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How global is my local milk? Evaluating the first-order inputs of “local” milk in Hawai‘i

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Abstract “Local food” is gaining in popularity, particularly within a rising alternative food movement, yet it remains an ambiguous term. We use an illustrative example—the case of “local milk” in Hawai‘i—to demonstrate this point. We evaluate “localness” by measuring the origins of production inputs by economic value and physical mass–an approach that is akin to the Made in America standard. The innovative method we propose is easily replicable to other food products or locations worldwide. We find that most first order production related inputs are obtained from non-local sources. Our findings are significant to the local food debate because a focus beyond the point of production to upstream inputs in the life cycle of a food item can push towards a re-framing what local means both in Hawai‘i and beyond. In particular, our findings suggest that production system type, as opposed to location of production end-point, might have a greater impact on the degree of localness of a product. Looking forward, a shift in focus towards production system characteristics may help researchers make headway in exploring the environmental and economic effects of local food.

Keywords Local food · Dairy · Hawai‘i · Sustainable food systems · Food labeling · Made in America

Introduction

A new social movement oriented around the re-creation of regional or local economies—captured by slogans such as “buy local”—is gaining increasing traction amongst consumers (Allen 2010; Mount 2012). This movement reflects widespread concern over the consequences of globalization and associates localized systems with various community and individual level benefits (Bailey et al. 2010). Re-localization initiatives have been particularly popular in the realm of food, as evidenced by the growth of local food sales through farmers’ markets, community-supported agriculture, and traditional retail stores (Marsden 2010; Kneafsey 2010). Many consumers use the term ‘local’ as a proxy for desirable attributes of food, including higher food quality (e.g., freshness) (Food Marketing Institute 2009); improved environmental performance (Thompson et al. 2008); local economic resilience (Enderton and Bregendahl 2014); a re-connection of producers and consumers (Kloppenburg et al. 1996; Grey 2000); greater transparency in the food system (Mount 2012) and preservation of rural landscapes (Hughes et al. 2007). Yet research has shown that localized food systems do not inherently provide such benefits (Matthews et al. 2008; Edwards-Jones et al. 2008; Weber and Matthews 2008; DuPuis and Goodman 2005; Purcell and Brown 2005; Nicholson et al. 2015).

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Despite local food's popularity, there is no legally binding definition for local food,[1] nor is there consensus on what local food means (Schmit 2008; Rushing and Goldblatt 2014). Rather, a multitude of definitions is commonly used. This raises concern since substantial financial and human resources are directed towards local food system development (McKalip 2014). In addition, a poorly framed concept might lend itself to "local-washing" as well as other forms of consumer deception (Negowetti 2012). Indeed, many consumers assume that local food embodies the three following attributes: sustainably produced, socially embedded, and supportive of the local economy (Brown 2003; Lea 2005; Selfa and Qazi 2005; Feagan 2007; Vogt and Kaiser 2008; DeLind 2011) Yet as previous scholars have noted, eating local food is not inherently more ecologically sustainable or socially just. Born and Purcell (2006) term this assumption "the local trap" and argue strongly against it. They draw from scale theory in political and economic geography to show that local food systems are no more likely to be sustainable or just than systems at other scales. Subsequent scholars have built upon their work to draw attention to the potential shortcomings of local food (DuPuis and Goodman 2005; Purcell and Brown 2005; Kneafsey 2010). Nevertheless, the local food movement remains powerful and "local" is increasingly part of the lexicon of the food and agriculture industry in the United States.

Though the concept of "local food" is multidimensional and complex, other geography-based standards exist which do systematically assess products' degree of 'localness' as a means to enhance the delivery of a particular benefit. For example, the *Made in America* label is a legally binding standard aimed at strengthening the American economy. The *Made in America* certification process assesses the economic value of a product's components and their origin (i.e., domestic or not) to determine whether they meet the standard's criteria (Federal Trade Commission 1998). Our study follows from the premise that spatially explicit labeling schemes like *Made in America* may be adaptable for local food evaluations. On the one hand, we recognize that they are limited in that they do not assess whether a product, geographically defined, actually delivers the attributes people expect from it (the subject of the "local trap" dialog). Nonetheless, they provide a model for at least an initial evaluation of local food on the most literal level—i.e., is "local" food local from even a geographical-spatial perspective? And more specifically, how geographically local is a product when first order inputs are taken into consideration?

[1] However at the time of writing the state of Vermont established a legal statute defining the term "local" as goods that originate within Vermont or 30 miles of the place where they are sold (http://legislature.vermont.gov/statutes/section/09/063/02465a).

