describe is based on a social accounting model that shares much of its structure with the National Income and Product Accounts (Kuznets 1955), which are the primary macroeconomic accounts for the United States. While the NIPA accounts track national economic activity, regional social accounts serve much of the same function for subnational regions. The regional social accounts explicitly track both local production and local consumption of goods and services and therefore is 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. Therefore, they can be used to estimate the contribution of local foods to the entire regional economy (Waters, Holland, and Weber 1999).

3.1 Outline of Modeling Approach

The method we describe in this paper is based on a 2012 social accounting matrix (SAM) for the State of Wisconsin. We begin by defining local food markets as all intermediate and local institutional demand sales associated with the state's local food production and processing sectors. We then account for the value of these direct sales. Following this we derive a Leontief inverse model (i.e. multiplier matrix) to account for all indirect rounds of local food sales.

After deriving the Leontief inverse, we measure the export base contribution of all local food sectors by interacting our Leontief inverse with a diagonal matrix of exogenous final demand. This estimates the total economic contribution of food exports and provides a useful comparison to the total economic contribution of intermediate demand associated with local food receipts.

Following this, we assume a shock to all local food markets that causes firms to cease producing for these markets. We remove local food receipts associated with intermediate and endogenous institutional demand and force industries to make up the difference by importing additional food inputs. This procedure hollows out the local supply chains represented in the SAM and forces a corresponding increase in exports to maintain a regional trade balance.

We then use this modified social accounting matrix to derive a new Leontief inverse. Because intermediate demand for locally-produced food has been removed, this new model represents an economy which has experienced a decrease in its output multipliers. Interacting this new Leontief inverse with the original level of exogenous final demand allows us to estimate the reduction in regional output that would occur if local food markets had ceased to exist. Comparing this reduction to the original level of regional output allows us to estimate an upper bound for the share of total direct and indirect economic activity attributable to existing local food markets.

Throughout the methodology section we refer to a hypothetical, three-sector SAM for illustrative purposes. However, in the results section we apply this method to a 440-sector IMPLAN SAM for the State of Wisconsin. Doing so allows us to derive an upper-bound estimate of the contribution of local food markets to the state's economy. Finally, we conclude our study by discussing the interpretation, assumptions and limitations of this method and suggest further research to refine our estimation technique.

3.2 Regional Social Accounts

The data necessary to evaluate the extent and economic contribution of local foods can be derived from regional social accounts and organized into a regional social accounting matrix (SAM). While there is debate as to what should be defined as "local food", the modeling framework and data architecture described here are invariant to definitional changes. Without a loss of consistency, the methodology described here could be applied to a broad set of definitions of what constitutes as "local food". Further discussion of the definitional issues are presented with numerical examples in Section 4.

A SAM is a statistical framework that utilizes double-entry bookkeeping to trace all monetary flows within a regional economy over a given period. It provides a framework to organize the flow-of-value statistical data for a national, state, or regional economy.

Mathematically, a SAM is a square matrix where each of its nonzero elements records the value of a financial transaction between economic actors. Table 1 presents a notational, 3-sector SAM for a hypothetical economy. Industry rows record sales and include intermediate demand (z), endogenous final demand associated with household spending (c) and exogenous final demand associated with investment, government spending and exports (x). Industry columns record purchases and represent Leontief production functions that include local input purchases, factor payments (income), and imported input purchases. Within the SAM accounting framework economic actors are required to meet their budget constraint in order to maintain equilibrium between buyers and sellers. As such, all row sums are balanced with corresponding column sums.

For convenience Industry A represents the region's manufacturing sector, Industry C represents the region's service/retail sector, and Industry B represents the region's aggregated food processing and food agricultural sector. Industry row B is partially highlighted to represent sales of locally-produced food to local industries and institutions. This definition includes locally-produced food products sold as inputs into other production processes ($z_{21} + z_{22} + z_{23}$). For example, this would include locally-produced milk that is sold to a local cheese manufacturer, grocery store, or restaurant. This definition also includes locally-produced food products that are directly marketed to local consumers (c_{24}) such as locally-produced milk that is 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 (x_2). For example, this would not include locally-produced milk that is shipped to Michigan, Illinois or other states.

Table 2 presents a numeric example of this 3-sector, notational SAM. In this example the local food industry (B) sells 2 units to manufacturing (A), 1 unit to other firms within the local food industry (B), and 2 units to the service/retail sector (C) for a total of 5 units of local intermediate demand. The local foods industry (B) also sells 3 units directly to local households (Consumption). Altogether the local food industry (B) 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 B also exports 14 units to markets and institutions outside the region, but this transaction is not part of the local food market. Instead, these exports fulfill demand from non-local food market.

Table 1. Notational SAM for a three-sector economy.

		Industry Purchases			Consumption	Exports (I+G+E)	Output
		A	B	C			
Industry Sales	A	z_{11}	z_{12}	z_{13}	c_{14}	x_1	q_1
	B	z_{21}	z_{22}	z_{23}	c_{24}	x_2	q_2
	C	z_{31}	z_{32}	z_{33}	c_{34}	x_3	q_3
Income		y_1	y_2	y_3		x_4	y_4
Imports		m_1	m_2	m_3	m_4		m
Outlays		q_1	q_2	q_3	c	x	q

Table 2. Numerical SAM for a three-sector economy.

		Industry Purchases			Consumption (C)	Exports (I+G+E)	Output
		A	B	C			
Industry Sales	A	1	2	1	5	10	19
	B	2	1	2	3	14	22
	C	1	1	1	6	7	16
Income		7	9	5		2	23
Imports		8	9	7	9		33
Outlays		19	22	16	23	33	57

3.3 Deriving the Leontief Inverse

To account for all indirect rounds of local food sales we derive the Leontief inverse (or multiplier matrix) associated with our underlying SAM. This begins by converting intermediate demand values to share form as given in the set of equations below:

1)

$$\begin{array}{cccccc} a_{11}q_1 & +a_{12}q_2 & +\cdots & +a_{1n+1}q_{n+1} & +x_1 & =q_1 \\ a_{21}q_1 & +a_{22}q_2 & +\cdots & +a_{2n+1}q_{n+1} & +x_2 & =q_2 \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\ a_{n+11}q_1 & +a_{n+12}q_2 & +\cdots & +a_{n+1n+1}q_{n+1} & +x_{n+1} & =q_{n+1} \end{array}$$

Source: (Chiang and Wainwright, 2005).

In this set of equations (1), each element of intermediate demand is expressed as a share of total industry outlay ($z_{ij} / q_j = a_{ij}$) multiplied by the sector's total industry outlay. Elements of endogenous household demand (c) are expressed as a share of total household consumption ($c_{in+1} / c_{n+1} = a_{in+1}$) multiplied by total household consumption. Finally, elements of exogenous final demand are expressed in levels (x_i). For each equation, the sum of an industry's intermediate demand, endogenous household demand and exogenous final demand equal total output for that respective industry.

Furthermore, the notation in equation (1) implies that the matrix of intermediate inputs is bordered by an additional row and column represented here as the sum of endogenous household income and spending respectively. The result is an augmented matrix of size n+1 x n+1 (Miller and Blair, p. 26).

In matrix notation the system of equations from (1) can be expressed as:

2) $$q = Aq + x$$

The matrix of intermediate input shares represented by the A term in equation (2) is known as the A matrix and represents the production function or spending pattern of each local industry and endogenous institution. Because the underlying SAM already includes a row account for imports, the shares derived in this A matrix are regionalized to reflect what percent of an input can be purchased from local producers and what percent must be imported from outside the region. Solving equation (2) for the dependent variable (q) in terms of its independent variable (x):

3) $$x = q - Aq$$

Simplifying equation (3) by combining like terms for the dependent variable (q):

4) $$x = q(I - A)$$

Re-solving for the output vector (q) as a function of exogenous final demand (x) yields the Leontief inverse or multiplier matrix.

5) $$q = (I - A)^{-1} x$$

The output vector (q) of equation (5) is the product of a matrix of output multipliers $(I\text{-}A)^{-1}$ and a vector of exogenous final demand (x). If $(I\text{-}A)^{-1}$ is denoted by $M = [m_{ij}]$ then equation (5) can also be written as:

6) $$q = Mx$$

Here M represents a matrix of first-order derivatives that relate the level of regional output (q) required to supply exogenous final demand (x). Through expansion and consolidation all partial derivatives can be summarized as a single matrix derivative:

7) $$M = \frac{\partial q^*}{\partial x} = \begin{bmatrix} m_{11} & m_{12} & m_{13} & m_{14} \\ m_{21} & m_{22} & m_{23} & m_{24} \\ m_{31} & m_{32} & m_{33} & m_{34} \\ m_{41} & m_{42} & m_{43} & m_{44} \end{bmatrix} = (I - A)^{-1}$$

Summing down the first three entries of each column of the M matrix (7) gives the total derivative or output multiplier associated with each local industry. Since M is a matrix of first-order derivatives equation (5) can also be interpreted to apply to marginal changes in exogenous final demand as follows:

8) $$\Delta q = (I - A)^{-1} \Delta x$$

The difference between equation (5) and (8) represents the difference between the economic contribution of an industry's total exogenous final demand and the economic impact of a marginal change in an industry's exogenous final demand.

The value of the derivatives in equation (7) are greater than the corresponding direct coefficients in equation (1) because they measure the value of all rounds of backward-linked spending required to meet exogenous final demand. This includes not only the first round of input purchases undertaken by industries that are directly impacted by final demand, but also all other rounds of intermediate spending undertaken by industries that produce inputs for industries that are directly impacted by final demand. For example, we know from algebra that a power series can be used to approximate 1/ (1-a) where |a|< 1. In matrix format the Leontief inverse can also be expressed as a power series where |I-A| ≠ 0 (Wang and vom Hofe, 2007):

9) $$(I - A)^{-1} = I + A + A^2 + A^3 + A^4 + A^5 + \ldots + A^n$$

Equation (9) demonstrates the rounds of input purchases embedded within the multiplier matrix. The identity matrix (I) represents the initial change in exogenous final demand and is known as the direct effect. The A matrix contains the coefficients from equation (1) and represents the first round of input purchases undertaken by industries directly impacted by a change in final demand. Subsequent terms in the power series represent input purchases from industries that provide inputs to sectors directly impacted by a change in final demand. Collectively, the power series terms are known as indirect effects and they represent all rounds of supply chain activity required from local industries in order to meet an initial change in exogenous final demand.

When added to the identity matrix the sum of all "A" terms equals the Leontief inverse or multiplier matrix identified in equation (7). The multiplier matrix is a primary difference between equation (2) and (5). While the A matrix in equation (2) accounts for the input purchases required from a single industry to meet a change in exogenous final demand, the multiplier matrix $(I\text{-}A)^{-1}$ from equation (5) relates the change in production across all local industries required to meet a change in any particular industry's exogenous final demand. In other words, equation (5) transforms industry-specific production functions into a linear economic model which estimates the production of all regional inputs required to meet a particular industry's exogenous final demand receipts.

A numerical example of this process is given below. Using the three-sector numerical SAM from Table 2, the region's augmented A matrix is presented below (Table 3). In our hypothetical three-sector economy local food purchases constitute 11% of production expenditures for manufacturing (A), 5% of production expenditures for the local foods industry (B), 13% of production expenditures the service/retail sector (C), and 13% of total consumption by households.

Table 3. Technical Coefficient (A) matrix for a three-sector economy.