In this paper, we use the case of milk produced in Hawai'i to empirically investigate a so-called local food's degree of "localness". We do this by examining the origin (i.e., local/non-local) of first order (i.e., direct) inputs required for the milk's production (e.g., feed, water, land, and labor). Following the *Made in America* standard, we determine economic 'localness' by assessing the economic value of each input to see whether overall, more than fifty percent of the economic value of inputs is sourced locally within Hawai'i's boundaries. We then repeat this calculation, yet instead of measuring the inputs' economic value, we measure their physical mass (i.e., lbs.) to determine whether more than fifty percent of overall inputs by mass are sourced locally. Quantifying the share of inputs locally sourced by economic value and mass allows us to understand whether money and nutrients remain within the local system or leak outside of its boundaries. Though tracing each single input back to its origin may provide the basis for a more comprehensive analysis, it is unlikely that going farther up the supply chain will reveal higher shares of locally sourced inputs. Thus, given the time and effort required for assembling information on all inputs from cradle to grave, to increase the practical applicability of the method proposed, we limit the analysis to first order inputs only.

Our findings suggest first that in the contemporary globalized economy, it may be difficult to find agricultural produce that can be considered truly local from a geographic perspective. As we demonstrate through our case studies of Hawaiian milk, most first order production related inputs are obtained from non-local sources. Second, since the majority of supporting industries (e.g., feed and fertilizer production) are located elsewhere, it is likely that the potential impacts of a 'local' production system on the surrounding economy, landscape, and community are limited. Our findings also suggest that it may be more illuminating to examine the impact of production system type (e.g., feedlot, grassfed), as opposed to location of production end-point on the degree of localness of a product.

We conclude by suggesting that that those working to create alternative food systems may be better served by focusing less on the locality of food and the policing of its definition and more on the types of agricultural production systems that could potentially reflect the goals behind the popularity of so called localized food systems.

Approaches to labeling local food

As concerns over the sustainability of the food system grow, there has been a concomitant proliferation of labeling (or arguably branding) systems for food, including those for "local" food. Yet even though conceptions of local food can include characteristics beyond geography, labels for "local" food products are usually limited to geographic origin. These labels build upon local food labeling schemes that became increasingly popular across the world in the 1990’s, and which certified and promoted specific locales, production processes and indigenous products (Ilbery et al. 2005). For instance, over 500 local food products have been registered in EU under PDO (Protected Designation of Origin) and PGI (Protected Geographical Indication) schemes since 1992 (Ilbery and Kneafsey 2000; Parrott et al. 2002).

Food labeled “local” suggests physical proximity between the producer and end consumer, though this exact distance is not uniformly defined (Thilmany et al. 2008). The word local itself is defined as “characterized by or relating to a position in space: having a definite spatial form or location” (Merriam-Webster 2015). The 2008 Farm Act describes “regional” or “local” food as food transported either less than 400 miles from its origin or within the same state. Another example is the high end retailer chain *Whole Foods*, which generally uses state lines to define local (Wholefoods). “Food miles” are in some cases are labeled on food products (Paxton 1994). However, no geography-based food labels currently take into account the origin of the upstream inputs required to produce a given product.

Made in America

In contrast, the *Made in America* standard, while not exclusive to a particular product category, is a geographically defined standard, which goes beyond final assembly or processing. Regulated by the Federal Trade Commission (FDC), for a product to be called *Made in America*, the product must be “all or virtually all” made in the United States. *Made in America* also considers factors not directly related to the physical aspects of production, including how much of the product’s total manufacturing costs can be assigned to domestic entities, and how far removed any foreign content is from the finished product.[2] A product may be labeled *Made in America* only if at least 51% of the economic value of the total content is sourced within US borders (Federal Trade Commission 1998). By going beyond final production and assembly stages, to examine the embodied economic value of the supply chain, the *Made in America* standard is able to ensure that the bulk share of economic activity takes place within US borders. In this way, the *Made in America* standard takes into account the geography of upstream inputs as well as finished product, which even the Congressional definition of “local food” (i.e., 400 mile radius) does not specify. However while there is little scholarly literature on the *Made in America* label, it has been criticized for allowing most of the components to be sourced outside the U.S., as long as a minimum percentage of the final product is assembled or substantially transformed in the U.S. Critics argue that this process can mislead consumers into assuming they are buying from primarily domestic sources when in reality they are not (Devaney 2012).[3] This is particularly relevant in the domain of food, where consumers care not only about where economic value accrues but also about qualities such as preservation of regional agricultural heritage and transparent supply chains.

Currently a food item’s “localness” is determined solely by its final production place. Indeed, where a carrot is grown or a cow is raised determines whether it is considered local or not, yet the origin of the inputs required to produce those food products is rarely considered. The focus on the production process’ end-point is problematic as it may obscure the fact that most of the economic and environmental impacts and benefits associated with the product might take place non-locally.

Adopting a broader definition of what should constitute as local could help capitalize on the potential benefits of various production stages. From an economic perspective for example, expanding the boundaries of the local components of food beyond the final production stage to include the first order inputs (e.g., fertilizer for crops, feed for animal farming) as well as end stages (dumping, recycling plants, etc.) may foster the formation of supporting as well as similar industry clusters (Porter 1998). From a bio-physical perspective, the origin of first order inputs is relevant when considering the potential for preserving local nutrient cycles and soil fertility (Dumont et al. 2013). Furthermore, such inclusion may also encourage increased use of byproducts and waste from existing industries operating nearby (use of mill as feed, manure as fertilizer etc.) or even forms of industrial symbiosis, thereby reducing overall environmental impacts (Chertow 2000).