		Industry Purchases			Consumption (C)
		A	B	C	
Industry Sales	A	0.05	0.09	0.06	0.22
	B	0.11	0.05	0.13	0.13
	C	0.05	0.05	0.06	0.26
Income		0.37	0.41	0.31	0.00
Imports		0.42	0.41	0.44	0.39
Outlays		1.00	1.00	1.00	1.00

The multiplier matrix derived from this A matrix is listed in Table 4. Because the A matrix is augmented to include endogenous income and consumption (i.e. closed with respect to households) the multipliers presented here represent Type II output multipliers that include direct, indirect and induced effects. The ***direct effect*** is attributable to the initial change in exogenous final demand. The ***indirect effect*** is attributable to all rounds of intermediate spending that occur in order to provide inputs needed to meet a change in exogenous final demand. The ***induced effect*** is attributable to the economic activity that is generated as employees from directly or indirectly impacted industries spend a portion of their additional wage on local household consumption.

In this example, summing down the first three cells of column (B) derives the total output multiplier for our hypothetical local foods industry (Table 4). In this case the multiplier is 1.76, which means that for every $1.00 dollar of additional final demand received by the local food industry (B), a total of $0.76 dollars will be re-spent within the local economy to produce required inputs, and to support household consumption attributable to additional wages generated by the additional dollar of final demand. Reading across row (B) gives the partial derivatives associated with local food purchases and estimates the total value of food input purchases, across all rounds of spending, which are required by all other industries in order to meet a marginal change in their own final demand. This point will become particularly important later in the paper as we make assumptions about the availability of local food receipts and determine how this will affect the value of each industry's output multiplier.

Finally, it's important to note that although an output multiplier is useful in estimating the number of times a dollar of final demand recirculates through a local economy, it also ends up inflating the value of production because it double counts input purchases. For example, when the cheese industry sources locally-produced milk the value of that milk is counted once as a sale from the milk industry and once as a purchase to the cheese industry. Fortunately, there is a fairly simple technique for scaling back output results to more meaningful economic measures. By multiplying a vector or matrix of output changes by a corresponding vector or diagonal matrix of output ratios, modeling outcomes can be converted to other useful measures. For example, a matrix of output changes can be reported as a matrix of value added changes by multiplying the output matrix by a diagonal matrix of corresponding value added-to-output ratios. Likewise, this method can be generalized to report the change in labor income or employment that is associated with a change in output.

Table 4. Multiplier matrix for a three-sector economy.

		Industry Purchases			Consumption (C)
		A	B	C	
Industry Sales	A	1.25	0.29	0.25	0.37
	B	0.26	1.21	0.27	0.29
	C	0.26	0.27	1.26	0.42
Income		0.65	0.68	0.60	1.39
Type II Output Multiplier		1.77	1.76	1.78	1.08

3.4 Measuring Gross and Base Output

As demonstrated in equation (5) when a matrix of partial output multipliers is multiplied by an associated vector of total final demand, the resulting product is a vector of industry output that equals the level of output observed in the underlying social accounts (Table 2). Although this procedure validates the economic model and provides an upper bound for marginal impact results, reproducing a vector of gross output is not particularly insightful since these values are already observed in the SAM. However, Waters, Holland & Weber (1999) have suggested a simple modification to equation (5) that increases the amount of useful information produced by the model. The procedure consists of diagonalizing the vector of final demand. To diagonalize a vector simply means to place the elements of the vector along the major diagonal of an nxn matrix (Table 5). By doing so the nxn multiplier matrix can then be multiplied by an nxn diagonal matrix of final demand. In matrix algebra, placing a “hat” over a final demand vector denotes a diagonal matrix where the elements of the final demand vector have been placed along the major diagonal (Miller & Blair, 2009):

10) $$Q = (I - A)^{-1} \hat{x}$$

Mathematically, this procedure weights each industry column in an nxn multiplier matrix by the corresponding major diagonal element from an nxn diagonal matrix of final demand. Applied to the Leontief model, this procedure results in an nxn output matrix (Q) instead of an nx1 output vector (q). It squares the amount of useful information produced by the model, simultaneously separates each industry’s export base 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 row). Given these subtle, but important differences, Watson et al. (2015) recommend that all economic contribution studies be conducted in this manner to prevent the possibility of double-counting or over-estimation.

Table 5. Diagonal matrix of exogenous final demand.

		Industry			Consumption (C)
		A	B	C	
Industry	A	10	0	0	0
	B	0	14	0	0
	C	0	0	7	0
Income		0	0	0	2

A numerical example of the resulting nxn output matrix is given in Table 6. The off-diagonal elements down each column of the matrix measure the production of intermediate and induced inputs across all other sectors that are needed to produce the goods and services required to meet a given sector’s exogenous final demand. This is known as an industry's export-base contribution or simply ***base output***. It measures a sector's contribution to regional output as it produces goods and services that bring new money into the region. In our three-sector example, the local food sector (B) is responsible for generating 24.69 units of economic activity as it produces goods and services to meet its exogenous final demand (Table 6).

The off-diagonal elements across each row of the matrix measure a sector's production of intermediate and induced inputs needed to supply all other sectors as they produce their goods and services to meet exogenous final demand. This is known as an industry's import-substitution contribution or simply ***gross output***. It measures a sector's contribution to regional output as it produces goods and services that keep money within the region. In Table 6 the local food sector (B) is responsible for generating 22.00 units of economic activity as it produces inputs needed to supply all other sectors as they produce goods and services to meet their own exogenous final demand.

The sum of export base and import-substitution contributions across all sectors is equal to each other and to total regional output. However, export base and import-substitution contributions are almost never equal by sector. The difference between gross and base output by sector can be used to discern the main role an industry plays in bringing money to or keeping money within a regional economy (Watson et al., 2015). In our three-sector example the local food market is responsible for generating more economic activity through its export sales to outside markets than it is from its intermediate demand sales to other industries. Thus, it can be said that, on net, this hypothetical local foods industry contributes more to the region's export base than it does to its import-substitution base.

Table 6. Gross and base output matrix for a three-sector economy.

		Base Output				TIO
		A	B	C	Consumption	
Gross Output	A	12.47	4.06	1.72	0.75	19.00
	B	2.60	16.91	1.92	0.57	22.00
	C	2.63	3.71	8.82	0.84	16.00
	Income	6.48	9.58	4.17	2.77	23.00
TIO		17.70	24.69	12.46	2.16	57.00

3.5 Calibrating the Leontief inverse to account for the value of local food markets

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 local food sector. However, local sales of locally-produced food products are not part of exogenous final demand and their contribution cannot be measured by introducing a shock to exogenous final demand. Instead, these markets represent demand which is internal to a region. As such, these receipts represent a form of import-substitution and their contribution should be measured by modeling a direct change to intermediate demand.