Our approach: made in Hawai‘i

Our study goes beyond previous approaches to quantitatively examine whether or not a food item should be considered local. Drawing on the guidelines of the *Made in America* standard, our assessment of “local” considers not only the final product but also the inputs required for its production. More specifically, we examine the mass and

[2] To determine the percentage domestic content in a particular product, manufacturers and marketers use the cost of goods sold or inventory costs of finished goods in their analysis. These costs generally are limited to the total cost of all manufacturing materials, direct manufacturing labor, and manufacturing overhead.

[3] While this is an important critique, it is worth noting that nearly all contemporary economic activity—from “local” food to manufactured items labeled *Made in America* - exists in the context of a globalized commodity system, which makes entirely ‘domestically produced’ items difficult to come by.

economic value of the first order inputs going into production, and compare the share of local versus non-local components. We demonstrate this methodology by analyzing and comparing two examples of "local milk" currently produced in Hawai'i according to an adjusted *Made in America* standard, which we term *Made in Hawai'i.*

We chose to examine economic and biophysical flows as they map on to several key domains sought by "locavores"—support for the local economy and a demystification of the food chain by means of physical proximity (*if I can see it I can understand it*) as well as a biophysical rational that seeks to close nutrient and material cycles. While the evidence that geographical localness provide such attributes is limited (see above), nevertheless the economic and biophysical dimensions of 'local food' hold powerful associations in the local food movement, and as such, warrant investigation. Though we acknowledge that sourcing the majority of inputs locally would not suffice to close nutrient cycles, it may at least be a step in the right direction. By adding a physical analysis to the economic one, we are thus able to expand the narrow scope of the *Made in America* label and address some of the criticism it receives.

It is important to note that existing methods such as life cycle analysis (LCA) can provide detailed accounts of various environmental impacts associated with the provisioning of specific products and services. Generally, LCAs and similar methodologies involve an inventory assessment of all inputs and outputs of material and energy over the full life cycle of a particular product or system (from raw material acquisition to end of life) followed by an interpretation of the subsequent environmental impacts. Though these analyses are no doubt comprehensive, it is questionable how much additional resolution they provide for the debate over the localness of produce. This is because if most of the direct inputs of "local" products are sourced non-locally, it is unlikely that examining inputs higher up the supply chain will increase the overall share of local inputs. Furthermore, LCAs tend to be extremely labor intensive and time consuming. As our goal in this study is not to evaluate the environmental impacts associated with a product (which LCA is well suited to do), but merely quantify its degree of localness, we believe that our approach is better suited for addressing the issue than LCA given that it is simpler, faster, and compatible with existing geographically based labels.

Case study of milk in Hawai'i

We take milk production in Hawai'i as our case study for several reasons. First, the dairy sector has been identified as an excellent example for examining the impacts of increased localization of food supply chains (Nicholson et al. 2011). This is in part because of the rapid transition of the US dairy supply chain over the past fifty years from local to global, and also because the complexity of the supply chain make localization of this industry particularly challenging. Second, given its reliance on food imports, geographic isolation, and susceptibility to increasingly prevalent natural disasters that can disrupt supply chains, Hawai'i has increasingly made food self-sufficiency a statewide goal. The Hawai'i State Constitution, the Hawai'i 2050 Sustainability Plan, the New Day Plan, the Hawai'i Comprehensive Economic Development Strategy (CEDS) and other state documents all explicitly support strengthening Hawai'i's local food system in order to promote food self-sufficiency (Higa 2008; DBEDT 2010, 2012; Abercrombie 2010). The State also incentivizes local food purchases by retail stores through its two branding programs (Island Fresh and Hawai'i Seals of Quality) and a Buy Local, It Matters campaign (Ulupono Initiative 2011; Loke and Leung 2013). In addition, these initiatives enjoy widespread popular support from Hawaiians. For example, in a recent study on food preferences of Honolulu residents, 81% of respondents stated that they believed too little food was grown locally (OmniTrak Group Inc 2011). Research shows that the primary motivations behind Hawaiians' support for local food are food security concerns and a desire to support the local economy (Gupta 2016). The ample public and private support for local food thus warrants a closer examination of what constitutes "local" food in the context of Hawai'i.

In some respects Hawai'i's small average farm size (161 acres, compared to 434 acres in the U.S.) (Arita et al. 2012), its sloped and dramatic topography (making it difficult to scale up farms), high costs of agricultural real estate (50% of agricultural land in Hawai'i is rented), as well as higher average costs for labor, electricity, fertilizer and transportation relative to their U.S. mainland and Japanese market competitors (Parcon et al. 2011; Arita et al. 2012) make it an anomaly. Indeed, there are only two remaining dairies in the State of Hawai'i (see Gupta 2016 for lengthy history of Hawaiian dairy industry and its decline). However, it arguably reflects—perhaps a heightened version of—both the growing desire for increased local food production as well as the challenges that local small-scale farmers face in many parts of the United States.