One approach would be to simply sum the intermediate demand receipts from all agriculture and food processing sectors. This would give a complete accounting of the direct contribution of local food sales (Table 8). However, this approach doesn't account for the rounds of backward-linked food sales that occur as other sectors manufacture inputs needed to produce goods and services for exogenous final demand. In order to estimate the total contribution of local food sales we must determine how a change in intermediate food demand affects the ratio of domestic and imported inputs and then observe how this affects the value of the output multiplier. This modified output multiplier can then be used as a basis for measuring the total contribution of local food markets through a shift in enhanced import substitution.

In their innovative work comparing the effects of export expansion to import-substitution, Cooke and Watson (2011) rigorously demonstrate how to compare the economic impacts of a change in final demand vs. a change in intermediate demand. For a one-sector economy they show that the Leontief output equation can be expressed in terms of domestic inputs (z), imports (m_0), and exports (x_0):

10) $$q = \left(1 + \frac{z}{m_0}\right) x_0$$

By totally differentiating equation (10) the Leontief output multiplier, or partial derivative of output (dq) with respect to exports (dx_0), can be expressed in scalar format as one plus the ratio of domestic and imported inputs:

11) $$\left.\frac{dq}{dx_0}\right|_{dm_0=0} = 1 + \frac{z}{m_0}$$

Through the same total differential the authors also derive the partial derivative of output (dq) with respect to imports (dm_0):

12) $$\left.\frac{dq}{dm_0}\right|_{dx_0=0} = -\left(\lim_{\Delta m_0 \to -\Delta z \to 0}\left(1+\frac{z}{m_0+\Delta m_0}\right)\right)$$

The derivative in equation (12) is almost identical to the output multiplier expressed in equation (11) except for the import change (Δm_0) identified in the denominator. This term (Δm_0) changes the ratio of domestic and imported inputs ($z/m_0 + \Delta m_0$), as well as the value of the output multiplier ($1 + (z/m_0 + \Delta m_0)$). 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 ($-\Delta m_0$) or hollowing out ($+\Delta m_0$) 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 A matrix and all partial derivatives from the Leontief inverse (Tables 3-4).

Chart 1 uses the levels of imports and intermediate demand given in our hypothetical three-sector SAM to graph the slopes associated with equation (11) and (12) (Table 2). The export expansion slope (11) shows a constant increase in output (dq) attributable to a unit change in exports (dx). The change is linear and represents the type of change that is expected from a traditional Leontief output model where a constant multiplier parameter is applied to a changing export shock. For a local food industry, such an impact would occur as the industry increases its sales to export markets or exogenous institutions.

On the other hand, the import-substitution slope (12) tells a very different story. In this case a unit decrease in imports (-dm or $-\Delta m_0$) causes the ratio of domestic and imported inputs ($z/m_0 + \Delta m_0$) to increase and leads to a larger output multiplier. The slope of the import-substitution line demonstrates the non-linear increase in output (dq) that occurs as an export constant (x) is applied to an increasing multiplier parameter. For local food markets, such an impact would occur as industries and household opt to purchase locally-produced food products over imported food products. Such an outcome would represent a deepening of inter-industry transactions and local supply chains, an effect that would be overlooked without careful consideration of structural changes in how local food markets interact.

Compared to the constant multiplier effect associated with export-expansion, it is clear that 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, without detailed information about local supply constraints and industry competitiveness, it is difficult to assume a priori the extent of a feasible import-substitution shock for local food markets. 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 (dm or Δm_0), we can model the reduction in economic activity associated with import expansion (Chart 2). In this case a unit increase in imports (dm or Δm_0) causes the ratio of domestic and imported inputs ($z/m_0 + \Delta m_0$) to decrease and leads to a smaller output multiplier. The slope of the import-expansion line demonstrates the non-linear decrease in output growth (dq) that occurs as an export constant (x) is applied to a decreasing multiplier parameter. As imports continue to increase it causes output growth to decelerate (dq) until the import expansion slope (12) under-performs relative to the export expansion slope (11). 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. As mentioned above, this represents an increase in imports (dm or Δm_0) that causes the ratio of domestic and imported inputs ($z/m_0 + \Delta m_0$) to decrease and leads to a reduction in output multipliers ($1 + (z/m_0 + \Delta m_0)$). When an export constant (x) is then applied to these reduced multipliers it results in a reduction of total industry output. Comparing this reduction to the original level of total industry output allows us to estimate the share of regional economic activity (direct, indirect and induced) attributable to existing local food markets. We interpret this difference to be an upper-bound estimate for the value of local food markets since it is unlikely that intermediate food receipts would ever fall below zero.

Table 7 demonstrates a shock to intermediate food demand using the numerical values from our three-sector social accounting matrix listed in Table 2. The first four elements of row (B) 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 where 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.

In our hypothetical example, this shock to intermediate demand has reduced all output multipliers (Table 7). Manufacturing's multiplier (A) has been reduced by 21% (0.38 percentage points), the local food industry's multiplier (B) has been reduced by 17% (0.30 percentage points), and the service/retail sector's multiplier (C) has been 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 may have been up to 20% smaller. We interpret this to mean that local food markets may contribute up to 20% of total industry output.

This technique 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 inputs to manufacture their own inputs that are 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 expenditures.

We interpret this result to be 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 (Table 7). 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 and the ex ante vector of exogenous final demand is applied against the ex post multiplier matrix.

Each of these modeling choices represent 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 it 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 the existence of 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 (as we have done in Table 7) it 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 to be somewhere in 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.

Unfortunately, a more precise estimate is not to be found within a single-period social accounting matrix. Further calibration would require either 1) a natural experiment within a time series of secondary marketing data or 2) a survey of local producers to determine more precisely how they would respond to a shock in intermediate demand receipts. Although this undertaking is beyond the scope of our current study, it does provide an exciting avenue for future food markets research.

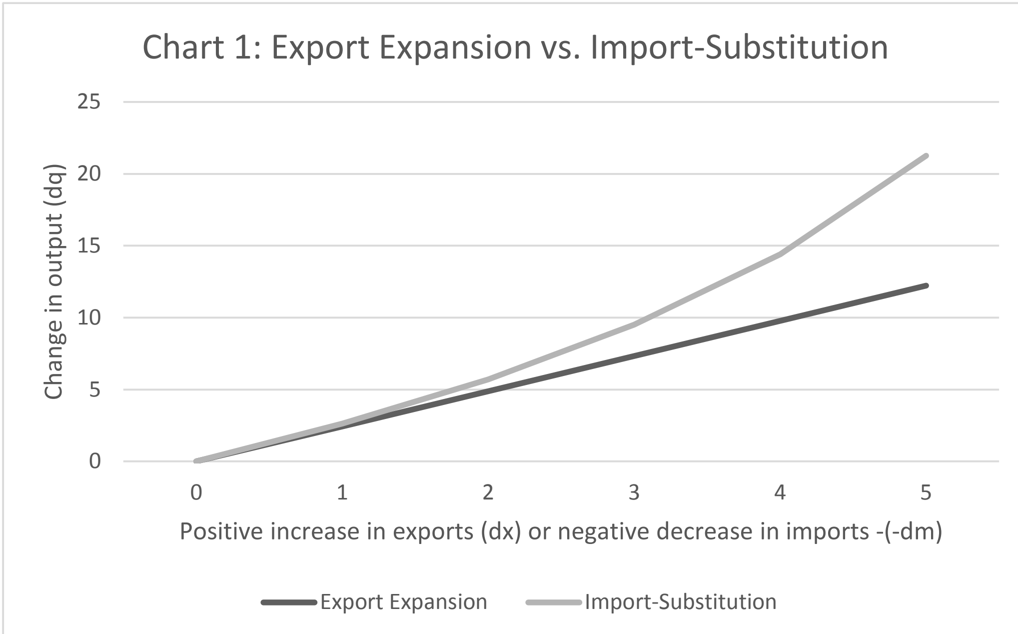
Chart 1: Export Expansion vs. Import-Substitution
Change in output (dq)
25
20
15
10
5
0
0
1
2
3
4
5
Positive increase in exports (dx) or negative decrease in imports -(-dm)
Export Expansion
Import-Substitution

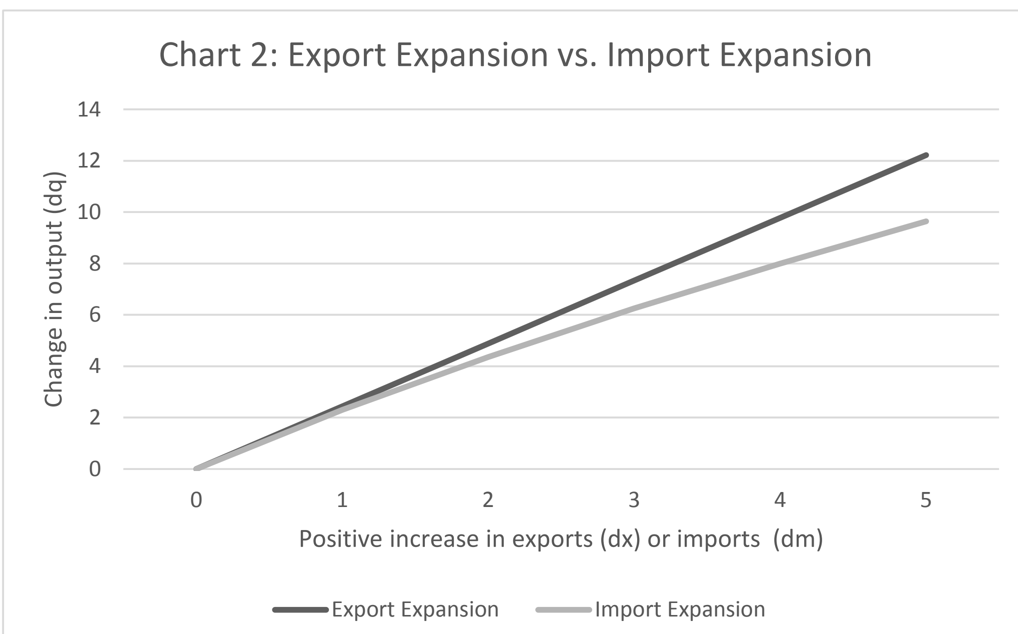
Chart 2: Export Expansion vs. Import Expansion
Change in output (dq)
14
12
10
8
6
4
2
0
0
1
2
3
4
5
Positive increase in exports (dx) or imports (dm)
Export Expansion
Import Expansion

Table 7. Numerical example of import expansion impact.

shock to ex ante social accounts

	A	*B*	*C*	*c*	*x*	*q*
A	1	2	1	5	10	19
B	0°	0°	0°	0°	$22^\bullet$	22
C	1	1	1	6	7	16
y	7	9	5		2	23
m	$10^\bullet$	$10^\bullet$	$9^\bullet$	$12^\bullet$		$41^\bullet$
q	19	22	16	23	$41^\bullet$	57

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

4 Empirical Application of Methodology

In order to provide an empirical application of the methodology described in Section 3 we first operationalize a definition of "local" food markets and distinguish it from non-local food markets. 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 11). This definition does not include receipts for exported food products or for dog, cat or other animal feed.

Although this is a wide definition, there has been growing interest in defining local food markets broadly in order to measure the contribution of an entire food system. For example, a recent study from the Center for Regional Food Systems at Michigan State University defined local food markets to include all agricultural and food processing sectors contained in a 2009 social accounting matrix for the State of Michigan (Miller et al., 2015). In addition, the Wisconsin Department of Agriculture, Trade and Consumer Protection has suggested that both agricultural production and food processing are important components of the state's local food system (Zimmerman, 2015). As such, we define Wisconsin local food markets to include all local sales of locally-produced food products.