Our analysis of local milk compares milk production in a newly proposed "pasture-based" (i.e., grass fed) dairy on Kaua'i Island (termed "Farm A") to milk production in a long-standing dairy on Hawai'i Island (termed "Farm B"; see Table 1 for description of the farms[4]). We selected these two dairies in part due to limitations of the sampling frame—Farm B is one of only two remaining dairies in the

[4] See Gupta (2016) for greater elaboration on Farm A.

Table 1 Characteristics of Farms A and B

	Farm A	Farm B
Location	Kaua‘i Island	Hawai‘i Island
Year founded	2015	1962
Area (acres)	582	892
Herd size (live heads)	~1850 milking, 1200 growing & rearing, 300 dry	~700 milking, 200 heifers, 100 dry
Carrying capacity (heads/ac)	4-5	1.1
Milk production (gallons/day)	~10,500	~3500
Production type	New Zealand pasture-raised model; high-intensity	Traditional (pasture + feed model); low-intensity

state of Hawai‘i. Nonetheless, these two dairies (Farm B in operation, Farm A under development) provide a fruitful contrast with each other, given that Farm B follows more conventional practices of dairying (i.e., feedlot), while Farm A is adopting a pasture-based approach. Farm A aims to “transform the dairy system in the state” (Tanaka 2013) by doubling the local milk supply through a New Zealand-based pastoral model of what they are describing as sustainable production. Rather than feed their cows imported grain, the proposed dairy plans to feed their cows grass, which will reduce reliance on imported inputs. In addition, both dairies are particularly appropriate for our study because they have made claims as to their “localness.” While Farm A is a new development, it advertises itself as “rooted in a belief that Hawai‘i’s milk should come from Hawai‘i” and states its’ mission to be providing “fresh nutritious milk that’s affordable for local families—produced in Hawai‘i for Hawai‘i” (http://www.hawaiidairyfarms.com). Meanwhile, at the main grocery retail chain on the island, Farm B’s milk is branded and sold under the “Mountain Apple” label, a storewide label for locally produced products.[5] Farm B has been in existence on Hawai‘i Island for over fifty years.

Methods

Goal and scope

The goal of this analysis is to evaluate the degree to which two examples of “local milk” produced in Hawai‘i, would meet the requirements associated with the *Made in America* standard, applied to the State of Hawai‘i. The *Made in America* label requires manufacturers to “…consider the origin of materials that are one step removed from the particular manufacturing process” (Federal Trade Commission 1998). Following these guidelines we focus on first order inputs going into the production of milk to determine whether more than half (i.e., 51%) are locally sourced. We conduct this analysis on an economic and a biophysical (mass) basis. Reflective of popular usage, we define “local” according to state boundaries, while non-local means outside of Hawai‘i. We focus on inputs rather than outputs as all sales of local milk are known to be local—no milk or dairy products are exported outside of the states.

To determine whether the milk should be considered “Made in Hawai‘i” from an economic perspective, we examine the origin and economic value of first order production expenses including feed, water, energy, fertilizer, labor and production overhead. To determine whether the milk should be deemed local from a biophysical perspective, we examine the origin and mass (in lbs. of dry matter) of first order inputs, focusing on biological-organic inputs (see Table 2). We choose to limit our mass based analysis to biological inputs for several of reasons. First, while it is highly unlikely that all farming or milking equipment (i.e., milking machinery and tractors) could be manufactured within Hawai‘i, the local ecosystem could potentially provide all biological-organic matter required for agriculture produce (see discussion section for more). Second, biological inputs become an intangible part of the local nutrient cycle (Dumont et al. 2013) and directly affect its balance (or lack of it) in the local environment. In addition, the biological inputs become a physical part of the food itself. Thus, ensuring that at least half are sourced locally should enhance transparency.

As the focus of our analysis is the degree of localness of the two systems, we do not address the production of by-products (e.g., meat and leather), but attribute all economic and material inputs to the production of milk. However, because we exclude any inputs past farm gate (e.g., packaging, transportation), allocating the resources needed between beef and dairy for example, would not change the

[5] In 1992, the grocery store chain KTA decided to pay the processing company Meadowgold for special processing of the milk from Farm B dairy destined for their stores. This Mountain Apple milk was kept separate from imported mainland milk and packaged into special cartons bearing the store’s Mountain Apple logo, which signifies items grown, processed or manufactured in Hawaii (as well as a disclaimer stating “free of artificial growth hormones”).

Table 2 The share of local and non-local first order organic inputs in dry mass, by origin

	Imported inputs (lbs./day)				Local inputs (lbs./day)					Total DM (lbs./day)
	Fertilizer	Alfalfa	Grains	**Subtotal**	Pasture	Mowed grass	Mill run	Milk*	**Subtotal**	
Farm A	493	N/A	25,160	**25,653**	61,920	N/A	N/A	N/A	**61,920**	**87,573**
	1%		29%	29%	71%				71%	
Farm B	N/A	9900	7865	**17,765**	11,200	4500	1800	172	**17,672**	**35,437**
		28%	22%	50%	32%	13%	5%	0.5%	50%	

Bold indicates sub-totals and overall totals

[a] Milk fed directly to calves—values for milk were converted from gallons assuming an average weight of 8.6 lbs/gallon

ratio between the local and non local inputs, but only the overall amounts (money or mass) associated with the milk, and thus our results would remain the same.