We then utilize this definition to apply our methodology to a social accounting matrix (SAM) for the State of Wisconsin (2012) in order to evaluate the economic contribution of the state's entire local food system. Such data can be readily obtained from sources such as IMPLAN. As described in Section 3, our methods includes 1) accounting for direct intermediate food receipts, 2) deriving a statewide Leontief inverse, 3) estimating measures of gross and base output, 4) estimating the import-substitution contribution of local food markets, and 5) comparing the import-substitution contribution of local food markets to the export-base contribution of non-local food markets.

One advantage of this methodology is that it is indifferent to the specific data and definitions used. If a researcher or policy maker wishes to use a different definition of a local food system, the methodology to examine the extent and contribution of that definition of the local food system would remain the same. For example, a local food market could be defined as only the sales from a particular farm producer or food processing firm. Likewise, without changing the methodology, additional primary data on the local food system can be readily incorporated into the SAM if and when it is available to better represent current dimensions of the local food market. Our modeling results for the State of Wisconsin are presented in sections 4.1-3 below.

4.1 Direct contribution of Wisconsin local food markets

The second and third columns in Table 8 shows the level of local intermediate and institutional food receipts for the state of Wisconsin. In 2012 these receipts added to almost $20 billion or 3.6% of total state output. Agricultural food sales made up about 35% of these local food receipts ($7.1 billion) and processed food sales accounted for the other 65% ($12.9 billion). Likewise, the fourth and fifth columns in Table 8 show the level of food receipts to exogenous final demand customers. These receipts summed to almost $30 billion or 5.3% of total state output. Agricultural food sales made up about 18% of exogenous food receipts ($5.3 billion) and processed food sales accounted for the other 82% ($24.3 billion). Together, intermediate and final demand make up total industry output for Wisconsin's agricultural food production and food processing sectors, which accounts for 9% of total state output.

It's interesting to note that food processing has a higher level of final demand sales ($24.3 billion) relative to intermediate demand sales ($12.9 billion), and that agricultural food production has a higher level of intermediate demand sales ($7.1 billion) relative to final demand sales ($5.3 billion). This pattern seems to illuminate a marketing chain between the two sectors where agricultural food production provides inputs for food processing and food processing produces final products that are sold into export markets.

Table 8: Wisconsin Food Markets, 2012 (Thousands $)*

Sector	Intermediate Demand		Final Demand		Output	
	Level	Share	Level	Share	Level	Share
Food Production (Ag)	$7,088,967	2.49%	$5,355,510	2.03%	$12,444,477	2.27%
Food Processing	$12,895,427	4.52%	$24,358,964	9.22%	$37,254,391	6.78%
Food Production & Processing	$19,984,394	7.01%	$29,714,474	11.24%	$49,698,868	9.05%
State Total	$285,034,743	100.00%	$264,287,334	100.00%	$549,322,078	100.00%

*Data source: IMPLAN input-output model.

The accounting contained in Table 8 represents the direct contribution of non-local food markets (final demand) and local food markets (intermediate demand) to state output. However, it does not account for the export base of local food industries (i.e. the indirect rounds of spending undertaken by local industries in order to produce the inputs required by Wisconsin'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).

To account for either the export-base contribution of local food sectors or the import-substitution contribution of local food markets, we must make use of the Leontief inverse derived from the underlying social accounting matrix.

4.2 Export-base contribution of Wisconsin's exogenous food markets

To measure the export-base associated with Wisconsin's local food sectors, we use an IMPLAN social accounting matrix to derive a statewide Leontief inverse. We then interact this inverse with a diagonal matrix of exogenous final demand to derive the export base of Wisconsin's food sectors (Section 3.3-4).

Table 9 presents a summary of gross and base output for local food sectors within Wisconsin. In 2012, the export base of food production and processing support over $61.5 billion in economic activity or a little over 11.2% of total state output. Agricultural food production accounts for a total of $9.7 billion in economic activity and food processing accounts for a total of $51.8 billion in economic activity. These estimates represent the total export base contribution of food production and processing. It includes $29.7 billion in direct exports and an additional $31.8 billion in indirect and induced activity that supports the production of those exports.

Table 9: Gross & Base Contribution of Food Production and Processing Sectors
Wisconsin, 2012 (Thousands $)

Sector	Base Output			Gross Output	
	Direct	Total	Share	Total	Share
Food Production (Ag)	$5,355,510	$9,741,190	1.77%	$12,444,477	2.27%
Food Processing	$24,358,964	$51,813,805	9.43%	$37,254,391	6.78%
Food Production & Processing	$29,714,474	$61,554,995	11.21%	$49,698,868	9.05%
Total State Output	$264,287,334	$549,322,078	100.00%	$549,322,078	100.00%

It's interesting to note that base output share for agricultural food production (1.77%) is smaller than 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%). Similar to the pattern identified in Table 8, this outcome demonstrates the existence of a marketing chain between local food processors and local food producers that helps Wisconsin retain the economic benefits associated with value-added food production.

The dynamic of this local marketing chain begins with the exports associated with the state's food processing sectors. Wisconsin's high level of food processing exports implies a competitive advantage that allows this industry group to attract new money to the state. In other words, Wisconsin's food processing sectors function primarily as export-base sectors within the state economy. However, the story does not end there. Once these export receipts are injected into the state's economy, the local marketing chain allows the money to be recirculated to agricultural producers when food processors purchase locally-produced agricultural products as inputs into their own production functions. This is why gross output is larger than base output for agricultural food production. Much of this sector's output represents intermediate demand. In other words, Wisconsin's food production sectors function primarily as import-substitution sectors within the state's agricultural economy. This finding is consistent with recent research by USDA, which found that 50-66% of U.S. local food sales were marketed to intermediated channels such as grocery stores, restaurants, or distributors (Low & Vogel, 2011).