Data collection

Economic and physical data on first order inputs (water, feedstuff, fertilizer, energy, equipment, and labor) as well as additional data required for our analysis (cattle head inventory, stocking capacity, pasture acreage, milk yield, wholesale price of milk, total expense sheet) were collected in a series of interviews with the general partner of Ulupono Initiative (Honolulu, Oʻahu Island), the organization developing Farm A (Kauaʻi Island) and the owner-manager of Farm B (Hawaiʻi Island). These interviews were conducted during the summer and fall of 2014. Origin of inputs was determined based on the interviews as well as additional data obtained from official government websites (e.g., USDA and Hawaiʻi DOE).

For farm A, our sources provided a detailed business plan including expected operating expenses (water, electricity, machinery maintenance) insurance costs, estimated production performance, estimated revenue and more. Their report also provided a detailed daily dietary plan for each cattle category (e.g., milking herd, replacements heifers, dry cows who no longer lactate) including feed mass in lbs., expected cost for each feed type (e.g., hay, alfalfa etc.), and where it is sourced from (e.g., California, Hawaiʻi island).

For farm B, our sources reported average monthly expenditure related to farm operations (utility bills, labor, repairs, land lease etc.) and monthly milk yields. In addition they also provided us with details regarding monthly feed purchases, average costs for each feed type and its origin, and the amounts of additional on-farm produced feed (e.g., milk fed directly to calves), and explained how the various feeds distributed among the herd's cattle categories.

Based on these reports we then calculated overall costs (economic analysis) and material requirements (physical analysis), needed for the production of 1 gallon of milk in each farm. Based on the inputs' origin and relative cost/-mass required to produce 1 gallon of milk we then estimated the share of local and non-locally sources components. A step-by-step description for each farm is provided in the following sections.

Physical analysis

Farm A

As mentioned previously, our physical analysis takes into account only first order agriculture inputs (i.e., purchased feed, raised feed and fertilizer) required for the production of 1 gallon of milk. As farm A did not report using any fertilizer we focus solely on purchased feed, raised feed, and pasture.

To estimate the mass of feed required per gallon, we begin by calculating the total daily amount of each feed type (both purchased and home grown) consumed by the entire herd. To do this we multiply daily individual diets for each cattle category (according to feed type and weight), by the respective number of cattle heads in that category. As no information was provided on pasture intake, following Eshel et al. (2015) we estimate pasture consumption based on general feed recommendations for dairy cattle. Assuming that in addition to other sources of concentrates and legumes, each cow consumes approximately 4% of body weight in pasture (NRC 2001), we derive total pasture consumption by multiplying the average animal weight in each category by 0.04 and then by the number of animals per category.

Next, we sum the herd's daily intake for each feed type, and convert weights into dry mass weight (i.e., zero water content, see table SI-2) using the National Research Council's nutrient composition data (NRC 2001). Finally, we divide the total mass of each feed (in dry matter) by expected daily milk production, to obtain mass requirements per gallon, and compare the share of local to non-local inputs based on their mass.

Farm B

To estimate fertilizer mass (used for on-farm production of mowed grass) we multiply the number of acres, by the average application rate per acre (as reported by the farm) and divide the result by monthly milk production in gallons.

To estimate feed inputs per gallon we rely on monthly feed purchases (reported in lbs.) in addition to reports on total daily amounts of mowed grass and milk fed to the herd. Following the same methodology described for farm A, we then estimate pasture intake, convert all feed mass to a dry mass basis, and finally divide the total mass of each feed by the expected daily milk production and compare the share of local and non-local inputs on a per gallon basis.

Economic analysis

Our analysis of economic localness focuses on operational costs. Similarly to the physical analysis, expenditure is considered local or non-local based on whether the inputs are sourced locally. Following this logic, we consider raised feed, pasture, labor, and pastureland rent as local, and account for their embedded energy (e.g., operation of tractors or mowing equipment) under the categories of fuel or electricity. We consider all renewable energy sources as local and all non-renewables as non-local (though fossil fuel based electricity is generated locally, we consider it non-local because the fuel originates from outside Hawai‘i). For grid electricity we partition the total amount purchased from the utility into local and non-local energy sources, following each location’s share of renewables in 2013, based on data from Hawai‘i’s Department of Energy (60 and 13% renewables in Hawai‘i and Kaua‘i respectively) (Kaua‘i Island Utility Cooperative 2013). Though water is a local resource, its price mostly reflects the energy demand for pumping and transportation. Thus, we partition the costs of water between local and non-local using the same allocation applied to electricity costs. All other inputs (e.g., off shore purchased feed, fertilizer etc.) are considered non-local.