In Wisconsin, the effects of this marketing chain seem to be driven, in large part, by the cheese manufacturing sector. The industry functions primarily as an export-base industry that generates over $8.63 billion in direct exports sales. This represents over 65% of the industry's gross output and over 35% of all food processing exports within the state. Once indirect and induced activity ($13.7 billion) is added to direct cheese exports ($8.63 billion), the export-base contribution ($22.3 billion) of these exports is 70% larger than the industry's entire gross output ($13.1 billion) (Chart 3).

Furthermore, a sizable portion of the value of cheese exports is recirculated within the state when the cheese manufacturing industry purchases inputs from other local food producers. For example, the cheese manufacturing industry spends $3.4 billion on input purchases from the state's dairy cattle and milk production industry. This represents nearly 65% of the dairy cattle and milk production industry's gross output and nearly 35% of all intermediate inputs purchased by the cheese manufacturing industry (Chart 3). As such, Wisconsin's dairy cattle and milk production sector functions primarily as an import-substitution sector that provides a primary input for cheese manufacturing.

The local marketing chain between cheese manufacturing and dairy cattle and milk production represents a good example of a marketing chain that both brings new money to the state (through cheese exports) and keeps money within the state (through input purchases from local dairy cattle and milk producers). Chart 3 also compares base and gross output for thirty other local food sectors within Wisconsin.

4.3 Import-substitution contribution of Wisconsin's local food markets

Now that the export-base contribution of Wisconsin non-local food markets has been discussed, we turn our attention to the focus of this paper, which is the import-substitution contribution of Wisconsin local food markets. As mentioned earlier the direct contribution of the state's local food markets accounted for approximately $20 billion in intermediate demand receipts. However, this does not include the indirect or induced effects associated with these markets. To estimate a total contribution associated with Wisconsin's intermediate food markets, we must first modify the social account matrix and then derive a new Leontief inverse.

As described in Section 3.5, we begin by zeroing out all intermediate and local institutional demand receipts associated with Wisconsin local food production and processing sectors. This simulates a shock to intermediate demand where local food receipts are no longer available for purchase and firms must increase their reliance then on imports to make up the gap in their production function. Within the IMPLAN modeling software, this is accomplished by zeroing out the average regional purchase coefficient (RPC) associated with each local food sector. The model is then reconstructed to remove intermediate food receipts and rebalance the accounts. The modified social accounts are then used to derive a new Leontief inverse.

During the rebalancing process, IMPLAN V3 assigns the value of local food receipts to corresponding elements in the import row. This reduces the regional input coefficients associated with food production and processing and results in a reduction of all regional output multipliers. The rebalancing process also forces a corresponding increase to associated elements of the export column, and leaves the analyst with a choice of whether to interact the new Leontief inverse with the original (ex ante) vector of exports or the modified (ex post) vector of exports.

As previously mentioned, using the ex post vector of exports assumes that local producers can transfer endogenous sales to exogenous markets with no increase in cost. In this case the increase in exports exactly corresponds to the decrease in output multipliers, resulting in no net change in total industry output. If this scenario were completely true it would imply that the value of local food markets is negligible because, given a shock to local demand, producers always have the option to switch to exogenous markets.

On the other hand, using the ex ante vector of exports holds the level of exogenous demand constant and assumes that firms reduce production because they cannot transfer endogenous sales to exogenous markets. In this case a decreased set of output multipliers is applied to a constant level of exports, which results in a net decrease in total industry output. Table 10 presents results from this scenario for output, value added, labor income, and employment. For Wisconsin, the disappearance of local food market receipts results in a 5.4% reduction in total state output ($29.5 billion) and a 3.6% reduction in Wisconsin's economic value added activity[§] or Gross State Product ($9.9 billion). These estimates include both the direct and indirect economic activity attributable to Wisconsin's existing local food markets.

We interpret this scenario to represents an upper-bound estimate of the value or contribution of Wisconsin local food markets because it accounts for all economic activity (direct, indirect and induced) that could cease to exist if farms and food companies stopped producing for intermediate markets and reduced production accordingly.

Table 10. Total economic contribution of Wisconsin local food markets, 2012

Decreased multipliers applied to:	**Wisconsin State Indicator** (thousands $)			
	Output	Value Added	Labor Income	Jobs
an increased level of exports	$549,322,078	$276,507,891	$152,481,790	3,480,619
a constant level of exports	$519,846,088	$266,580,454	$148,109,607	3,352,239
Difference	**-$29,475,990**	**-$9,927,437**	**-$4,372,183**	**(128,380)**
% Change	-5.4%	-3.6%	-2.9%	-3.7%

[§] Value-added is often considered a better measure for reporting economic change. It is an equivalent measure to Gross Domestic Product (GDP) or Gross State Product (GSP) and only counts the value-added portion of production activity.