Farm A

The farm’s business plan included a detailed breakdown of expected costs required for the production of one CwT of milk (i.e., a short hundredweight equal to 100lbs.), including operational costs for utilities (water and grid electricity), fuel, renewable energy, labor, maintenance (repairs), raised feed, and misc. For our analysis, we therefore convert the figures reported in the business plan to a per gallon basis (assuming 11.63 gallons per CwT). As no information was provided for pasture, we estimate its economic value based on the monthly cost of leasing the land and the additional labor expenses associated with the grazing. We then divide this monthly cost by monthly milk production to get a per gallon cost estimate. Finally, we sum up all costs per gallon and compare the share of local and non-local expenditure out of the total.

Farm B

For farm B, no easy breakdown of costs per milk produced was available. Therefore, to estimate costs per gallon we first calculate the overall costs associated with one months’ worth of milk production and then proceed to divide this overall sum by the number of milk gallons produced monthly to derive results on a per gallon basis.

For water, electricity, fuel, labor, and repair, we used monthly expenditure averages as reported by the farm. For feed, we multiply the herd’s daily requirement per feed type (in wet mass) by its price/lb to obtain overall daily costs. Here too, we estimate pasture costs based on the monthly cost of land lease and the additional labor required. Finally we divide all monthly expenses by the number of milk gallons produced to obtain a per gallon cost estimate and compare the share of local and non-local inputs according to cost.

Results

Physical analysis: made in Hawai‘i

From a physical perspective, Farm A exceeds the 51% requirements, sourcing approximately 71% of physical organic mass from local sources, placing it well above the *Made in Hawai‘i* threshold (see Table 2). Whether Farm B should be considered local from a physical point of view is questionable as exactly 50% of its organic inputs by mass are locally sourced (see Table 2), putting it very close to the threshold of *Made in Hawai‘i* (see Table 2).

Economic analysis: made in Hawai‘i

Figure 1a, b show partitioning of first order inputs required for the production of one gallon of milk by economic value into local and non-local. In both cases, the milk produced by these two dairies would not be considered local under our proposed *Made in Hawai‘i* standard as less than half of the expenditure is local (41 and 27% for Farm A and Farm B respectively). However, while Farm B spends 50% on imported feed alone, Farm A, which incorporates a larger

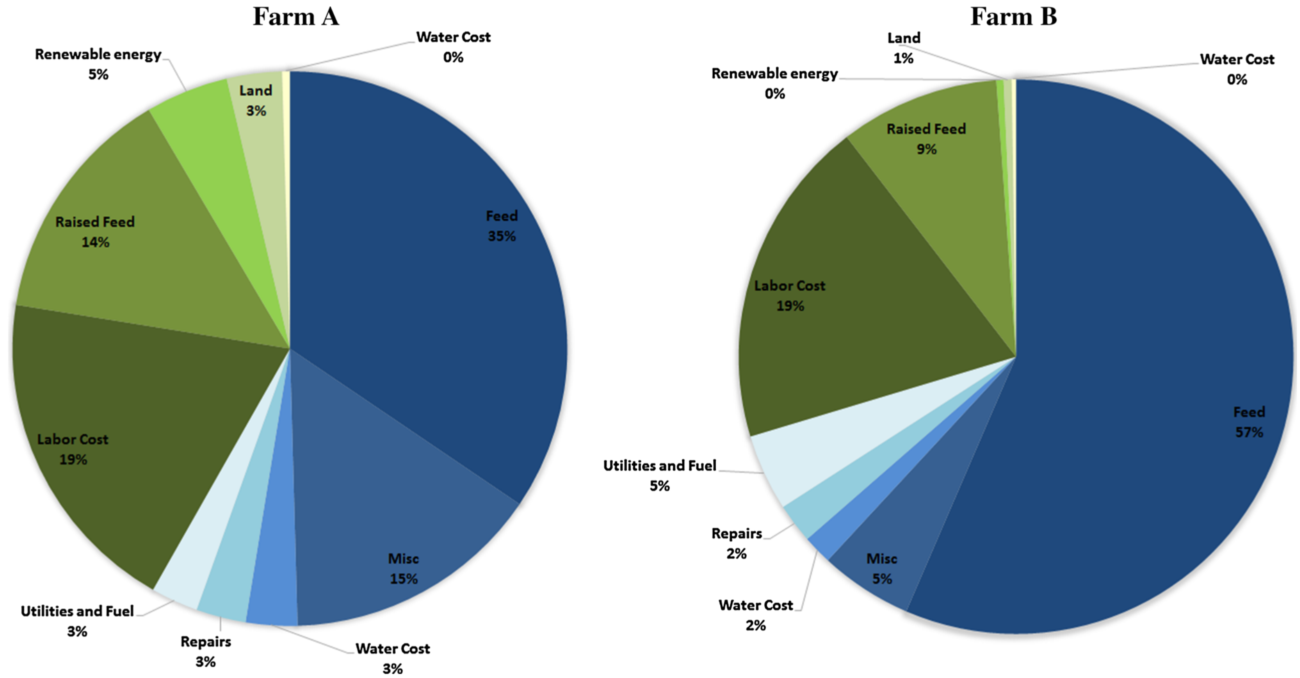

Fig. 1 Economic value of inputs per gallon of milk produced in farms A and B by origin. Local inputs represented in *green shades*, non-local inputs in *blue shades*. (Color figure online)

portion of pasture in the cattle's diet, spends only 34% of operational expenditure on imported feed. They also spend an additional 15% on miscellaneous, which is composed mostly of payments for improved breeding techniques, genetics consulting, and technology experts. For both farms, labor costs are a significant expense representing 19 and 17% of overall costs for farms A and B respectively.

Discussion

In our study we analyze the operational aspects of milk production in Hawai'i to determine whether two systems of milk production should be considered local from an economic and physical perspective. We do this by defining an economic and physical *Made in Hawai'i* standard and tracing the origins of operational expenses and material inputs that are one step removed from the farm-level, to determine whether the local components exceed 51% of the total.

From an economic perspective we find that in both cases, the milk produced by these two dairies would not be considered local since less than half of their expenditure is in-state. Currently, most inputs are non-local because the high cost of production of inputs in Hawai'i is prohibitive. This means that while local inputs could potentially be produced in Hawai'i, in reality, they are likely to continue to be produced elsewhere. It is important to note that this situation is by no means unique to Hawaii. Indeed in a globalized economy in which the transport of goods is easy and inexpensive, procuring production inputs (agricultural or industrial) from remote locations is often cheaper compared to regional "local" inputs.

From a physical perspective, we find that while Farm A would no doubt be considered local, Farm B is a borderline case in which its "localness" is inconclusive. Following this approach, while Farm A can call its milk *Made in Hawai'i* milk, Farm B might not be eligible to do so.

While our study makes strides in deconstructing the "myth of local," it is important to note that our findings face several limitations. First, as results for Farm B are borderline, they are sensitive to the conversion factors chosen to convert feeds from wet to dry mass (see Table SI-2). Using different dry matter content values for the imported Farm B feeds could have a substantial impact on our results. A higher value would place more weight on the non-local inputs while a lower value would place more weight on the local inputs.

Second, our results are sensitive to our decision to focus on the origins of agricultural inputs, as opposed to inputs such as machinery and equipment. As the origin of these kinds of inputs would fall into the non-local category, our analysis gives an underestimate of the proportion of non-local overall inputs to each dairy and the system boundaries we examine (i.e., the analysis cut off point). Furthermore, including additional lifecycle stages in our analysis could influence the percentage of local inputs. For example, if higher links in the supply chain (e.g., manufacturing of milking equipment) were taken into account in our analysis, the share of local inputs would most likely fall, while if downstream links of the supply chain (e.g., value added by the milk distributer or retailer) were added, the share of local inputs could be higher. Such a recognition points to the fact that our results are sensitive to the system boundaries definition, a common issue within life cycle analyses.

In addition, we chose to include labor under local expenses. As farm labor in Hawai‘i typically has a large share of immigrant workers, one could claim that their income may not support the local economy especially if worker remittances to other countries are high. Further research should investigate the degree to which inputs such as labor circulate money in the local economy versus elsewhere. Furthermore, because Hawai‘i is unusual in terms of its geographic isolation from other states, a *Made in Hawai‘i* type framework may look quite different in other states where the state boundaries are not representative of local foodsheds. For example, in small states on the East Coast where food is produced, farmers often work in regions that cross state borders. In those instances, there may be a more appropriate geographic unit of analysis than that of the state (e.g., “foodshed”) (Peters et al. 2008) .

Nonetheless, we believe that our analysis and the insights gained through the examination of the two case studies can help to reshape the discussion around local food by drawing greater attention to the wider production system in which it is embedded. A focus beyond the point of production to upstream inputs in the life cycle of a food item can push us re-think what local means anywhere, not just in Hawai‘i. Indeed, while our focus on the unique case of Hawai‘i makes it challenging to generalize our results, the innovative method we propose is replicable to other locations worldwide. In particular, we believe that our finding that the amount of non-local inputs is more sensitive to the type of production system (i.e., grass-fed vs. feedlot) than its location will hold for other locations as well. In reality, in the U.S. most dairy (and beef) cattle are produced on feedlots and production of animal feed is centered in a handful of locations. Thus, any feedlot operation located outside of the specific areas where feed is produced would be unlikely to reach the 51% threshold for qualifying as local. Systems that are 100% grass fed on the other hand, could potentially meet our threshold for localness yet this would depend on the quality of grass available locally and whether supplements (e.g., alfalfa) are required as dietary supplements. The point here is that production system may matter more than location in influencing the outcomes of a similarly conducted analysis in regions outside of Hawai‘i. These finding are in line with results from the LCA literature which show that production often has a greater impact on the greenhouse gas emissions related to a specific food item, than its food-miles (Avetisyan et al. 2014).