Table 11. IMPLAN Sectors included in Wisconsin Local Food Markets

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

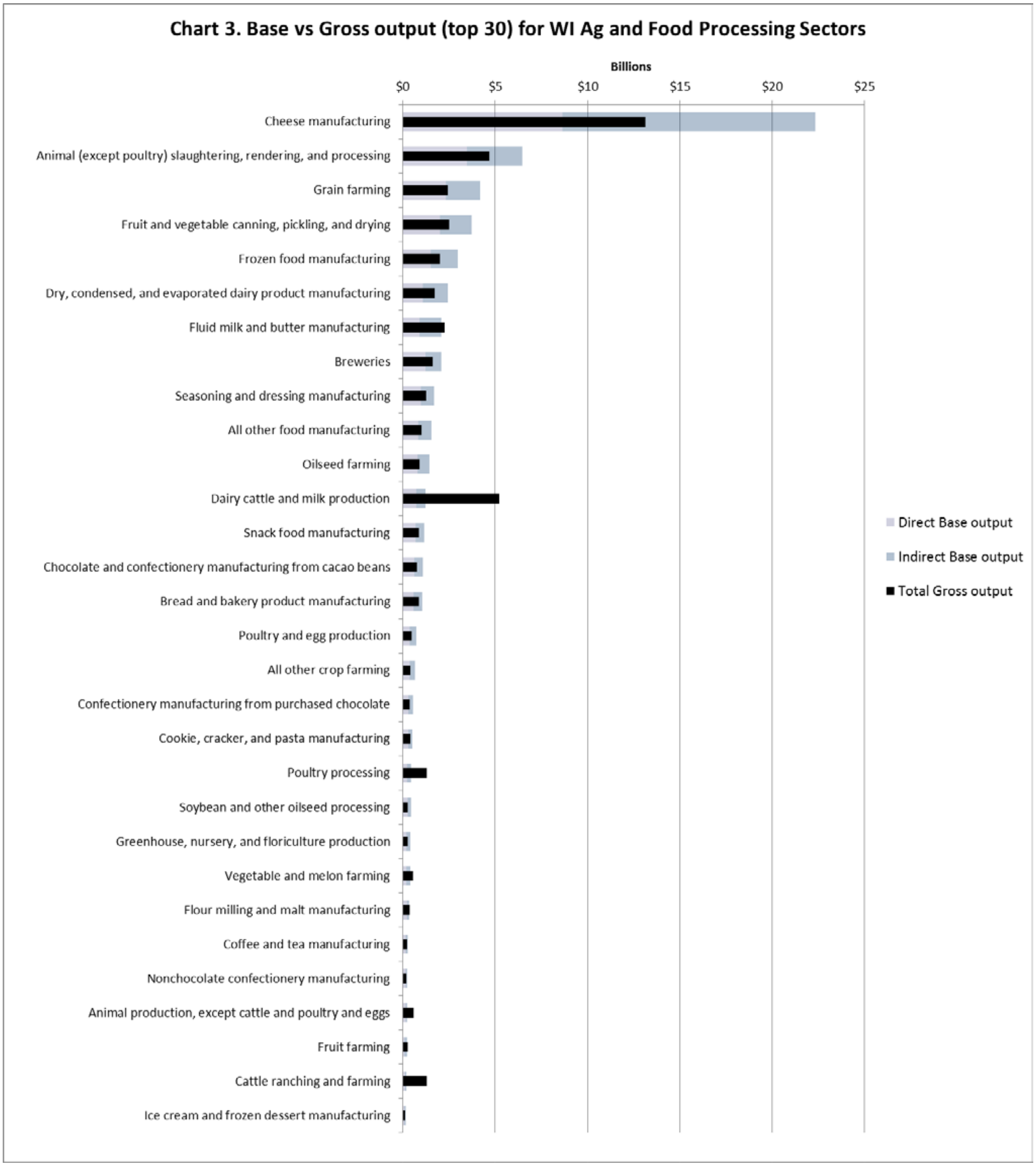
Chart 3. Base vs Gross output (top 30) for WI Ag and Food Processing Sectors
Billions
$0
$5
$10
$15
$20
$25
Cheese manufacturing
Animal (except poultry) slaughtering, rendering, and processing
Grain farming
Fruit and vegetable canning, pickling, and drying
Frozen food manufacturing
Dry, condensed, and evaporated dairy product manufacturing
Fluid milk and butter manufacturing
Breweries
Seasoning and dressing manufacturing
All other food manufacturing
Oilseed farming
Dairy cattle and milk production
Snack food manufacturing
Chocolate and confectionery manufacturing from cacao beans
Bread and bakery product manufacturing
Poultry and egg production
All other crop farming
Confectionery manufacturing from purchased chocolate
Cookie, cracker, and pasta manufacturing
Poultry processing
Soybean and other oilseed processing
Greenhouse, nursery, and floriculture production
Vegetable and melon farming
Flour milling and malt manufacturing
Coffee and tea manufacturing
Nonchocolate confectionery manufacturing
Animal production, except cattle and poultry and eggs
Fruit farming
Cattle ranching and farming
Ice cream and frozen dessert manufacturing
Direct Base output
Indirect Base output
Total Gross output

5 Conclusion

According to the methodology outlined in this paper, we estimate that Wisconsin food exports support a total of $61.5 billion in regional economic activity or 11.2% of the state's total industry output. We also estimate that Wisconsin local food markets support a total of $29.5 billion in regional economic activity or 5.4% of the state's total industry output. A comparison of these two measures invokes 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 state's food production and processing markets, but also relates to the role that each of these markets plays within a broader marketing chain.

In Wisconsin the economic contribution of food exports ($61.5 billion) is larger than the economic contribution of local food markets ($29.5 billion) simply because the exogenous final demand market for locally-produced food products ($29.7 billion) is 49.25% larger than the intermediate demand market for the same products ($19.9 billion). The food processing sectors, cheese manufacturing in particular, drive much of this outcome because the industry group is a) much larger than the food production group, and b) primarily oriented toward export markets (Table 8 and Chart 3).

The existence of a large, export-oriented food processing sector benefits the state's food production sectors because it creates an intermediate demand market for raw agricultural food commodities. For example, nearly 65% of dairy cattle and milk production's gross output is purchased by the cheese manufacturing sector as an intermediate input. Furthermore, the existence of a local marketing chain between food producers and food processors benefits the state as a whole for at least two reasons. First, it ensures that more of the economic benefits from the valued-added chain remain local. Second, it helps diversify the state's industry mix and deepens the inter-connection between local industries. In short, the existence of a local marketing chain represents a much more ideal regional development outcome compared to a scenario where a region only captures the value-added associated with exporting raw agricultural commodities.

Finally, it's worth noting two important caveats associated with the methods outlined in this paper. First, our method for estimating the contribution of intermediate demand markets relies heavily on an assumption that local producers cannot transfer

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

intermediate demand sales to exogenous markets. 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 intermediate 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 the linear modeling caveats apply (i.e. fixed isoquants, fixed prices, unlimited supply, etc.) (Meter & Goldenberg, 2015). Further calibrating these classical input-output assumptions would require a more flexible economic model (i.e. computable general equilibrium model).

However, despite these limitations we believe the method outlined in this paper provides an important contribution to the local foods literature on at least three accounts. 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 sub-markets within a region's food system.

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