Additionally, while *Made in America* is a useful analogous framework for illustrating our key points, is not a perfect model for articulating whether something is local or not. Namely, the *Made in America* labeling scheme bears some key differences from how the term of local is usually conceptualized, particularly in terms of scalar and relational elements. First, the United States is much larger than the geographic region to which “local” usually refers. Second, and more importantly, unlike advocates of the *Made in America* label, for those who approach local food from an alternative food system perspective, the value of local food comes not just from shrinking physical distance, but also shrinking relational distance (Trivette 2015). This means that an item could merit a *Made in X region* label from biophysical perspective but lack the level of social connectedness that local food proponents desire.

Indeed, our study does not account for qualitative measures of “local” as we only include certain quantifiable economic and biophysical measures of “local”. Building on our proposed method, future work could also add a social assessment relating for example to labor or ties to the community that are beyond the scope of this study. It is worth noting, for example, that despite Farm A performing better according to our measures of local, Farm A is a new project started by a company perceived as “outsiders” by many local residents, whereas Farm B has been in existence for more than five decades and is considered part of the island’s local fabric. In fact, Farm A has been criticized by nearby residents for its failure to properly engage and inform the local community about its proposed dairy development plans. In this way, even the milk that qualifies as local from a biophysical perspective is not necessarily part of a short supply chain that links producers with consumers in a way that achieves greater transparency.

Conclusion

Our case study examines the economic and biophysical “localness” of milk produced in Hawai‘i. Our findings are significant to the local food debate because they show that a local product may be comprised of a majority of upstream non-local inputs, which calls into question the “localness” of that product. If local products were evaluated according to similar criteria as *Made in America* products, many of them, like our two examples of milk, would not meet the standard from both an economic and physical perspective. As such, our study affirms the notion that “local food” remains a ubiquitous and ambiguous term.

An evaluative tool akin to our *Made in Hawai‘i* standard could help clarify debates over local by serving as a standardized metric for empirically assessing the geographic origins of a given product. This would allow consumers to determine the relative degree to which a given product is indeed "local" to the region it claims to be from (i.e., "local to Hawai'i"). However, this tool would still not be able to assess the validity of products that do not specify the region to which they are "local" (i.e., "local," but to where?). In addition, this approach does not offer a composite matrix to evaluate both economic and physical localness together. Therefore, it is possible that a product would be considered local from a physical perspective, yet non-local from an economic perspective. While a "one-stop" composite metric may be appealing to consumers (as well as to policy makers) we believe that such a matrix could only add to a lack of transparency and hide the fact that different benefits commonly attached to local foods do not necessarily go hand in hand. Furthermore, such a tool would not account for the social goals associated with local food, such as trust-based relations between farmers and consumers. Given that social embeddedness is a key goal identified by many local food advocates, we believe that further research should incorporate social and cultural dimensions into analyses of local food. Such evaluations would likely do best to incorporate qualitative as well as quantitative measures of socio-cultural dimensions.

Our study is also significant to the local food debate because while we did not formally measure economic impact, our two cases do suggest that the ability of these kinds of "local" milk sales to support agricultural clusters in Hawai'i and strengthen the local economy—one of the benefits consumers most commonly associate with local food—is questionable (Food Marketing Institute 2009). Namely, if the majority of the inputs into the production of milk are not local, as is the case currently, then the trickle-down benefits for the local economy may be limited. More specifically, our finding that Farm A's greater percentage of local inputs by dollar value suggests that its ability to support the existence of a rural agricultural landscape through enhanced agricultural clustering (e.g., milk production in proximity to feed production) is slightly higher compared to that of Farm B's, which is more reliant on imported feed. Yet the high degree of non-local inputs in both dairies suggests that local milk in Hawai'i may not strengthen the local economy as much as consumers imagine. Instead, the production of milk in Hawai'i supports rural suppliers (e.g., feed, fertilizer) operating outside of Hawai'i.

While there is some research examining the links between local food sales, farm-level profitability and community economic growth (Hughes et al. 2008; Vogel 2012; Brown et al. 2014), data teasing apart these links remains limited. Future research should focus on the types of sales and economic structures that facilitate farm-level profitability and trickle-down community benefits, to test the popular assumption that proximity of food production alone can promote regionalized economic growth. Such data could result in metrics that capture the degree to which a product promotes regionalized economic development.

In sum, our work provides empirical evidence of the gap between the spirit of what "local" is thought to be and what it means in practice. Namely, so-called "local goods" are often comprised of non-local inputs. One logical conclusion is that we need to better align the theory of local with its reality—for example by including consideration of the origins of a product's inputs into the definition of local and then better policing what counts as "local". Yet another solution might be to push the local food community to move beyond the trope of "local" to new terms and concepts that better address the issues at stake. For example, drawing from our own findings, it might be more useful to set out to measure not the localness of two operations that market themselves as local, but instead the ability of different types of production systems (e.g., grass-fed versus feedlot operation) to utilize local inputs. Framed differently, researchers may be able to make headway in determining the key factors that determine the degree of localness of a product. Understanding these dynamics will hopefully provide at least an initial step towards clarifying what "local food" actually means.

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